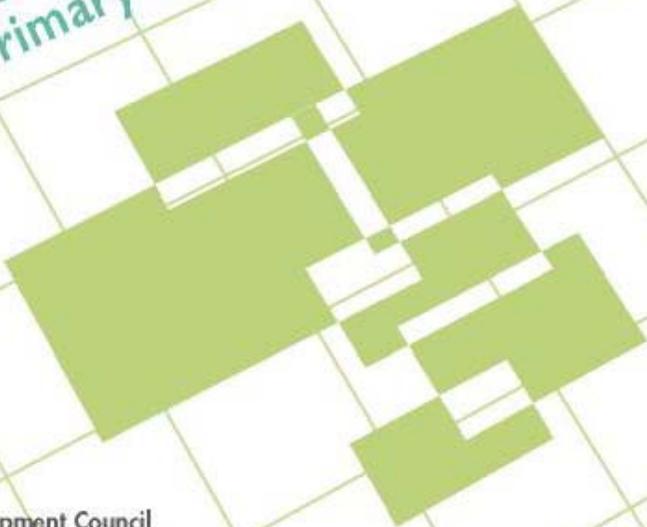


# Science Education

## Key Learning Area Curriculum Guide (Primary 1 - Secondary 3)



Prepared by  
The Curriculum Development Council

Recommended for use in schools by  
The Education Department  
HKSAR  
2002

# Curriculum Development Documents and Supporting Resources

Learning to Learn –  
The Way Forward in  
Curriculum Development  
(2001)



Exemplars of Curriculum  
Development in Schools

Basic Education Curriculum Guide –  
Building on Strengths  
(2002)



Key Learning Area Curriculum Guides  
(2002)



Subject Curriculum Guides



Learning and Teaching  
Resources

Teaching Kits, Videos, Tapes,  
CD-ROMs, Booklets, Leaflets, Reports



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## Preamble

A series of eight Key Learning Area (KLA) Curriculum Guides (Primary 1 to Secondary 3) and the General Studies (GS) for Primary Schools Curriculum Guide (Primary 1-6) have been developed by the Curriculum Development Council (CDC) to support the *Basic Education Curriculum Guide - Building on Strengths* (2002) and to help realize the recommendations made in the CDC Report on *Learning to Learn - The Way Forward in Curriculum Development* (2001) and in the Education Commission's (EC's) education reform final report, *Learning for Life, Learning through Life* (2000).

The CDC is an advisory body giving recommendations to the Hong Kong Special Administrative Region Government on all matters relating to curriculum development for the school system from kindergarten to sixth form. Its membership includes heads of schools, teachers, parents, employers, academics from tertiary institutions, professionals from related fields or related bodies and representatives from the Hong Kong Examinations Authority, as well as officers from the Education Department.

The KLA and GS Curriculum Guides are based on the *Learning to Learn* consultation documents of the respective KLAs and GS published in November 2000. Relevant KLA committees under the CDC have taken into consideration the concerns, needs and interests of schools, teachers and students as well as societal expectations expressed during the consultation period when developing these Guides.

Each KLA or GS Curriculum Guide aims to present a curriculum framework, specifying the KLA's or GS's curriculum aims, learning targets and objectives, and providing suggestions regarding curriculum planning, learning and teaching strategies, assessment and resources. In addition, each Curriculum Guide provides exemplars of effective learning, teaching and assessment practices. Schools are encouraged to adopt the recommendations in the Curriculum Guides and to achieve the learning goals of the school curriculum (CDC Report, 2001) and aims of education (EC Report, 2000), taking into consideration their contexts, needs and strengths.

Schools are also encouraged to make cross-reference to the *Basic Education Curriculum Guide - Building on Strengths* (2002) and the related subject guides as often as possible. This will ensure that there is a coherent understanding of curriculum planning at school, KLA and subject levels.

As curriculum development is a collaborative and on-going enhancement process, the KLA and the GS Curriculum Guides as well as their related subject guides will be updated and improved from time to time to meet new needs of students and society.

Ideas and suggestions on the development of the Science Education Curriculum are always welcome and may be sent to:

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24 Tin Kwong Road  
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## Key Messages

### Science Education

- ❖ provides learning experiences through which students acquire scientific literacy
- ❖ develops the necessary scientific knowledge and understanding, process skills, values and attitudes, for their personal development, and for contributing towards a scientific and technological world

### Entitlement of Students

- ❖ all students should learn science from P1-S3
- ❖ core elements of the General Studies Curriculum Guide and the Science (S1-3) Curriculum

### Guiding Principles for Action

To enable students to learn how to learn better in science, the following curriculum emphases are recommended:

- ❖ Nurturing interest in science
- ❖ Emphasizing scientific thinking
- ❖ Developing students to become active learners in science
- ❖ Helping students to make informed judgements based on scientific evidence
- ❖ Catering for students with strong interest and talent in science

### The Central Science Education Curriculum: An Open and Flexible Framework

The central curriculum, in the form of an open and flexible framework, sets out what schools are encouraged to help students develop:

- ❖ Subject knowledge and skills as embodied in the learning targets and objectives of the six strands
  - Scientific Investigation
  - Life and Living
  - The Material World
  - Energy and Change
  - The Earth and Beyond
  - Science, Technology and Society

- ❖ Generic skills that are developed through learning activities - generic skills such as communication skills, creativity, critical thinking skills and problem-solving skills are accorded priority positions
- ❖ Values & attitudes that should be permeated in the learning and teaching of science - curiosity, openness to new ideas and respect for evidence are accorded priority positions

### **Learning and Teaching of Science**

- ❖ Learning of science should centre on scientific investigation and move away from “recipe” approach. Students should develop understanding of scientific concepts and the interconnections between science, technology and society.
- ❖ The organization of learning experiences should start from where the students are at, utilize their background knowledge, set a context which they perceive to be relevant, and build upon their experience and understandings, so that students could put together conceptual frameworks of their own and develop their own understanding of the world around them.
- ❖ Students should learn how to plan and take control of their own learning.

### **Assessment**

- ❖ Assessment provides information for students to plan and take control of their own learning.
- ❖ Quality criteria derived from learning targets and objectives will be developed for the six strands to serve as a guide for teachers to provide quality feedback for improvement of learning and teaching and as indicators of student achievements

### **Connecting School-based Curriculum Development to Central Curriculum**

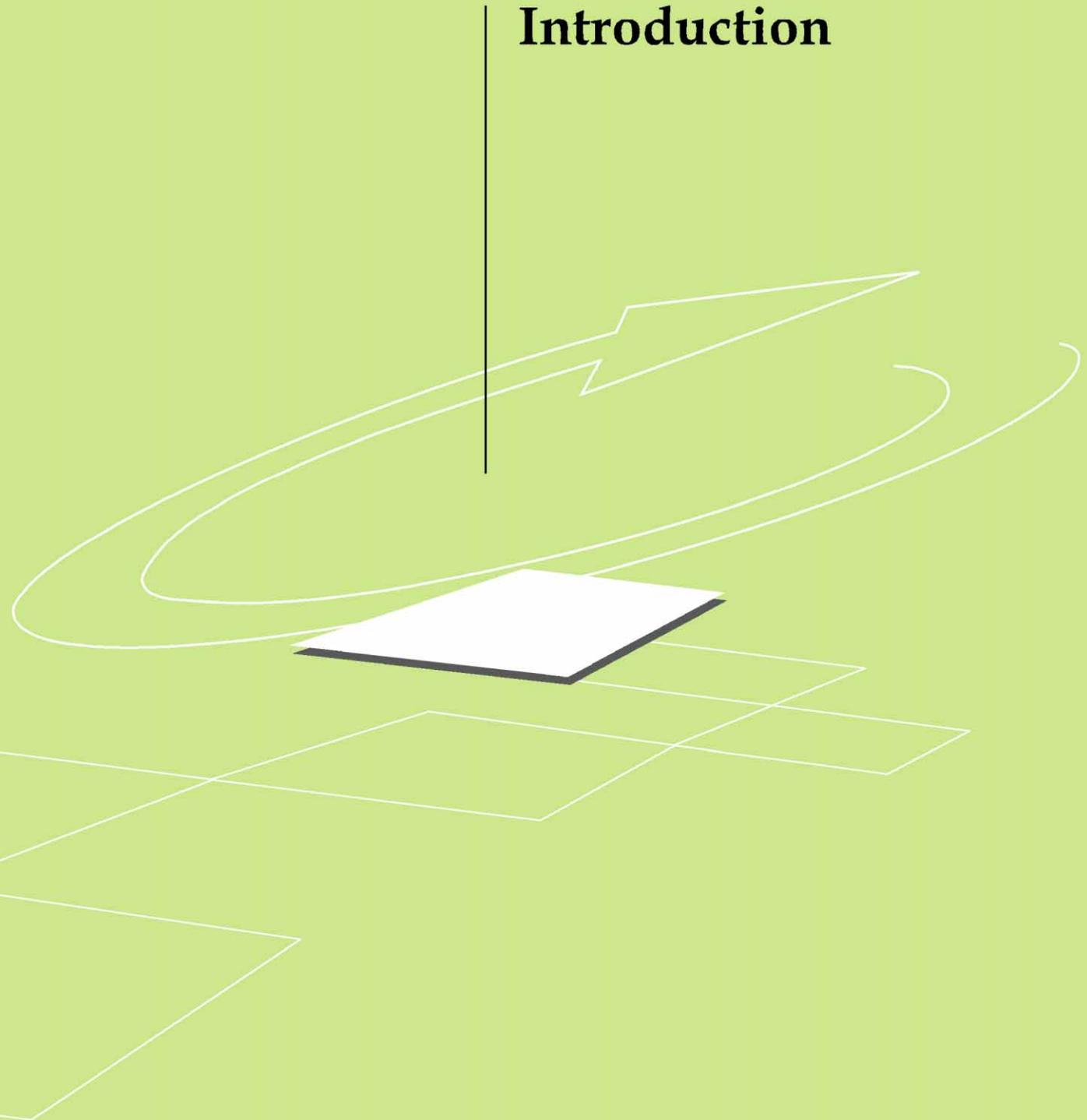
- ❖ Schools should adapt the central curriculum by varying the organization of contents (including the choice of extensions), contexts, learning and teaching strategies and modes of assessment according to the interests, abilities of students, the strengths of schools and teachers
- ❖ School-based science curriculum development is an on-going process through which teachers will develop professionally and as a result students will benefit.

## Short-term Targets of Science Education KLA up to 2005-06

Our Students	Our Teachers
<b>Primary Level</b>	
<i>Please refer to the General Studies Curriculum Guide (P1-P6).</i>	<i>Please refer to the General Studies Curriculum Guide (P1-P6).</i>
<b>Junior Secondary Level</b>	
<ul style="list-style-type: none"> <li>• will design and carry out scientific investigations</li> <li>• will show an interest in exploring contemporary science and related issues</li> <li>• will demonstrate fundamental scientific knowledge, creativity, basic communication and critical thinking skills in science and technology learning activities</li> </ul>	<ul style="list-style-type: none"> <li>• make use of the core and extension parts of the science curriculum to design a school-based curriculum</li> <li>• arrange more scientific investigations and problem-solving activities</li> <li>• create an open atmosphere for discussion and infuse process and thinking skills into science lessons</li> <li>• be aware of new developments in science and encourage students to explore these developments</li> </ul>

# Chapter 1

## **Introduction**



# 1 Introduction

The purpose of this Curriculum Guide is to set out the general directions for curriculum development of school science education in Hong Kong to fulfill the vision of enabling students to attain life-wide and life-long learning. It is a guidebook on the central curriculum of science in the form of curriculum framework for school principals, school curriculum managers and science teachers. Schools should follow the curriculum framework while making school-based adaptation as recommended in the Guide. Academics, educators and other members of the society will also get useful information about the school science curriculum by referring to this Guide.

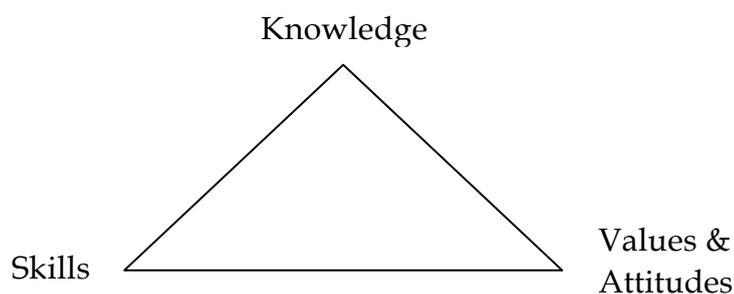
This Guide and the curriculum guides of other key learning areas (KLAs) together with the *Basic Education Curriculum Guide - Building on Strengths (2002)* are based on the related consultation documents of November 2000. They are published in support of the curriculum document *Learning to Learn - The Way Forward in Curriculum Development* (hereafter called "*Learning to Learn*") prepared by the Curriculum Development Council (CDC) (June 2001) and should be read together with it. The *Learning to Learn* document is the outcome of the Holistic Review of the School Curriculum conducted by CDC, beginning in 1999, which was done in parallel with the Education Commission's Education System Review.

To reach more information about science education in schools at P1-S3 levels, the *General Studies for Primary Schools Curriculum Guide (Primary 1-6) (2002)* and *Syllabus of Science (Secondary 1-3) (1998)*, *Safety in Science Laboratories (2002)* and other related circulars issued by the Education Department should be referred to.

## 1.1 What is a Key Learning Area (KLA)?

A Key Learning Area (KLA) is an important part of the school curriculum. It is founded on **fundamental and connected concepts within major fields of knowledge** which should be acquired by all students. A KLA provides a context for the development and application of both generic skills (e.g. creativity, communication, critical thinking and collaboration) and

subject-specific skills, positive values and attitudes through appropriate use of learning and teaching activities and strategies. It also serves as a context for the construction of new knowledge and the development of understanding. The studies offered in each KLA may have an academic, social or practical orientation or a combination of these, depending on their purpose(s). They can be organized into subjects, modules, units, tasks or other modes of learning. The interrelationships among Knowledge, Skills, and Values and Attitudes are depicted below:



## 1.2 Position of Science Education KLA in the School Curriculum

Science is the study of phenomena and events around us through systematic observation and experimentation. Science education cultivates students' curiosity about the world and enhances scientific thinking. Through systematic enquiry, students will develop scientific knowledge and skills to help them evaluate the impact of scientific and technological development. This will prepare students to become lifelong learners in science and technology.

Science education promotes scientific literacy through equipping our students with scientific understandings and process skills to participate intelligently in public discourse and debate about important issues that involve science, technology and society. A scientific habit of mind is also of increasing importance to our students. It helps to prepare them to deal sensibly with problems, and this often involves evidence, quantitative considerations, logical arguments, creativity and uncertainties. To lead a fulfilling and responsible life, our students need to be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science and the processes of science contributes in an essential way to these skills. As one of the key learning areas in the school curriculum, science

education aims to develop students' capability for lifelong learning while maintaining their sense of wonder about the world around them.

A good science education for our students is vital for Hong Kong to keep pace with technological advancements and for enhancing Hong Kong's economic growth and sustainability.

Science education in Hong Kong is implemented through a series of subjects at the primary and secondary levels. At the primary level, Science Education is an integral part of the General Studies (GS) curriculum, which also embraces learning elements of Personal, Social & Humanities Education (PSHE) and Technology Education (TE). At the junior secondary level, the core subject Science (S1-3), consisting of topics from various science disciplines, is taught in all schools. At the senior secondary level, Biology, Human Biology, Chemistry and Physics are offered as optional subjects at S4-5, while Biology, Chemistry and Physics are further developed into Advanced Supplementary Level and Advanced Level subjects in the sixth form curriculum.

#### **Existing Subjects of the Science Education KLA**

##### **Primary Level**

General Studies (Primary 1-6)

##### **Junior Secondary**

Science (Secondary 1-3)

##### **Senior Secondary**

Biology (Secondary 4-5)

Human Biology (Secondary 4-5)

Chemistry (Secondary 4-5)

Physics (Secondary 4-5)

Biology (Advanced Supplementary Level & Advanced Level)

Chemistry (Advanced Supplementary Level & Advanced Level)

Physics (Advanced Supplementary Level & Advanced Level)

In 1999, Science Education, as one of the key learning areas of the school curriculum, was critically examined as part of the holistic review of the

school curriculum. The aims of science education have been re-defined to align them with the new aims of education for the 21<sup>st</sup> century - enabling our students to enjoy learning, enhancing their effectiveness in communication and developing their creativity and sense of commitment. Essential learning elements in science education are identified for the whole-person development of our students.

Recommendations are made to introduce changes for improvement which will enable students to learn how to learn better in science through an improved curriculum framework and learning, teaching and assessment strategies. Science education, besides contributing to the development of science capabilities in the students, will also promote the development of generic skills, values and attitudes through a range of learning activities. Students' learning experiences in the eight KLAs are closely linked, and learning activities, if carefully planned, can facilitate effective learning within the limited curriculum time.

### **1.3 Direction for Development**

The science curriculum framework builds on the strengths and good practices in science education in Hong Kong. It also makes suggestions on ways to provide students with wider access to meaningful and effective science learning experiences that will enable them to meet the needs and challenges of society. **The strengths of secondary school science education in Hong Kong are:**

- ❖ **delivery of the curriculum by subject-trained teachers;**
- ❖ **sufficient provision of hands-on learning activities for students;**
- ❖ **adequate teaching resources including laboratory facilities and equipment and teaching aids;**
- ❖ **good support from laboratory technicians; and**
- ❖ **rising support from scientists and academics.**

The science education in Hong Kong should build on the above strengths to enhance students' scientific thinking through progressive learning activities. These involve asking questions, hypothesizing, observing, measuring, designing and evaluating procedures, analyzing data, and examining

evidence. Learning science will encourage our students to learn independently, and will enable them to deal with new situations, reason critically, think creatively, make decisions and solve problems.

Through science activities, students should develop an interest in science and thus they will be motivated to become active learners in science. Students should also develop an understanding of the interconnections between science, technology and society (STS). They should be able to make informed decisions based on evidence.

Students with high ability or a strong interest in science need more challenging learning programmes to stretch their capabilities in science.

#### **1.4 Strategies for Development**

Science education in Hong Kong should be comparable with the standards of high-achieving countries. The Science Education KLA Curriculum Guide is developed according to the broad aims of education in Hong Kong. It will serve as a reference for developing a school-based science curriculum.

The new developments in the curriculum framework and in various science subjects will be supported by try-out schemes to ensure that the proposed changes are feasible. Surveys and research studies will be conducted to provide systematic information to support curriculum innovation in science education, such as effective use of project learning and life-wide learning in science.

Schools wishing to try out the new approaches proposed in the science curriculum framework will be supported and their experiences will be evaluated and disseminated. Schools and teachers are encouraged to promote learning to learn through infusing generic skills into the learning and teaching of science subjects. They are also encouraged to adapt the curricula to suit the needs of their students.

It is hoped that by the 2005-06 school year, all schools will have gone through the process of developing a school-based curriculum to meet the needs of

their students with reference to the learning targets and objectives set out in this Guide. The following recommendations are proposed to help schools move along this direction:

❖ **Nurturing Interest in Science**

It is important to nurture students' interest in science learning. Students are generally intrigued by new things. They are interested in problems that puzzle them and have a natural urge to find solutions to settle them. Organizing the curriculum around problems or phenomena that puzzle students helps motivate students to learn.

Rather than relying solely on the textbooks, teachers of General Studies and science subjects are encouraged to make use of hands-on exploratory learning activities to develop students' interest in science. It is essential that students participate in a wide range of activities to develop enjoyment in the process of science learning. This will help them develop an ownership of the learning process and become active learners in science. An example is shown as follows:

### **Hands-on and Minds-on Science Activities in General Studies**

**Level: Primary**

**Curriculum: General Studies**

**Emphasis: Enhancing science learning experience**

- Teachers can enrich their lessons and extend students' learning by introducing some simple and safe model-making activities or activities suggested in the Young Scientists Award Scheme. These activities are developed to fit into the present GS curriculum and are intended to stimulate an ongoing interest in the study of science and promote science-learning activities at classroom level.
- Science model-making activities can be employed as teaching resources to introduce a new topic, as consolidation exercises after a topic, or as starting material for scientific investigation. While the activities suggested in the Young Scientists Award Scheme are of various types and the level of difficulty varies from individual information search to guided scientific investigation, teachers may choose and adopt those that they like to suit the characteristics of their students and their school setting.
- Through engaging in these activities, students gain precious hands-on experience in science and technology. Their curiosity, creativity and spirit of inquiry are cultivated. Students' communication, collaboration and study skills are also developed.

To promote students' interest in science and to take care of their learning experience beyond the classroom, partnerships with academic institutions and professional bodies (such as faculties of science in the universities and the Science Museum) will be established to help develop a range of science learning activities to promote understanding of science and to provide authentic learning experiences in science.

*Exemplar (1) for illustration: "Thematic Science Day in Primary Schools"*

## ❖ **Emphasizing Scientific Thinking**

To empower students with the capability of learning to learn, due emphasis should be placed on enhancing students' scientific thinking and strengthening their science process skills.

Scientific thinking helps students to become better decision-makers, problem-solvers and critical thinkers. Students should be led to follow the steps taken by scientists to explain phenomena and to provide experimental evidence to support or disprove claims. They will make generalizations about physical phenomena from observations, develop self-constructed theories and then modify these theories when challenged to develop more sophisticated ones. The following is an example:

### **Inspiring the Inquiring Mind**

**Level: Junior Secondary**

**Curriculum: Science**

**Emphasis: Developing an inquiring mind**

- Students are asked to propose hypotheses for an intriguing phenomenon, such as "Why does a goldfish stay steadily in the water without either floating upwards or sinking further when it sleeps?". They will then design and conduct experiments to test their hypotheses, and draw conclusions from experimental results for explaining the phenomenon.
- The process will provide insights into how scientists inquire into physical phenomena and how science principles are derived from experiments.
- Through engaging in hands-on and minds-on scientific investigations, students will begin to appreciate the nature of science and develop a disposition to inquire into the world around them.
- Students' curiosity, creativity, communication skills, collaboration skills and problem-solving abilities are nurtured and strengthened.

### ❖ **Developing Students to Become Active Learners in Science**

Students have to take an active role in connecting learning experiences across various KLAs to render learning more meaningful.

Students should be engaged actively in designing and conducting experiments to explore science concepts and develop science investigation skills for their own construction of science knowledge. Students should also be exposed to frontiers of science and develop an interest in the advancements of science and technology.

### ❖ **Helping Students to Make Informed Judgements Based on Scientific Evidence**

It is the role of school science education to promote public understanding of science and to help students make informed judgements based on scientific evidence. Through science learning activities that involve an examination of evidence, quantitative considerations and logical arguments, our students will be equipped with essential scientific understandings and a scientific habit of mind could be nurtured. They can then participate intelligently in public discourse and debate about important societal issues involving science and technology.

Scientific and technological literacy should be promoted throughout the years of schooling to enable students to handle science and technological issues in their daily life. The Science (S1-3) Curriculum has laid down a foundation for such. There is, however, a need for all students beyond S3 to have a better understanding of science and technology to enable them to cope with a dynamically changing environment and to make informed judgements in a technological society. Hence, a new subject, Science and Technology at S4-5 level aiming at non-science students, will be introduced in September 2003. Modules such as health science, environmental science and telecommunication will be included as options, and related scientific issues will be examined.

### **Informed Decisions Based on Scientific Evidence**

**Level: Junior Secondary**

**Curriculum: Science**

**Emphasis: Making informed judgements**

- These are activities to promote students' critical thinking and rational decision-making skills applicable to major science-related issues of personal and public concern. Students will be asked to collect evidence, design experiments to test for some claims (if possible), to judge the reliability and validity of these claims and data, and to develop arguments or make informed judgements based on evidence.
- Advertisements, the Choice magazine and newspaper clippings provide a vast resource for discussion.
- Examples of topics for such activities include "The effectiveness of sun-glasses and sunscreens in the market", "Facts and Myths on slimming methods", "EM Radiation of Mobile Phones" etc., which illustrate the intertwining nature of science, technology and society.
- Discussion of these issues may lead to scientific investigations or open forums. In the former, students design and perform investigations to collect evidence to support or disprove claims. In the latter, the teacher will act as the chairperson to introduce an issue and provide background information. The teacher plays the role of a facilitator to guide students to look for relevant information, to provide guiding questions, to encourage students to express their opinions, and to help to clarify values.
- Students will develop their science process skills and critical thinking skills as well as other generic skills in the search for information, in analyzing problems, and in their debates/presentations.

#### **❖ Catering for Students with a Strong Interest and Talent in Science**

Students with high ability or a strong interest in science need more challenging learning programmes. These programmes should stretch the students' science capabilities and offer them opportunities to develop their potential to the full.

A variety of learning activities in the form of science competitions and research projects are essential to develop students' capabilities in science and technology. These activities may be conducted in the form of school-based programmes or in collaboration with tertiary institutions, professional bodies or the commercial sector.

#### 1.4.1 Short-term Expectations

We hope that from now to 2005-06:

Our Students	Our Teachers
<b>Primary Level</b>	
<i>Please refer to the General Studies Curriculum Guide (P1-P6).</i>	<i>Please refer to the General Studies Curriculum Guide (P1-P6).</i>
<b>Junior Secondary Level</b>	
<ul style="list-style-type: none"> <li>• will design and carry out scientific investigations</li> <li>• will show an interest in exploring contemporary science and related issues</li> <li>• will demonstrate fundamental scientific knowledge, creativity, basic communication and critical thinking skills in science and technology learning activities</li> </ul>	<ul style="list-style-type: none"> <li>• make use of the core and extension parts of the science curriculum to design a school-based curriculum</li> <li>• arrange more scientific investigations and problem-solving activities</li> <li>• create an open atmosphere for discussion and infuse process and thinking skills into science lessons</li> <li>• be aware of new developments in science and encourage students to explore these developments</li> </ul>
<b>Senior Secondary Level</b>	
<ul style="list-style-type: none"> <li>• will apply their scientific knowledge and critical thinking skills in making informed decisions</li> <li>• will evaluate evidence and make use of critiques and arguments derived from science during</li> </ul>	<ul style="list-style-type: none"> <li>• arrange more scientific investigations and learning activities on science, technology and society</li> <li>• will be more open to ideas and accept multiple solutions in discussions about scientific issues</li> </ul>

Our Students	Our Teachers
<p>discussions</p> <ul style="list-style-type: none"> <li>• will demonstrate concern about the impact of science and technology on society</li> </ul>	<ul style="list-style-type: none"> <li>• will keep abreast of frontier developments in science and provide support to students in exploring them</li> <li>• will explore learning opportunities for students with talent or a strong interest in science</li> </ul>

#### *1.4.2 Medium-term Development from 2006-2007 to 2010-2011*

The science curriculum framework with refined learning targets and objectives will serve as a reference for schools to develop and provide learning programmes for their students. With territory-wide support and experience gained through various sources, schools should continue to develop their own school-based curriculum to enable students to attain the learning targets in science education.

Schools and teachers should continue to work on the focuses listed in the short-term phase and

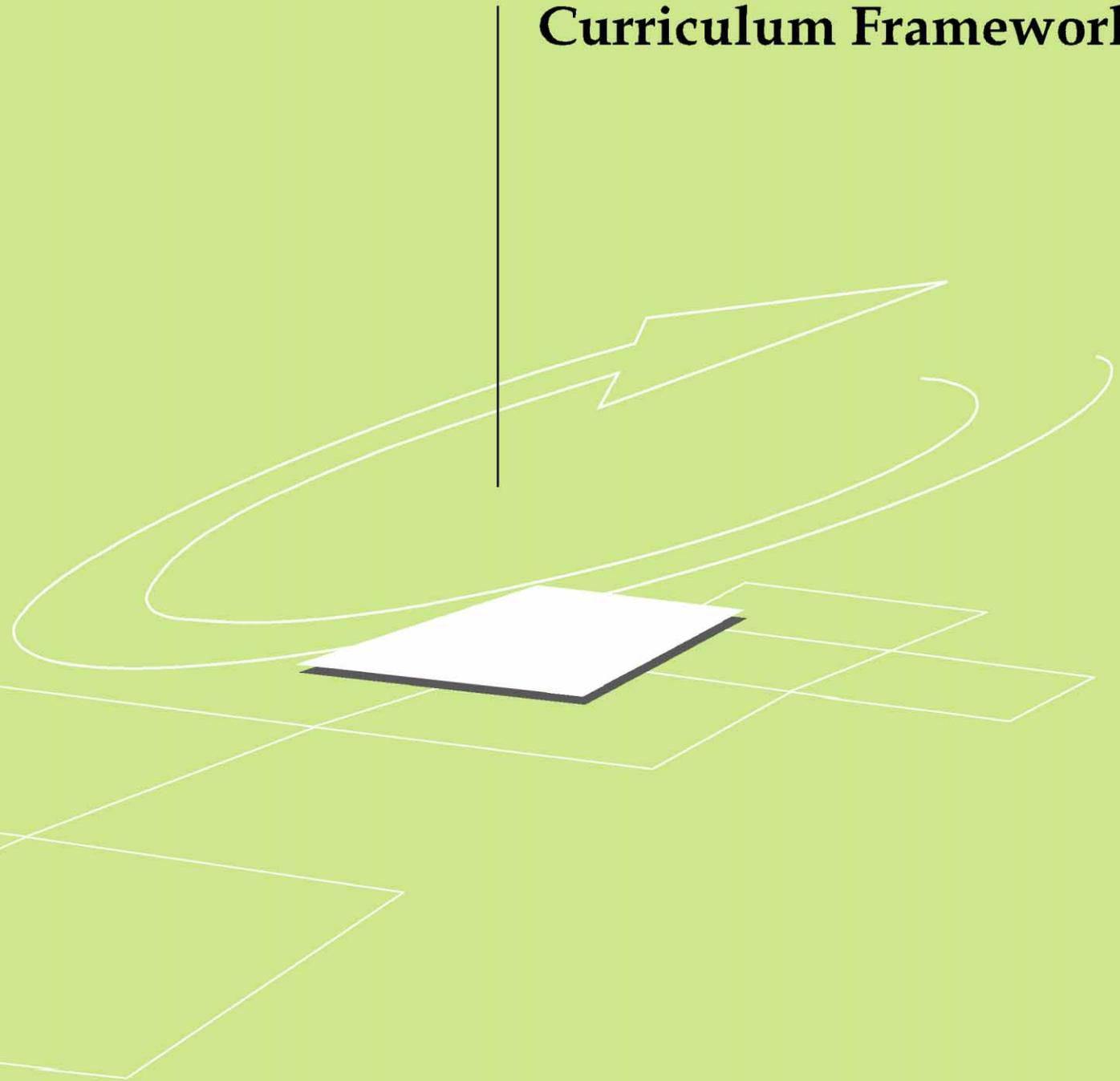
- ❖ strengthen the teaching-learning-assessment cycle by using the quality criteria in describing students' achievement and in encouraging students to self-regulate their own learning;
- ❖ further enhance team building and experience sharing among teachers;
- ❖ develop modules of learning to facilitate flexible, coherent and integrated organization of learning experiences; and
- ❖ work towards a balanced school-based science curriculum that caters for the diverse needs of students.

### ***1.4.3 Long-term Development Beyond 2011***

The long-term goal of science education is to help students develop an interest in science and to master the essential scientific knowledge and skills to become life-long learners in science and technology. Science education should also help students learn how to deal with the pace of scientific and technological development and prepare them for an ever-changing world.

## Chapter 2

# Curriculum Framework



# The Hong Kong School Curriculum



## 2 Curriculum Framework

The curriculum framework for Science Education is the overall structure for organizing learning and teaching for the science subjects. The framework comprises a set of interlocking components including:

- ❖ subject knowledge and skills, which are expressed in the form of learning targets and learning objectives;
- ❖ generic skills; and
- ❖ values and attitudes.

The framework sets out what students should know, value and be able to do at various stages of schooling. It gives schools and teachers flexibility and ownership to plan and develop alternative curriculum modes to meet their varied needs.

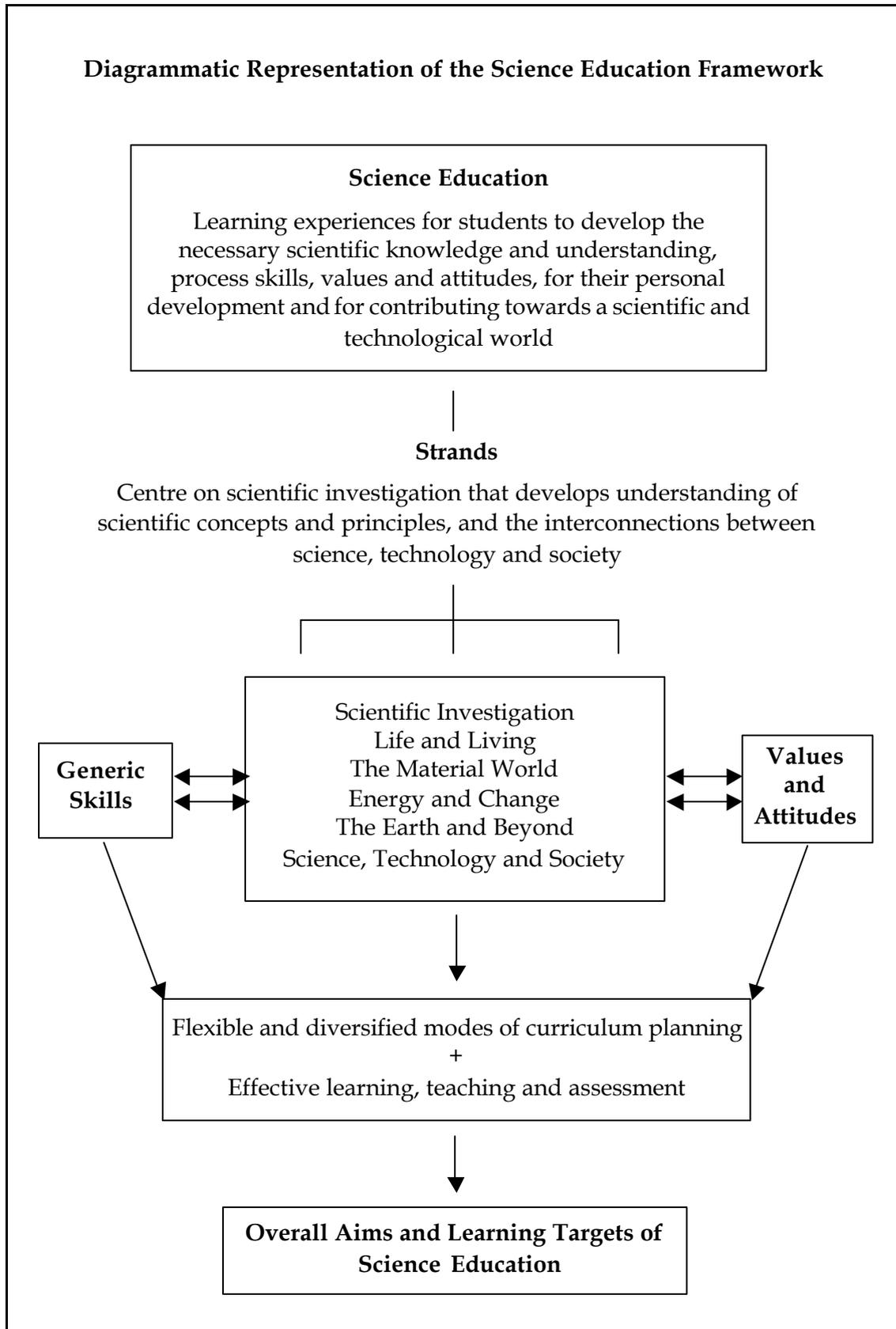
### 2.1 Aims of Science Education

School science education will provide learning experiences through which students acquire scientific literacy. Students will develop the necessary scientific knowledge and understanding, process skills, values and attitudes, for their personal development, for participating actively in a dynamically changing society, and for contributing towards a scientific and technological world. Science education aims for students to:

- ❖ develop curiosity and interest in science;
- ❖ develop the ability to inquire and solve problems;
- ❖ acquire basic scientific knowledge and concepts for living in and contributing to a scientific and technological world;
- ❖ recognize the usefulness and limitations of science and the interconnections between science, technology and society and to develop an attitude of responsible citizenship, including respect for the environment and commitment to the wise use of resources;
- ❖ become familiar with the language of science and be equipped with the skills to communicate ideas in science-related contexts;

- ❖ appreciate and understand the evolutionary nature of scientific knowledge;
- ❖ attain personal growth through studying science; and
- ❖ be prepared for further studies or enter careers in scientific and technological fields.

## 2.2 The Curriculum Framework



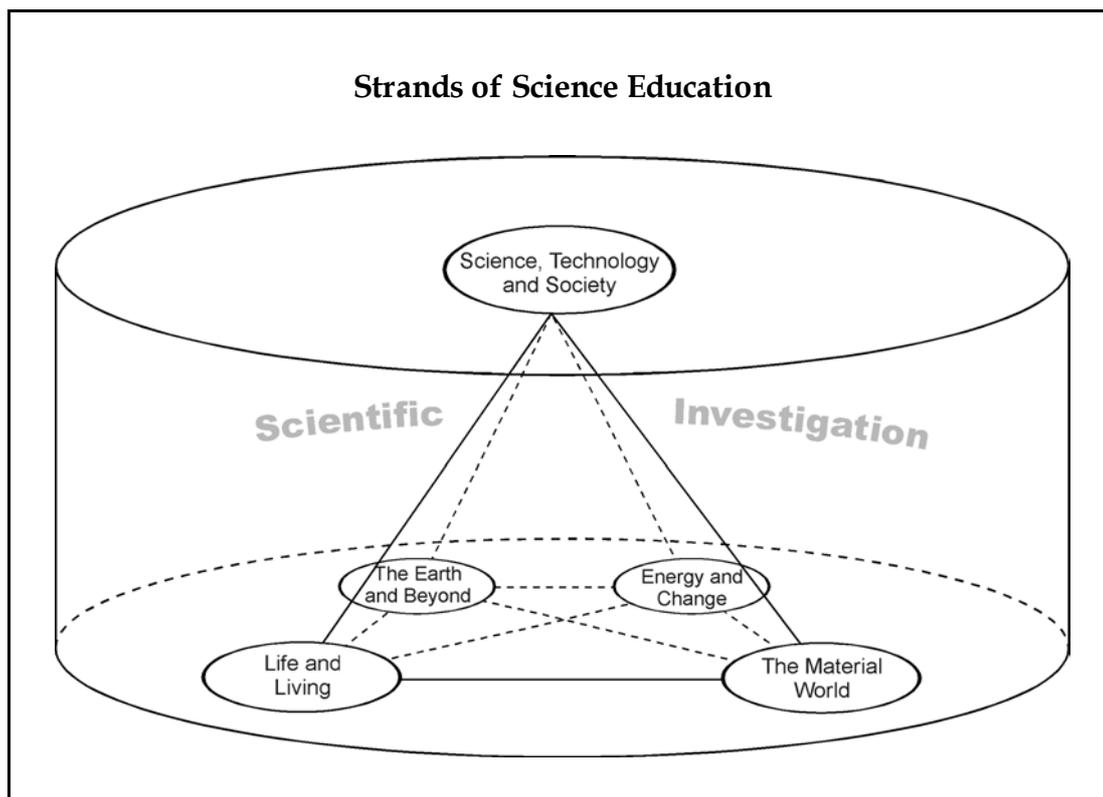
### 2.2.1 *Strands, Learning Targets and Objectives*

#### **Strands**

The arrangement of major learning elements in science into six strands in the science curriculum is needed for the purpose of curriculum planning and organization.

- ❖ **Scientific Investigation** – to develop science process skills and understanding of the nature of science
- ❖ **Life and Living** – to develop understanding of scientific concepts and principles related to the living world
- ❖ **The Material World** – to develop understanding of scientific concepts and principles related to the material world
- ❖ **Energy and Change** – to develop understanding of scientific concepts and principles related to energy and change
- ❖ **The Earth and Beyond** – to develop understanding of scientific concepts and principles related to the Earth, Space and the Universe
- ❖ **Science, Technology and Society (STS)** – to develop understanding of the interconnections between science, technology and society

The six strands are inter-related and can be represented graphically in the following diagram:



### **Learning Targets and Objectives**

Through various stages of schooling, students will acquire the necessary knowledge, skills and attitudes in science education. The learning targets of science education at these stages are described below.

#### **On completion of the primary level, students should:**

- ❖ show curiosity and interest in science and ask questions related to Nature and to their environment;
- ❖ use focused exploration and investigation to acquire scientific understanding and skills;
- ❖ relate their understanding of science to domestic and environmental contexts;
- ❖ relate their understanding of science to their personal health, and develop sensitivity to safety issues in everyday life and take action to control risks;
- ❖ use their knowledge and understanding of science to explain and interpret a range of familiar phenomena; and

- ❖ have some understanding of how to treat living things and the environment with care and sensitivity.

**On completion of the junior secondary level, students should:**

- ❖ acquire basic scientific knowledge and concepts for living in and contributing to a scientific and technological world;
- ❖ have developed an ability to define problems, design experiments to find solutions, carry out practical work and interpret the results;
- ❖ apply their understanding of science to technological applications, social issues, and their daily experiences;
- ❖ recognize the usefulness and limitations of science and the evolutionary nature of scientific knowledge;
- ❖ relate their understanding of science to their personal health and cultivate an awareness of safety issues in everyday life and take proper action to control risks; and
- ❖ consider the effects of human activities on the environment and act sensibly in conserving the environment.

To plan for the interface of science curriculum at junior and senior secondary levels, schools may also refer to the following learning targets.

**On completion of the senior secondary level, students should:**

- ❖ have a fundamental understanding of essential scientific knowledge and concepts for contributing towards a scientific and technological world;
- ❖ have the ability to solve problems by employing scientific approaches and methods;
- ❖ make informed judgements and decisions based on scientific evidence;
- ❖ be able to comprehend and discuss issues related to the nature and development of science and technology;
- ❖ make sensible judgements on their personal health and take responsible actions in safety issues; and
- ❖ acknowledge the effects of human activities on the environment and be committed to act responsibly in conserving the environment.

The learning objectives for the different strands at the various stages of schooling are outlined below.

## **Learning Objectives at Key Stage 1 (Primary 1-3)**

### **Scientific Investigation**

- To show curiosity and interest in science.
- To demonstrate interest in exploring their environment and solving simple scientific problems.
- To plan and conduct simple investigations in familiar situations.
- To record and discuss observations and make simple interpretations.

### **Life and Living**

- To recognize the features of living things through observing and interacting with Nature.
- To develop healthy living habits.
- To appreciate the characteristics of living things.
- To develop a general understanding of life processes.
- To work with peers in the care of living things.

### **The Material World**

- To identify daily materials and their uses.
- To list the ways materials are used for different purposes.
- To identify characteristics and changes in materials using the senses.
- To be committed to environmentally friendly practices.

### **Energy and Change**

- To describe ways energy is used in daily life.
- To identify sources of energy in daily life.
- To recognize some of the properties of heat and movement.
- To be aware of safety issues in the use of energy in daily life.

### **The Earth and Beyond**

- To identify and describe the basic patterns and objects in the sky.
- To identify simple features of weather change.
- To recognize the Earth as a wealth of resources.

### **Science, Technology and Society**

- To appreciate some of the ways scientific and technological advancements have influenced our life.
- To show concern for the environment and make wise use of natural resources.
- To recognize some of the ways modernization and the information era have influenced us.

## **Learning Objectives at Key Stage 2 (Primary 4-6)**

### **Scientific Investigation**

- To show curiosity and inquisitiveness in science.
- To demonstrate interest in exploring the environment and solving simple scientific problems.
- To plan and conduct simple investigations in familiar situations.
- To record and discuss observations and suggest simple interpretations.

### **Life and Living**

- To appreciate the existence of a variety of living things.
- To identify personal needs and the needs of other familiar living things.
- To identify observable features of individuals and be aware of the functions of different parts of the human body as the basis for self-care.
- To identify animal and plant features that change over time.
- To recognize the interdependence of living things and their environment.

### **The Material World**

- To suggest how materials are used and the related consequences.
- To distinguish between changes that cannot be easily reversed and those that can.
- To illustrate ways natural materials are used and the consequences on humans and the environment.
- To be committed to the wise use of natural resources and the conservation of the environment.

### **Energy and Change**

- To recognize some of the patterns and phenomena related to light, sound, electricity and movement.
- To report on patterns of energy use in the home, school and other workplaces.
- To identify safety measures associated with the use of different forms of energy.
- To be committed to the wise use and conservation of energy in daily life.
- To design and make models enabling the efficient transfer of energy.

### **The Earth and Beyond**

- To list ways that the local environment influences our daily life.
- To explain the alteration of day and night and relate it to patterns of our daily life.
- To identify and describe weather and seasonal changes and their effects on living things.
- To illustrate patterns of changes observable on the Earth caused by the movement of the Sun, the Earth and the Moon.
- To appreciate that people have always marvelled at the vast universe and their efforts in trying to learn more about it.

### **Science, Technology and Society**

- To appreciate some of the ways scientific and technological advancements have influenced our life.
- To show concern for the environment and make wise use of natural resources.
- To appreciate that the study of science is partly for creating meaning in our world and partly to improve our quality of life.
- To discuss and recognize some of the ways modernization and the information era have influenced us.

### **Learning Objectives at Key Stage 3 (Secondary 1-3)**

#### **Scientific Investigation**

- To propose hypotheses and devise methods for testing them.
- To plan and conduct scientific investigations.
- To evaluate the fairness of tests and draw conclusions based on findings.

#### **Life and Living**

- To appreciate the diversity of life and to understand the basic principles of classification systems.
- To recognize that cell is the basic unit of life.
- To develop a basic understanding of some of the life processes.
- To appreciate and understand how a new life is born and be aware of the physiological and emotional changes during puberty.
- To recognize the importance of maintaining body health.

#### **The Material World**

- To understand physical and chemical properties.
- To understand how materials are used and the related consequences.
- To investigate some chemical changes and the substances involved.

#### **Energy and Change**

- To compare energy options available for particular purposes in the community.
- To identify processes of energy transfer and conditions that affect them.
- To identify forms and transformations of energy in sequences of interactions.
- To relate observed changes in an energy receiver to the quantity of energy transferred.

#### **The Earth and Beyond**

- To understand that the earth's crust is a useful source of minerals.
- To describe the effects of gravity and frictional forces on the motion of an object on the Earth.
- To understand the basic concepts and conditions for space travel.

**Science, Technology and Society**

- To understand the development and use of materials and their impact on our living and on the environment.
- To recognize the effects of human activities on the environment.
- To act responsibly in conserving the environment.
- To recognize the limitations of science and technology.

**Learning Objectives at Key Stage 4 (Senior Secondary)**

(included for planning of interface of science curriculum at junior and senior secondary levels)

**Scientific Investigation**

- To select and follow appropriate methods of investigations for specific purposes.
- To plan and conduct science experiments for solving problems.
- To collect information and draw conclusions for decision-making.

**Life and Living**

- To develop a basic understanding of the essential life processes.
- To understand the basic principles of genetics and its applications.
- To evaluate the impact of global environmental issues on the quality of life.
- To be committed to a healthy lifestyle.

**The Material World**

- To understand the relation of the uses of domestic chemicals and their properties.
- To examine classes of chemical reactions and their applications.
- To investigate the processing of raw materials.
- To evaluate the use of materials.

**Energy and Change**

- To describe systems whose purpose is to transfer energy efficiently.
- To explain the principles of energy input-output devices.
- To apply ideas of energy conservation and efficiency to sequences of interactions.
- To analyze and compare situations to demonstrate the conservation of energy.

**The Earth and Beyond**

- To know ways in which technology has increased our understanding of the universe.
- To recognize natural changes in the environment, such as seasonal changes, geological changes and natural disasters.
- To describe the impact of human activities on the environment, such as the construction of roads and buildings, and the extraction of natural resources.

### **Science, Technology and Society**

- To evaluate the impact of science applications on human activities.
- To analyze ways that scientific and technological development influences our society.
- To identify the pros and cons of scientific applications for making informed judgements.
- To develop an awareness of the need to evaluate environmental issues from a variety of perspectives.
- To demonstrate responsibility for local and global environments.

### **2.2.2 Generic Skills**

Generic skills are fundamental in helping students to learn to acquire knowledge, to construct knowledge and to apply knowledge to solve new problems, thus allowing students to explore and investigate the scientific and technological world. Generic skills should be developed throughout all stages of schooling, across all key learning areas. Students should be able to transfer them from one learning context to another, be it within science or not. The transferability of these skills will help students continue to learn and succeed in personal development and life-long learning.

The nine generic skills advocated in *Learning to Learn* are :

- ❖ Collaboration Skills
- ❖ Communication Skills
- ❖ Creativity
- ❖ Critical Thinking Skills
- ❖ Information Technology Skills
- ❖ Numeracy Skills
- ❖ Problem-Solving Skills
- ❖ Self-Management Skills
- ❖ Study Skills

For 2001-02 to 2005-06, priority should be placed on **communication skills**, **creativity** and **critical thinking skills**, and specifically for science education, **problem-solving skills** are also one of the focus areas.

The science curriculum provides ample opportunities and rich learning

experiences for students to develop generic skills as well as scientific process skills. Activities such as scientific investigations, experiments, project work, field work, group discussion, debates, which allow students to be actively engaged in the learning process, are effective ways to motivate learning and to develop generic skills.

Scientific investigations and experiments allow students to gain personal experiences of science through hands-on activities and to develop the skills associated with the practice of science. Students have to ask relevant questions, to pose and define problems, to formulate hypotheses, to plan what to do and how to research, to predict outcomes, to conduct experiments, to interpret results, to draw conclusions and suggest ideas for improvement. These experiences allow students to develop and demonstrate their communication skills, creativity, critical thinking skills, collaboration skills, numeracy and problem-solving skills.

Project work provides an excellent context where students will experience science as interesting, challenging and dynamic, and helps students integrate their everyday life experiences into their learning of scientific concepts, skills and attitudes. Students have to set goal, to gather information and collect data, to analyse and synthesize information, to prioritize tasks and review, to communicate and present their ideas and findings. These involve a variety of generic skills, e.g. self-management, study skills, creativity, communication, problem-solving, as well as collaboration skills when conducting group project work.

Group discussion, role-play and debate provide opportunities for students to interact with others, to express their opinions and exchange viewpoints. Students have to demonstrate their mastery of scientific language, and understanding of concepts through the process of researching and analyzing information, organizing and presenting ideas, and making judgements from arguments. They have to organize themselves and others to participate actively in group work. By reading, discussing, and role-playing scientific controversies, students see situated, contingent and contextual features of scientific knowledge. In the reporting process, students become self-critical, and learn to accept evaluation from others, as well as being critical in evaluating others. Thus critical thinking skills, collaboration skills, creativity,

problem-solving skills and communication skills are nurtured throughout these processes of active learning in science.

To further illustrate the development of the four focused generic skills, namely communications skills, creativity, critical thinking skills and problem-solving skills, the tables in Appendix 1 provide the descriptors of expected achievement across the school curriculum and examples of implementation in science education at each key stage.

### 2.2.3 *Values and Attitudes*

The development of values and attitudes are essential elements of the school curriculum. A set of values and attitudes advocated in *Learning to Learn* is provided in Appendix 2. For 2001-02 to 2005-06, priority should be given to the development of values and attitudes such as responsibility, commitment, perseverance, respect for others and national identity.

Values and attitudes should be permeated in the learning and teaching of science to foster the scientific ways of thinking and working, and these include:

- ❖ Curiosity
- ❖ Perseverance
- ❖ Critical reflection
- ❖ Open-mindedness
- ❖ Appropriately valuing the suggestions of others
- ❖ Caring for the living and non-living environments
- ❖ Willingness to tolerate uncertainty
- ❖ Respect for evidence
- ❖ Creativity and inventiveness

Science thrives on curiosity - and so do children. Science education fosters curiosity and teaches children how to channel that curiosity in productive ways.

New ideas are essential for the growth of science and for human activities in general. People with closed minds miss the joy of discovery and satisfaction of intellectual growth. As the purpose of science education is wider than

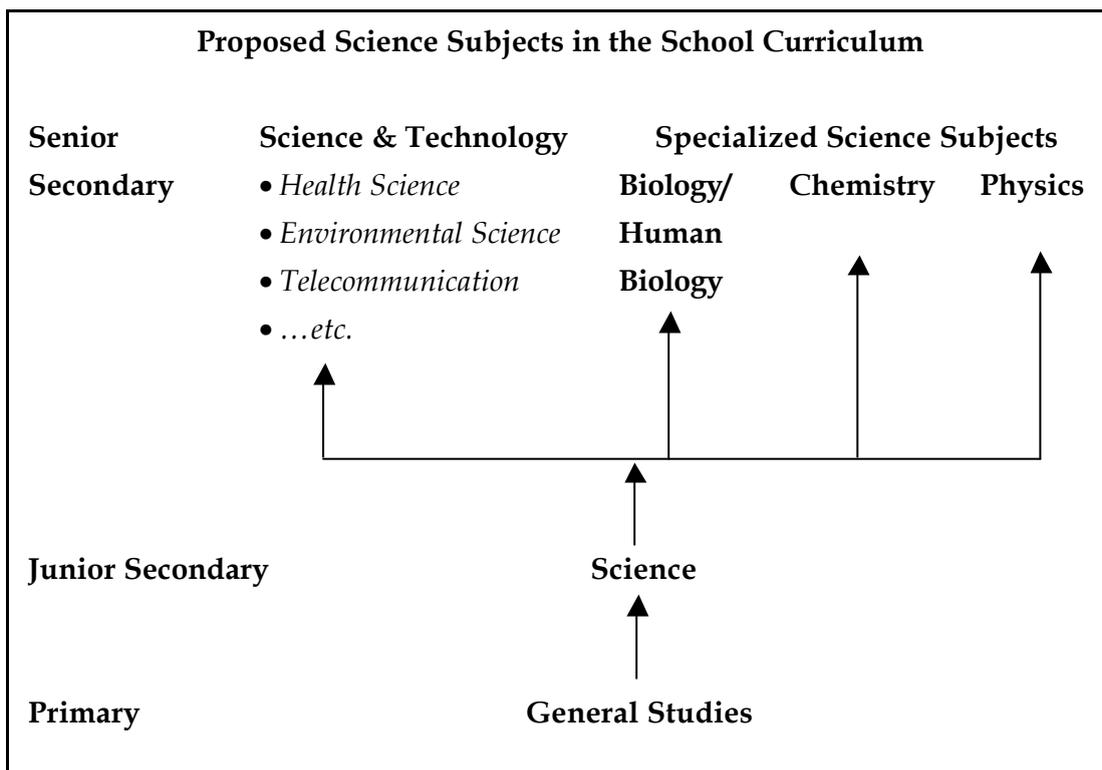
simply producing scientists, it should help all students understand the great importance of carefully considering ideas, and the push and pull of conflicting ideas.

Science is characterized as much by scepticism as by openness. Before a new theory is received it has to be borne out by evidence, has to be argued with explanations, and is tested for logical consistency with other existing tested principles. Acceptance of a new theory is a process of verification and refutation. Science education can help students to develop a healthy balance in their own minds between openness and scepticism.

All these values and attitudes can be fostered in the Science Education KLA in appropriate themes such as environmental conservation, pollution, technological development in ancient China, as well as learning and teaching strategies such as project work, field work and scientific investigations. It should be noted that the development of values and attitudes should be within a meaningful context, not in a vacuum and not in isolation. It should be fostered together with developing students' science process skills and generic skills through various challenging, meaningful learning activities. A list of learning objectives attributing to the development of values and attitudes in science education is listed in Appendix 2.

### **2.3 Curriculum and Subject Organizations**

Proposed science subjects for primary and secondary schools are as follows:



In the short term, new approaches are explored in the re-design of the General Studies curriculum, an outline of which is contained in Appendix 3.

The Science (S1-3) Curriculum with enhanced features of scientific investigation has been implemented in September 2000. Core and extension parts have been included in the curriculum, and schools may make reference to these parts in the process of school-based curriculum development. Appendix 4 contains an analysis of the connection between the Science (S1-3) Curriculum and this Guide.

The curriculum guides for Biology, Chemistry and Physics at S4-5 level have also been developed and are scheduled for implementation in September 2003. They reflect the changes in the new science curriculum framework. They are continuations of the science curriculum at S1-3 level and the subject curriculum guides share the same common features, such as emphasizing scientific investigation, the inclusion of core and extension parts, and enhancing STS connections.

The proposed subject, Science and Technology at S4-5 level is undergoing multiple stages of consultation. Related documents can be found in the website: <http://cd.ed.gov.hk/>.

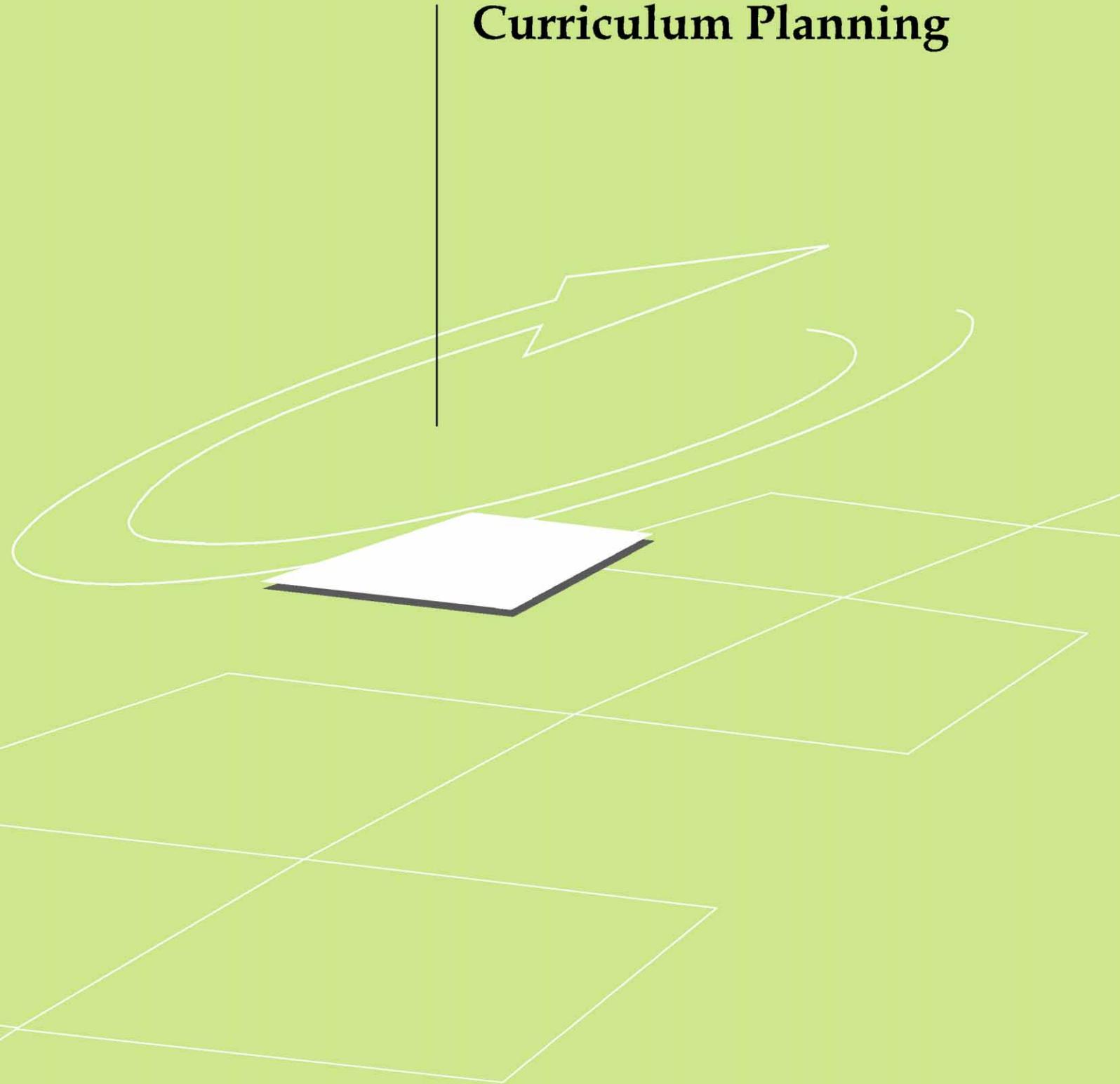
#### **2.4 Interfacing with Secondary 4-5**

To plan for the interface of science curriculum with S4-5, schools should refer to the learning targets and objectives of the various key stages as depicted earlier in this chapter, as well as the curriculum guides for S4-5 Biology, Chemistry, Physics and Science and Technology. Schools should make arrangements to ensure bridging of the science curriculum at junior and senior secondary levels by completing the core parts of the Science (S1-3) Curriculum before starting the science curricula at S4-5 level.

**Schools may refer to Booklet 9B of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on the above.**

## Chapter 3

# Curriculum Planning



## 3 Curriculum Planning

### 3.1 A Balanced Curriculum

Science education plays a significant role in students' whole-person development. It is also the entitlement of every student. Students should be provided with appropriate science learning activities so as to develop their basic scientific concepts and essential process and thinking skills. In view of this, schools should develop a curriculum policy to ensure that all the necessary resources (time allocation, human and financial resources, etc.) are provided for a balanced curriculum, of which science education is an integral part.

### 3.2 Central Curriculum and School-based Curriculum Development

The Science Education KLA Curriculum Guide is one among other KLA Guides prepared by CDC to set the direction of curriculum development for the learning and teaching of Science from Primary 1 to Secondary 3. It provides a **central curriculum in the form of an open and flexible framework** with learning targets and objectives, and essential contents. Schools are expected to fulfill the basic requirements spelt out in the Guide to ensure that students receive their entitlement to the same learning opportunities. The Guide, however, is not a prescribed syllabus to be taught uniformly to all schools and students, as it is well understood that the concept of "one-size fits all" does not work.

Each school, with its unique characteristics of teachers and students, should attempt to **adapt the central curriculum to different degrees by varying the organization of contents (including the choice of extensions), contexts, learning and teaching strategies, and criteria and modes of assessment** to help their students achieve the learning targets.

It has been made clear in the CDC document *Learning to Learn* (p.69) that

School-based curriculum development is **not** simply

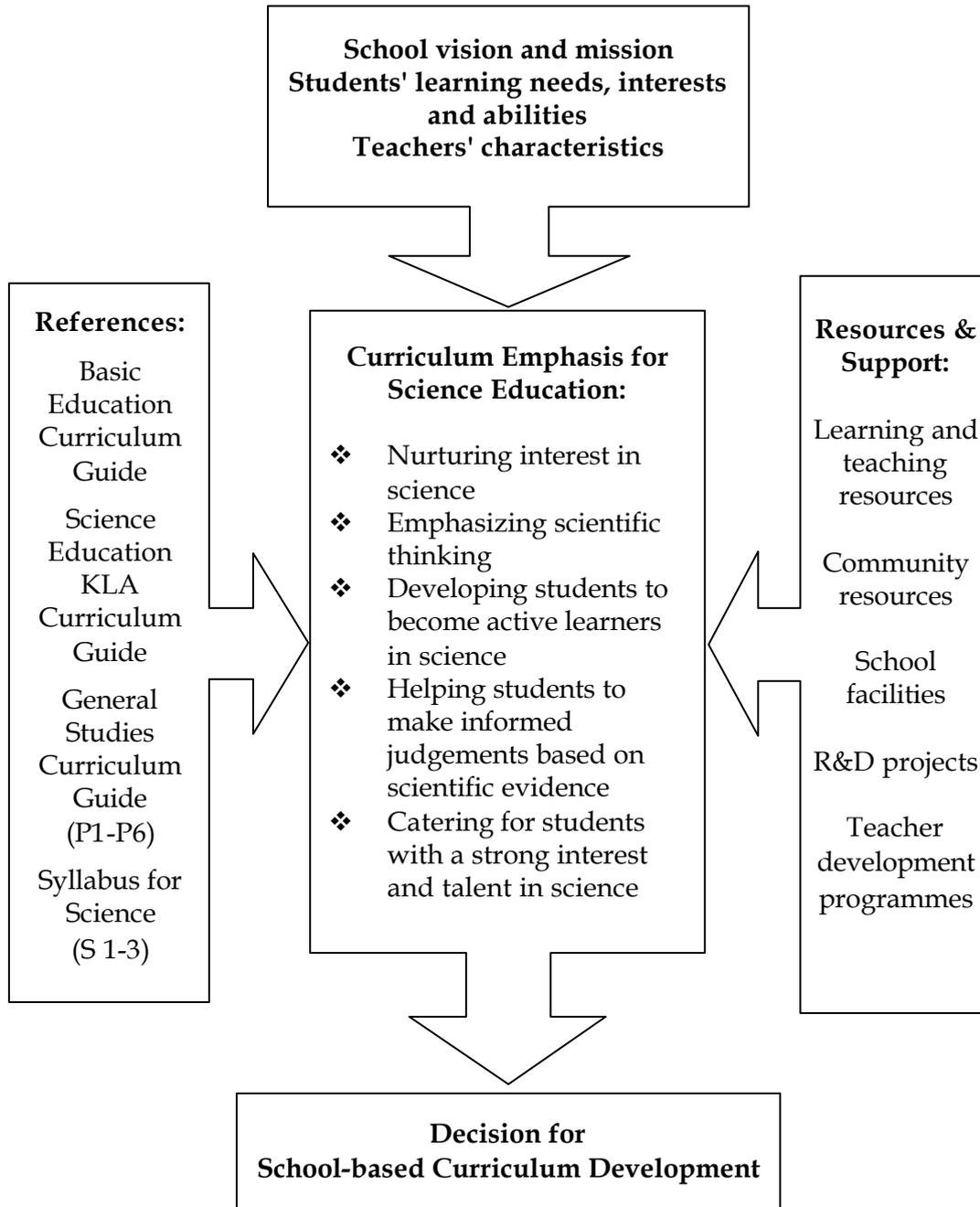
- deletion of subject content
- compilation of school-based curriculum package
- teachers working alone

Curriculum development is an on-going process. In school-based curriculum development for science education, schools should:

- follow the direction and learning targets set out in this Guide
- help students achieve the learning targets
- ensure that students have completed the core elements set out in the subject curriculum guides (e.g. the core part of the Syllabus for Science (S1-3) (1998))
- build on strengths of schools and needs of students
- provide more space for student learning through options/extensions
- provide opportunities for students to pursue contents they are interested in and develop their potential to the full
- vary the organisation of contents
- develop learning, teaching and assessment strategies
- adapt learning resources
- decide on the % of time allocation based on the recommendation in Booklet 2 of the *Basic Education Guide – Building on Strengths* (2002) (10-15% total lesson time) and use the time flexibly
- develop teachers professionally and collaborate with other partners
- reflect and improve based on informed practice

There is a need for schools to go through the school-based curriculum development process for the KLA from now to 2005-06. The following diagram shows how schools could conduct a situational analysis and arrive at a curriculum decision.

## Situational Analysis and the Curriculum Decision Process



Different modes may be adopted for organizing the essential elements of the six strands in science education for common as well as different purposes of learning. These diversified modes may be in the form of subjects, modules, short courses, projects, etc. or a combination of these. Each mode of curriculum organization has its own advantage(s) and disadvantage(s). The most important consideration in using any one approach should rest on whether it could reflect **the learning needs of students and strengths of the school** concerned. Whichever mode schools may adopt, they should ensure that **the benefits to student learning be given the first priority**. Learning experiences should be provided across all six strands in science education through the nine years of basic education and within the contexts relevant to Hong Kong students.

### *3.2.1 At Primary Level*

The General Studies curriculum integrates the learning of Science Education (SE), Personal, Social and Humanities Education (PSHE) and Technology Education (TE). To enable a smooth interface with the pre-primary curriculum which uses an approach focused on themes related to students' daily life, schools are encouraged to continue to use the thematic approach at Primary 1 & 2. Furthermore, the curriculum for P1-2 will put more emphasis on PSHE. From P3 upwards, alternative modes of curriculum planning focusing on either PSHE or SE and TE may be considered to cater for different needs and interests of students. In order to help students master basic understanding of scientific concepts and cultivate the habit of exploring science with an open mind, students should be involved in scientific investigations. It is recommended that students should engage in not less than **15 hours of hands-on learning activities in science and technology at Key Stage 1 and 20 hours at Key Stage 2**.

Curriculum Development Institute (CDI) in collaboration with a number of schools have developed a number of approaches to introduce hands-on activities into the primary classroom and these include:

- ❖ Young Scientists Award Scheme – The Scheme aims at stimulating an ongoing interest in the study of science. Students are given logbooks to take record of the science activities they have done. The activities are of

various nature, e.g. information search, investigations and model-making. Some of them can be done in class while others can be done at home.

- ❖ Science Day - The Science Day aims to provide an extended science learning experience for students. The theme-based exploratory activities are generated from the GS curriculum and extended much further from it. The occasion allows students to learn collaboratively in an informal setting at their own pace, and to exercise their imagination and creativity.
- ❖ Primary Science Project Competition - It is an annual function aiming at arousing students' interest and motivation in learning science through involving them in inquiry activities. Students are required to design and conduct their own projects or design and make new artefacts. The Competition has successfully stretched the potentials of the students. Some schools run similar competitions in their schools before selecting teams to represent the school, and this creates opportunities for more students to participate in hands-on investigative activities.
- ❖ Science Model Making - The models are portable, affordable, simple and safe. They are suitable for P3-4 students. The activities are designed for classroom setting and centered on topics of light, electricity, magnetism and force. They can be employed as teaching resources to introduce a topic or consolidating exercises for a topic. The models also allow students to explore on their own and reach beyond the scope tackled in the textbooks.

Details related to these learning activities can be found at <http://cd.ed.gov.hk/sci>.

### ***3.2.2 At Junior Secondary Level***

Core and extension parts are included in the subject curriculum of S1-3 Science. The core parts are basic components of the science curriculum for all students whereas the extension parts are generally more demanding and designed for students intending to pursue their study of science related

subjects further. For some students, it will be more beneficial, less stressful and more effective to concentrate on the core parts so that more time is available to master the basic science concepts and principles. For others, the challenging experience provided by the extension parts may lead to a higher degree of satisfaction and to a more thorough understanding of science concepts. Thus, a good school-based science curriculum should have an in-built flexibility to cater for the different interests and abilities of students.

### 3.3 Cross KLA Links

It is very important that teachers can help students connect their learning experiences in science and with those in other KLAs. This will facilitate effective learning with limited lesson time. Some of the examples showing how other KLAs contribute to Science Education KLA are:

KLA	Examples
Chinese and English Language	<ul style="list-style-type: none"> <li>• read science fiction, stories of scientific discovery and scientists for fostering interest in science</li> </ul>
Mathematics	<ul style="list-style-type: none"> <li>• manipulate data for the investigation and interpret quantitative information</li> </ul>
Personal, Social & Humanities	<ul style="list-style-type: none"> <li>• engage in cross-curricular studies such as health education, sex education and environmental education</li> </ul>
Technology Education	<ul style="list-style-type: none"> <li>• apply scientific principles in design and problem-solving processes</li> </ul> <p><i>(It is widely accepted that learning experiences in science and technology are intertwined. Appendix 5 illustrates the interface between science education and technology education.)</i></p>
Arts	<ul style="list-style-type: none"> <li>• appreciate the beauty of natural phenomena</li> </ul>
Physical Education	<ul style="list-style-type: none"> <li>• engage in cross-curricular studies, such as sports science</li> </ul>

### 3.4 Time Allocation

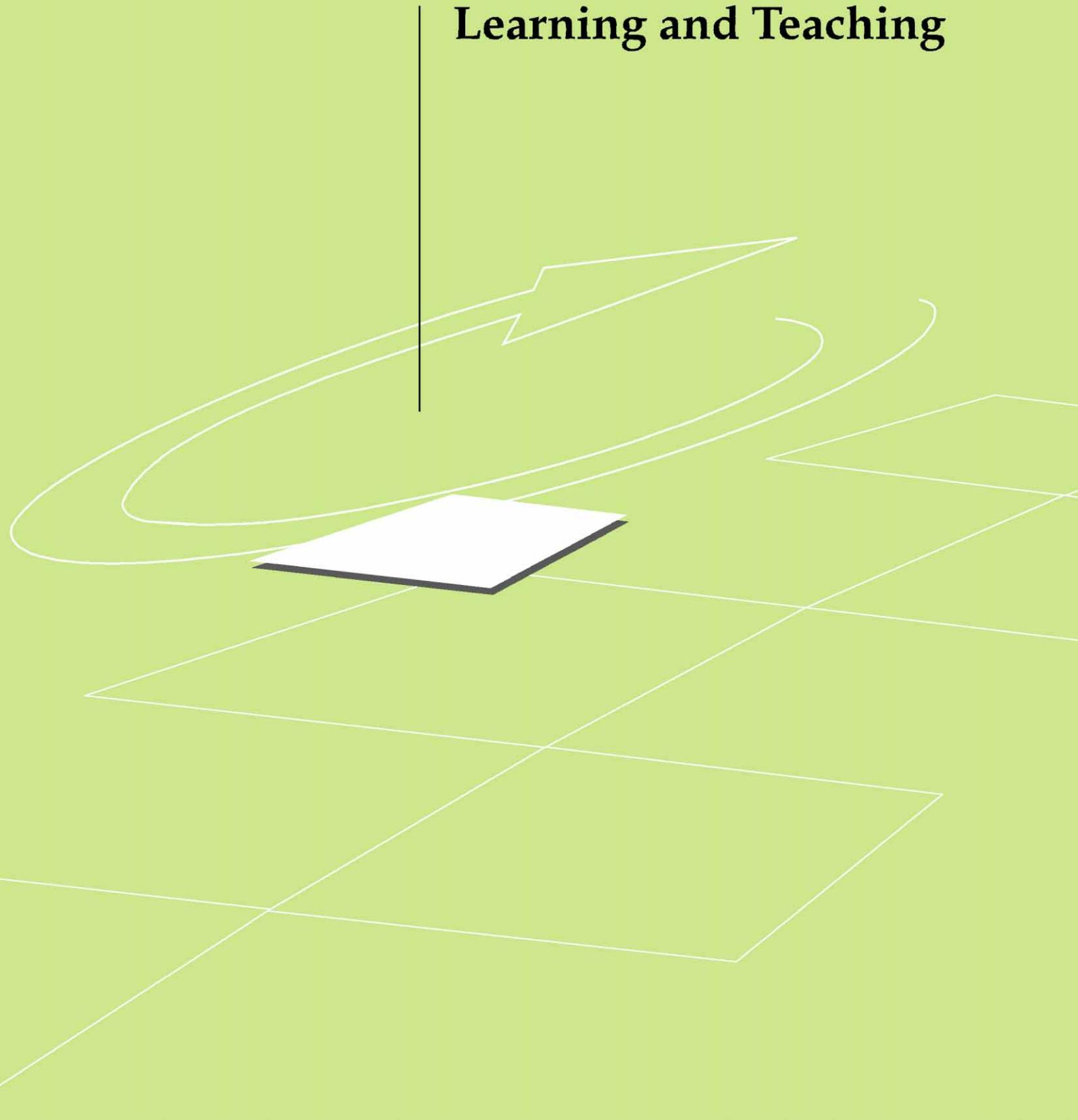
At the primary level, the lesson time allocated to GS is 12-15%. As recommended by the General Studies Curriculum Guide (P1-P6), schools can create curriculum space by spending about 80% of the total learning time on core elements and flexibly arrange learning activities for the remaining 20%.

**The suggested time allocation for S1-3 Science is 10-15% of total lesson time.** For schools which place a strong emphasis on technology education, the time allocation of 810% is acceptable, provided that the schools can connect students' learning in science and technology. This can be realized through introducing scientific exploratory activities and problem-solving activities in technology lessons. Also, during the technology learning activities, teachers may also introduce or consolidate science concepts through discussion and guided exploration.

At S3, some schools may allocate a higher percentage of lesson time for science. One of the common practices is to allocate 15% lesson time to science, with 3 separate science disciplines, each having 5% lesson time. In this situation, schools should ensure good co-ordination of the science curriculum to ensure that the core parts of the S1-3 Science curriculum are being covered and that any additional time spent in science is geared to the interests and abilities of students.

## Chapter 4

# Learning and Teaching



## 4 Learning and Teaching

Learning and teaching are interactive processes; they involve complex and dynamic relationships between the individual learner, the teacher, and the learning context. How students learn, strategies for promoting learning to learn and the positions of students and teachers in the process of effective learning in science are being discussed in this chapter. The role that parents could play in complementing and supplementing their children's school learning experiences in science is also introduced.

**Schools may refer to Booklet 4 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on learning and teaching.**

### 4.1 Guiding Principles

Current theories of learning and science education suggest that knowledge is not passively received but is actively built by the learner. Organization of learning experiences should start from where the students is 'at', utilize their background knowledge, set a context which they perceive to be relevant, and build upon their experiences and understandings, so that students could put together conceptual frameworks of their own and develop their own understanding of the world around them. The provision of a learning environment with due consideration of the characteristics of the students is of paramount importance.

As a long-term goal of fostering life-long learners, students should also be led to take responsibility for their own learning. Helping students to set learning goals, reflect on and evaluate their own learning process, and develop learning strategies that facilitate self-regulated learning will contribute towards the goal of life-long learning.

#### 4.1.1 *The Role of the Students*

Active participation in various kinds of learning activities fosters students' personal as well as social construction of meanings. The following are ways to involve students actively in science learning processes. Students:

- ❖ initiate their own learning and take responsibility for their own learning. Learning science involves making inquiries. The problem to be investigated should come from within the students, from their need to know or to find a solution. Students need to shape the questions themselves so that the investigations become their task. This way they feel they are in control of and are fully involved in their own learning.
- ❖ take part in making decisions and solving problems. When students are allowed to make decisions towards the solution of a problem they will begin to feel ownership of the problem-solving process.
- ❖ learn to transfer skills and learning from one context to other contexts in science. Transferability of the process of investigation and acquisition of new knowledge will help students continue to learn.
- ❖ organize themselves and others. Active learning in science requires students to work both independently or within a group. They will use a range of study skills, and select the most appropriate resources and information and the means of gaining access to them.
- ❖ be able to display their understanding and competence in a number of different ways. Students are expected to select the most appropriate means of reporting an experiment or project to the audience, to present their data (e.g. whether to use graphs or tables, and which ones to use), to communicate and to explain their ideas and understanding so that others can appreciate them.
- ❖ learn to be in control of their own learning process. They should learn how to evaluate their progress and be ready to reflect on what they have learnt and to decide what they want to pursue in the next step.
- ❖ feel good about themselves as learners. Active learners believe in themselves and grow in enthusiasm for what they are doing. It is hoped that success breeds confidence, and that in turn confidence breeds positive feelings and motivation.

### 4.1.2 *The Role of the Teachers*

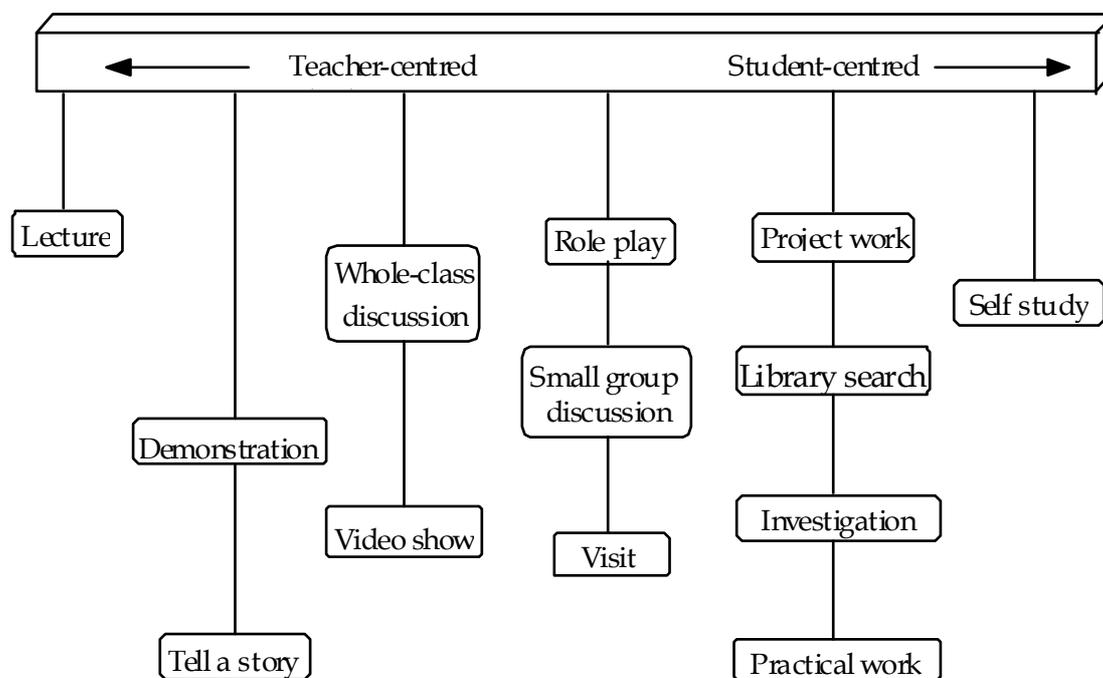
Professional teachers of science create environments in which they and their students work together as active learners. They use assessment of students and evaluation of their own teaching to plan and conduct their teaching. They build strong and sustained relationships with students based on a sound knowledge of students' learning characteristics. The role of the teacher ranges from a transmitter of knowledge to resource person, facilitator, consultant, counselor, assessor, and very often, a mixture of some of them. All of these roles share the common mission of fostering students into life-long learners. Science teachers should be well acquainted with the aims and objectives of the school science curriculum and plan meaningful learning activities for their fulfillment by:

- ❖ providing learning context that is relevant to students' daily life, so that students realize the intertwining nature of science, technology and society
- ❖ setting clear objectives for each lesson and explicitly sharing them with students
- ❖ catering students' learning styles by employing a variety of teaching methods
- ❖ eliciting students' prior knowledge or preconception by open-ended questions or thought-provoking activities and by probing further into their thoughts
- ❖ engaging students in collaborative learning activities that encourage co-construction of knowledge among students
- ❖ developing an open atmosphere in which students are able to express views and comments without the fear of being judged
- ❖ engaging students in discussions related to the nature of science, the evolutionary nature of scientific knowledge, the effectiveness and limitations of science models
- ❖ refining the focus and direction of classroom discourse according to students' questions and comments
- ❖ fostering students' self-regulatory learning by encouraging them to reflect on their work and keep a learning journal
- ❖ using various modes of assessment as a means for promoting learning

With considerations of the characteristics of the students, teachers are encouraged to employ a variety of teaching methods to provide students with

diversified learning experiences. The spectrum below suggests a variety of strategies ranging from very teacher-centred methods to very student-centred methods.

### Spectrum of Teaching Methods



Teachers should decide on appropriate teaching strategies in accordance with the topics/skills to be taught as well as the interests and abilities of their students. The following are some factors to be considered when deciding on the teaching strategies for a particular topic:

- ❖ Learning objectives to be achieved
- ❖ Abilities and learning styles of students
- ❖ Interests of students
- ❖ Prior knowledge of students
- ❖ Availability of resources
- ❖ Amount of time available

Safety is of first priority in the planning of science learning activities. In designing practical work for students, teachers should provide proper supervision to ensure that safety measures are observed. Teachers are advised to try out new or unfamiliar experiments with the help of laboratory technicians so that any potentially dangerous situations can be uncovered

before students are involved. The handbook *Safety in Science Laboratories (2002)* is a good reference for safety management in schools.

### 4.1.3 *Quality Homework*

Effective homework has positive effects in reinforcing classroom learning, stimulating thinking, encouraging active and independent learning, and fostering a better link between learning in school and at home.

Homework should help students learn to process important ideas developed in class. It should help students focus on important learning points and check their own progress. Teachers should be clear about and make known to students the purpose of the homework - consolidation, applying knowledge, exercising creative thinking, etc. They should let students understand their expectation and give quality feedback to students. Mechanical repetition, like copying notes or vocabularies, is routine and boring. Such homework makes students learn in a passive way and should be avoided.

Teachers should provide clear guidance when giving homework to students. Inspirational materials in the form of newspaper cuttings, extracts from articles, flow-charts, photographs, diagrams, statistical tables or graphs, etc. can be provided so that students can have some concrete materials to base on, some food for thought, as well as an incentive for attempting the exercise.

Some examples of meaningful science homework include: library search, writing a learning journal, designing a new device, building a model, writing an experimental report and collecting newspaper cuttings.

Below is an extract from a homework checklist used by teachers in a school.

### Homework Checklist

Name of subject teacher: \_\_\_\_\_ Subject/Class: \_\_\_\_\_

Date of issue of homework: \_\_\_\_\_ Deadline for handing in homework: \_\_\_\_\_

Expected time needed for finishing homework: \_\_\_\_\_

Objectives of the homework design: (Can be more than one)

- |  |   |
|--|---|
| <input type="checkbox"/> Consolidate learning    | <input type="checkbox"/> Extend classroom learning      |
| <input type="checkbox"/> Apply knowledge         | <input type="checkbox"/> Practise logical thinking      |
| <input type="checkbox"/> Gather information      | <input type="checkbox"/> Exercise creative thinking     |
| <input type="checkbox"/> Organize information    | <input type="checkbox"/> Reading                        |
| <input type="checkbox"/> Prepare for next lesson | <input type="checkbox"/> Others (Please specify: _____) |

**Schools may refer to Booklet 8 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on meaningful homework.**

## 4.2 Four Key Tasks for Promoting Learning to Learn

The CDC document *Learning to Learn* recommends that four key tasks – Moral and Civic Education, Reading to Learn, Project Learning, Information Technology (IT) for Interactive Learning – be encouraged in all KLAs. These tasks can be adopted and adapted in the Science Education KLA to enliven learning and teaching, and to help learners progress towards the vision of whole-person development and learning to learn.

### 4.2.1 Moral and Civic Education

Learning opportunities within and beyond the science classroom should be provided for students to develop and reflect on their values and attitudes. Teachers can make use of events relevant to students' daily life to cultivate positive values and attitudes. Establishing a collaboration with parents would facilitate the nurturing of values and attitudes. The following learning and teaching processes illustrate how certain values can be nurtured:

- ❖ Through visiting home-for-the-aged or hospitals, students are asked to observe the needs of the aged and the disabled and apply what they have learnt in science to develop some artefacts to help them, e.g. the invention of a toilet tissue dispenser which can be operated single-handedly. Such values of care and concern for others, creativity, sensitivity can thus be developed in a science context.
- ❖ Teachers can invite speakers from the Mothers' Choice or the Birthright Society to give talks to students when dealing with the topic of Cells and Human Reproduction in the S1-3 Science curriculum. Students will recognize the responsibility within relationships and be able to make judgement on appropriate behaviour in relationships. At the same time students will appreciate the value and sanctity of life, the importance of responsibilities of parenthood, and develop a positive attitude towards life.

**Schools may refer to Booklet 3A of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on moral and civic education.**

#### **4.2.2 Reading to Learn**

Reading provides opportunities for students to acquire information independently. Good reading habit needs to be nurtured as reading helps develop thinking skills and enrich knowledge. At the primary level, through reading stories about scientists and the history of science, students will understand how scientists looked for evidence and inferred from experimental results. Besides helping students to appreciate the achievement of scientists, this may help them develop curiosity, healthy skepticism and perseverance. At the secondary level, students should be given the chance to get access to a wide range of books, newspapers, magazines, encyclopedias, websites, etc.

- ❖ A "Science Corner" can be set up in the classroom or the laboratory to display interesting science articles from various sources. This can help to raise students' awareness of current issues related to science. Students can be also asked to write short summaries with reflections on these articles.
- ❖ A suggested list of references and journals for teachers and students can be found in the CDI website: <http://cd.ed.gov.hk/>. Some articles written

to enrich the Science (S1-3) Curriculum are also available at the website.

As science and technology are changing rapidly, reading is an important means to keep in touch with the frontier developments.

**Schools may refer to Booklet 3B of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on reading to learn.**

#### ***4.2.3 Project Learning***

Project learning is a powerful learning and teaching strategy to promote self-directed and reflective learning. Project with an investigative nature contributes towards the promotion of scientific inquiry. Projects that aim at solving everyday problems help to bring relevancy to the science that students learned in class.

Project learning in science may be in the form of scientific investigation, research proposal, design and make of artefact for particular purposes, etc. Examples of projects include:

- ❖ Applying concepts of force and energy in the design and make of a car, powered by elastic bands, that can go farthest.
- ❖ A study into the historical development of the materials used in making a tennis racket.

These projects enrich students' science knowledge and strengthen their science process skills. They also help students to make connections between their learning experiences in science and technology.

**Schools may refer to Booklet 3C of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on project learning.**

#### ***4.2.4 IT for Interactive Learning in Science***

There are numerous and growing opportunities to use IT in science learning and teaching:

- ❖ Interactive CD-ROMs such as “Be Friends with Nature”, “Energy” and “Electrical Safety” produced by the ED facilitate students to explore specific

topics at their own pace.

- ❖ Collaborative learning projects such as “Science Across the World” (<http://www.scienceacross.org/>) provide platforms for concerted effort amongst students world-wide to construct knowledge through exchanging survey data and ideas.
- ❖ Animations can help students visualize abstract concepts and processes such as the process of photosynthesis. Simulation experiments that allow students to manipulate variables help students visualize physical phenomena and grasp scientific principles, such as the motion of particles in a liquid as its temperature changes.
- ❖ Through a video-imaging device, students can watch experiments or demonstrations that otherwise cannot be observed by the whole class together in greater details, such as the growth of crystals or the Brownian motion.
- ❖ Through the use of data-loggers, students can be relieved from mechanical and time-consuming work in data collection and the graphical presentation of data. They can then have more time to analyze, discuss and evaluate experimental results, and to answer “what if” questions. For example, a position sensor can be used in testing the elasticity of a new material by measuring its elongation under stress.
- ❖ On-line assessment tools such as multiple choice question banks provide instant feedback on students’ understanding of a concept and may help identify any misconceptions held by the students.

While the use of IT allows space for developing students’ scientific thinking, creativity and problem-solving skill, teachers should exercise their professional judgement in the appropriate use of IT and ensure that the students are provided with sufficient opportunity for hands-on experiments to develop their science process skills.

**Schools may refer to Booklet 3D of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on IT for interactive learning.**

### **4.3 Life-wide Learning**

In addition to learning science in classrooms and laboratories, students can also gain precious learning experience through visiting the following places:

- ❖ The Ocean Park and Kadoorie Farm & Botanic Garden provide guided educational visits to stimulate students' appreciation of Nature and to arouse their support for environmental conservation.
- ❖ The comprehensive exhibits of Science Museum and Space Museum provide interesting hands-on activities for students. They may gain first-hand experience in observation and data-recording in performing simple investigations.
- ❖ The Health InfoWorld has built up good connections with various organizations in the health and medical fields. It provides a wealth of resources for students on topics related to health.

During these visits, students can draw upon a substantial and wide-ranging variety of information. Students' classroom learning experiences will be supplemented through these visits. Besides, with community support, there is also a wide range of learning programmes available for students, and these include popular science lectures, issue-based debates and forums, invention activities, science competitions, science exhibitions, field trips, laboratory research and experiments, etc. More information about community resources for science education can be found in Appendix 7.

**Schools may refer to Booklet 6 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on life-wide learning.**

#### **4.4 Catering for Student Diversity**

Every class is made up of individuals who are different in terms of motivation, learning styles, needs, interests, abilities, etc. A student will use one or more types of intelligence to write a science report, and another type in solving a science problem. Some students are visual learners and will be able to comprehend diagrammatic and graphical information very easily, while others will need to learn through doing. For effective learning and teaching, teachers should take into consideration student diversity and take appropriate action to help different students learn better.

An open and flexible curriculum framework allows teachers to devise different teaching schemes to meet the different needs of the students. In the curricula of Science (S1-3), Biology (S4-5), Chemistry (S4-5) and Physics (S4-5), core and extension parts are included to facilitate the design of teaching

programmes. Teachers can select more challenging content and activities for students with a strong interest or high ability in science.

#### **4.5 The Role of Parents in Science Education**

Parents and schools are close partners in education, and this also applies to science education. Parents can play the role of both facilitators as well as co-learners of science. The family is as important as the school in the development of the scientific habits of mind and the nurturing of values and attitudes. The provision of a non-threatening environment that enables children to develop their curiosity, to inquire, to take risks without fear of failure is also of paramount importance. Parents can assist to provide their children science learning experiences in the form of hands-on and minds-on science activities both at home and outside home. In short, parents can contribute by helping their children to get into the spirit of science and to like science.

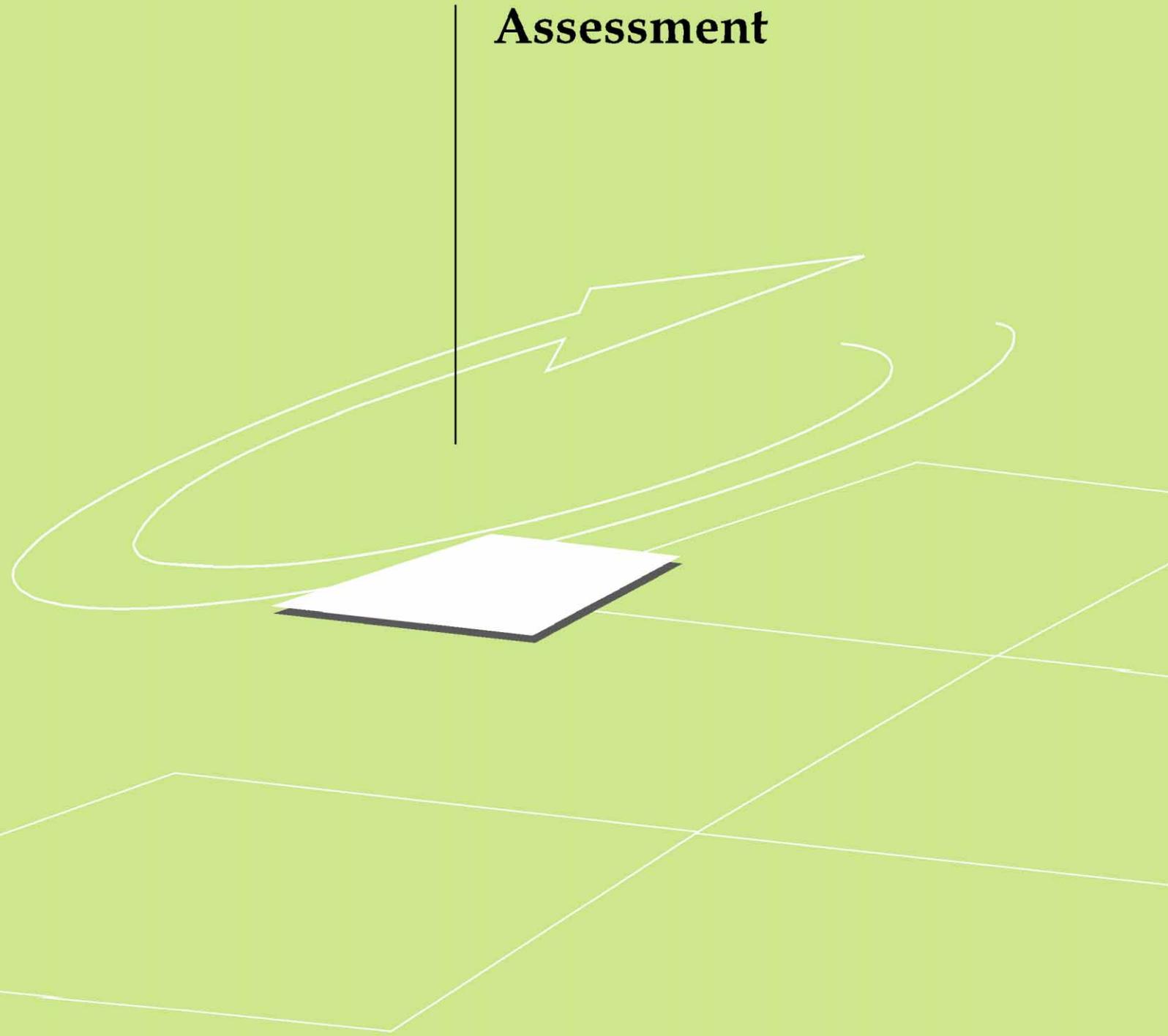
Parents can complement and supplement their children's school learning experience in science by

- ❖ participating in fun science activities/science days/open days;
- ❖ acting as chaperons during visits;
- ❖ taking their children to the Flower Market, Bird Street, Science Museum, Space Museum, Country Parks, Nature Education Centres or join any of the local ecotours;
- ❖ encouraging their children to ask questions about Nature, to seek answers, to collect things, make measurements and qualitative observations, and discuss findings etc.;
- ❖ reading books on science or science fictions with their children, watching science TV programmes or simply sharing their joy and experience of keeping pets or growing plants with their children;
- ❖ assisting their children to dismantle some toys or used appliances to study how scientific principles are applied; and
- ❖ acting as a facilitator/co-learner at home through making systematic observations and problem-solving.

For parents who are engaged in science, engineering or medical fields, they may serve as mentors for independent research projects for students.

# Chapter 5

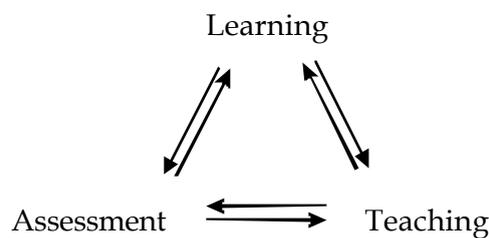
## **Assessment**



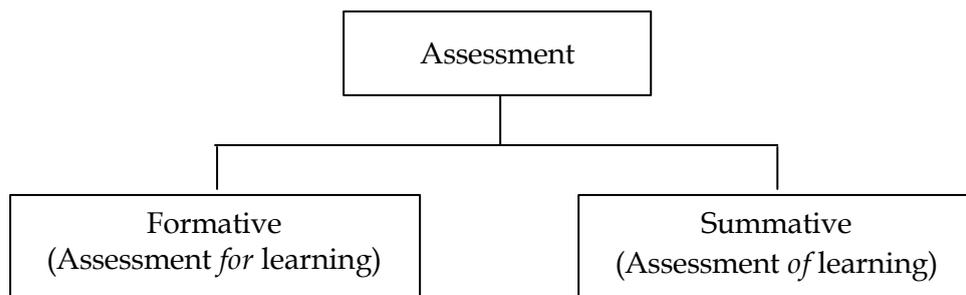
## 5 Assessment

### 5.1 Guiding Principles

Assessment is the practice of collecting evidence of progress in students' learning. It is an integral part of the learning and teaching cycle. Assessment provides information for both teachers and students on the processes of and the improvement in learning and teaching. It is essential that assessment should be aligned to the processes of learning and teaching.



In addition to summative assessment such as tests, end-of-term examinations and public examinations, formative assessment needs to be introduced to serve as a diagnostic tool to provide feedback to help improving students' learning. School-based assessment, both of formative and summative nature, should be given due consideration.



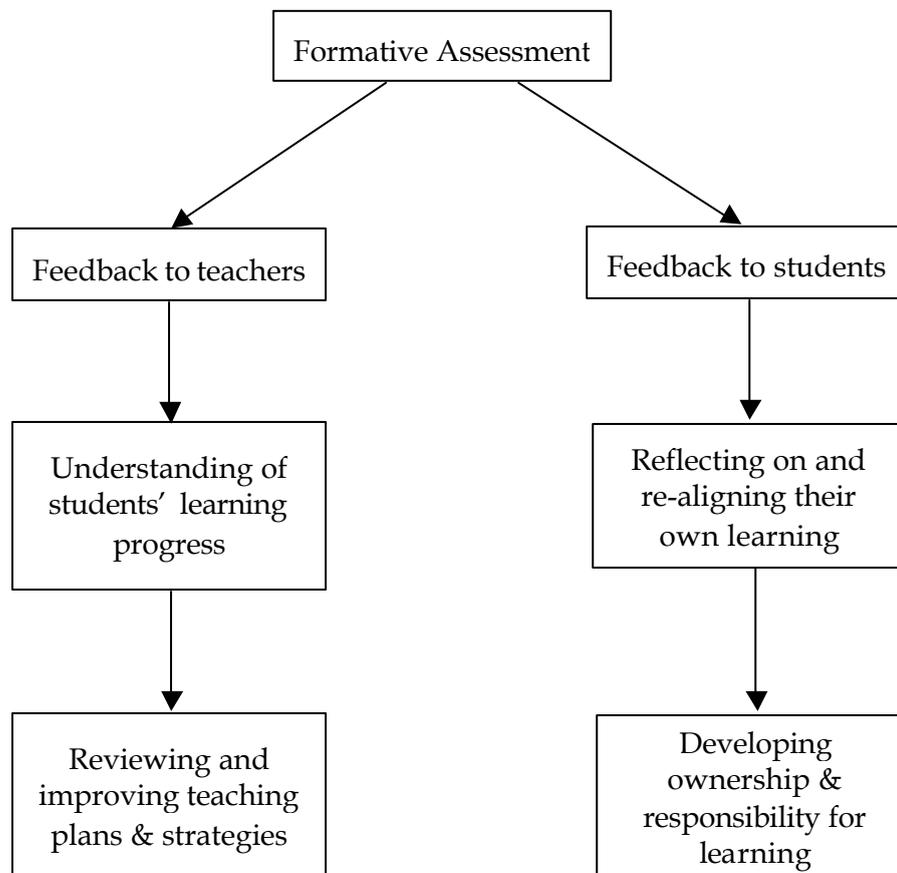
### 5.2 Modes of Assessment

#### 5.2.1 Formative Assessment

Formative assessment should be carried out on a continuous basis using different methods such as oral questioning, observation of students'

performance, assignments, project work, practical tests and written tests. It should be integrated with learning and teaching throughout the course with the purpose of promoting their quality and effectiveness. It should provide feedback to teachers who can then make decisions about what should be done next to enhance students' learning and adopt an appropriate teaching method.

In formative assessment, teachers will also provide feedback to students to promote assessment for learning, so that students understand how to plan and to take control of their learning. Students can be engaged in self- and peer-evaluation during the process of learning. With the help of their teachers and making reference to the appropriate assessment criteria, students plan their course of study, evaluate their own progress and thus recognize their own competence and weaknesses. All these will promote active learning and in the end help students develop into life-long learners in science.



Quality criteria derived from learning targets and objectives serve as a guide for teachers to provide quality feedback for improvement and for students to design their learning plans. Systematic development of quality criteria in science will be undertaken through the research and development project on assessment for learning in science and validated through try-outs in schools. These criteria will be developed in the form of a range of learning outcomes, which can be demonstrated by students in relation to the learning objectives and will be provided for supporting school-based assessment in 2005. Professional development programmes will then be provided to equip science teachers with the essential knowledge and skills to employ these criteria in planning and conducting assessment. Teachers will also be trained to use the feedback information generated from assessment activities for improvement purposes.

*Exemplar (2) for illustration: "Quality Feedback in the Teaching, Learning and Assessment Cycle"*

### **5.2.2 Summative Assessment**

Summative assessment can be viewed as an assessment of learning. It provides information about what students have learned at the end of a term or a unit. Tests and examinations in schools and public examinations are common examples of summative assessment, measuring students' standards or attainments, reporting them in terms of marks or grades. Summative assessment, however, has its own limitations e.g. it cannot provide immediate feedback on how to improve learning and teaching, and therefore it should not be used as the only means of assessment.

The diagram at the end of this chapter is an overview of assessment for learning as adapted from Shirley Clarke (2001).

### **5.3 Assessment Strategies and Reporting**

Assessment should be carried out regularly and through the use of different methods, for example, oral questioning and observation of students by teachers, project work, practical and written tests. Only when assessment is

carried out on a continuous basis can the teacher have the feedback to plan his day-to-day teaching. Besides, a variety of assessment methods should be adopted to measure the attainment of the different aims of science education. For example, a paper and pencil test could be used effectively to test for recall of facts and understanding of science concepts. However, in assessing students' attitudes, it would be more appropriate to use an observation checklist. The following are some common assessment methods which teachers are encouraged to use flexibly in drawing up their assessment plans. Teachers should have well-thought-out plans on how to assess students' achievements and should let students know how they will be assessed.

❖ **Paper and pencil tests**

Paper and pencil tests have been widely employed as the major method of assessment in schools. However, the prolonged reliance on this type of assessment has a narrowing effect on both learning and teaching. Teachers should avoid testing only basic information recall and should try to construct test items that assess the understanding of concepts, problem-solving abilities and higher order thinking skills. Incorporation of open-ended questions in tests and examinations could help evaluating students' creativity and critical thinking skills. Teachers should analyze students' performance in tests and examinations, and use the information for future planning as well as helping students to identify what or where their strengths and weaknesses are.

❖ **Written assignments**

Written assignment is an assessment tool that provides information about students' progress, efforts, achievements, strengths and weaknesses. The scores or grades for assignments can be used to form part of a record of students' progress. Teachers are encouraged to make use of students' written assignments as a formative assessment tool. Comments on students' written work with concrete suggestions for improvement provide valuable feedback to students. The results of assignments provide information to assist teachers to set further targets for students and adjust their teaching.

❖ **Oral questioning**

Through oral questioning teachers gain specific information on how students think in certain situations. Students' responses often provide clues to their strengths, weaknesses, misunderstandings, level of understanding, interests, attitudes and abilities. Teachers are encouraged to use a wider range of questions involving fact finding, problem posing, reason seeking to promote higher levels of thinking. Problems based on information that is unfamiliar to students could also be set. A balance between open-ended and closed-end questions should be maintained. Teachers should allow time for students to respond and listen carefully to the responses with an open mind. Quality feedback should be provided to help students reflect on their learning.

❖ **Observation**

While students are working in groups or individually, teachers can observe and note different aspects of their learning. When engaged in learning activities, teachers should observe the approaches students take to solve problems and whether they display attitudes such as perseverance, independence, cooperation, and willingness to address difficulties. In practical sessions, teachers can find out what choices students make with regard to the equipment they use, the safety measures they adopt, the activities they prefer, whom they work and interact with. Teachers should keep brief records and use such information for making further judgements about students' learning.

❖ **Practical assessment**

The assessment of students' attitudes and practical skills should be carried out over a period of time and based on students' performance in daily practical work, scientific investigations as well as in practical tests. This would allow for a more comprehensive assessment. Assessment of daily practical work through observation is generally carried out in an authentic environment where learning and assessments are integrated, and feedback can be given to students immediately.

Scientific investigations provide an opportunity for students to show their resourcefulness, ingenuity, originality, creativity and perseverance. Teachers can use appropriate criteria to assess students' scientific knowledge, application of scientific method, ability to handle data, awareness to safety, and the interest and enthusiasm in the work done. Students' written laboratory or investigation reports can serve as an effective means of assessing students' performance in scientific activities and provide a more complete picture about student learning.

Practical tests can be organized to focus on assessing either the process or the product of learning. Students can be tested on whether they can follow and carry out instructions accurately, use an apparatus effectively and safely, observe or measure accurately and systematically, present results in a precise and logical form and draw conclusions from results of experiments. Students should be told in advance how their performance would be assessed: by the teacher observing students doing work and questioning students, or marking the work submitted by students at the end of the practical test, or by both these methods.

<i>Exemplar (3) for illustration: "Assessing Science Practical Work"</i>
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❖ **Project work**

Project work allows students not only to exercise their practical skills and apply what they have learnt, but also to employ various skills and thinking processes such as identifying problems, formulating hypotheses, designing and implementing strategies and evaluation. Teachers can make use of a combination of assessment strategies to collect evidences of student learning in the knowledge and skill domains, and gauge their creativity, communication skills, collaboration skills and problem-solving abilities. Teachers can also make use of appropriate criteria to assess students' values and attitudes demonstrated in the process of doing a project.

❖ **Portfolios**

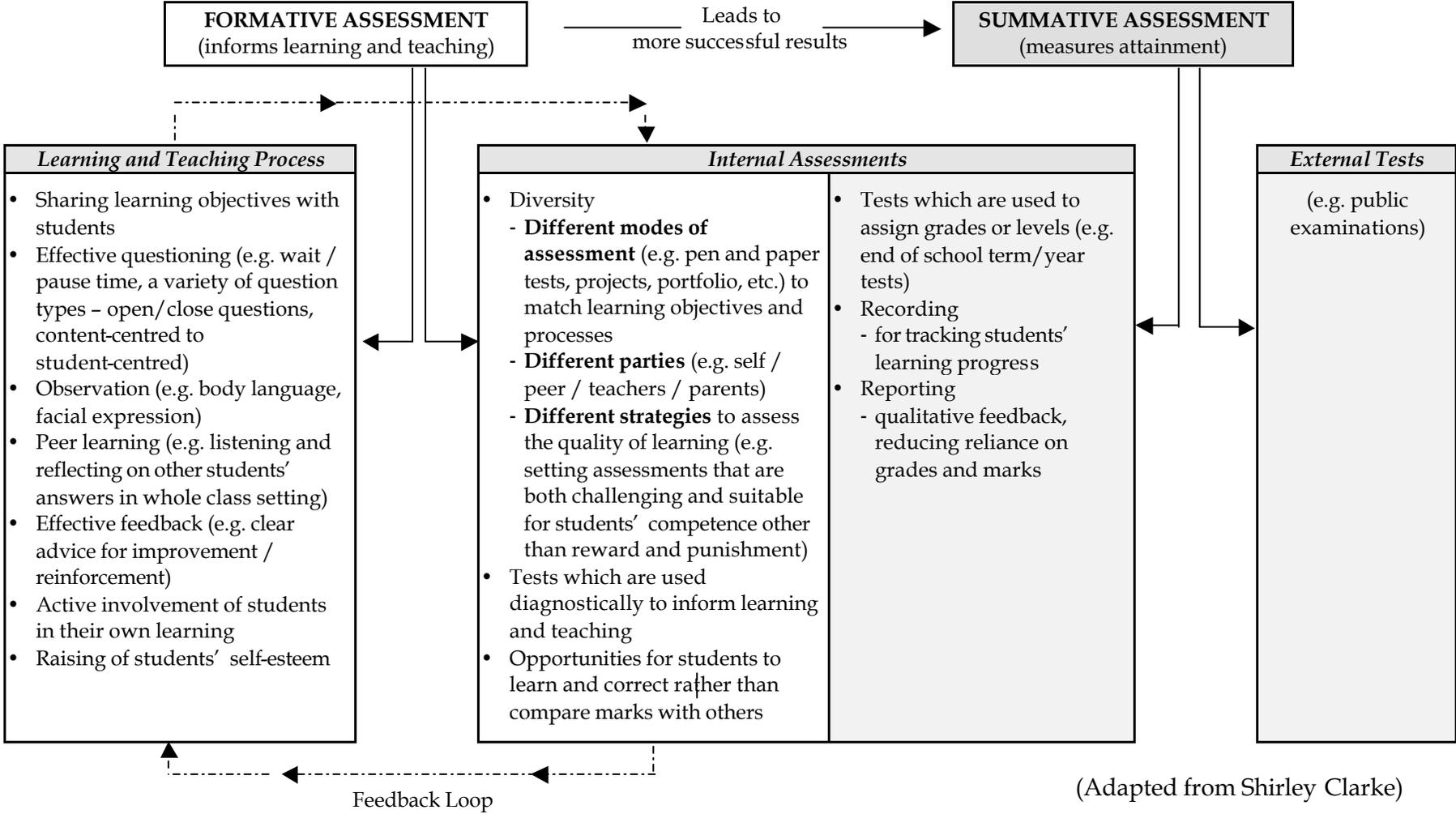
A portfolio is a purposeful collection of a student's work that demonstrates his knowledge and understanding, process skills, value

and attitudes in a given area of study. The portfolio also provides a continuous record of a student's development in these three aspects. It allows teachers and parents to gain insights into the student's progress and achievements, and allows the student to have self-reflection and self-evaluation by revisiting his own portfolio.

The assessment strategies suggested above are by no means exhaustive. Adopting a combination of assessment strategies enables teachers to build up a comprehensive picture of students' achievements. Teachers should explore other appropriate assessment strategies to meet the needs of their schools and students.

**Schools may refer to Booklet 5 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on assessment.**

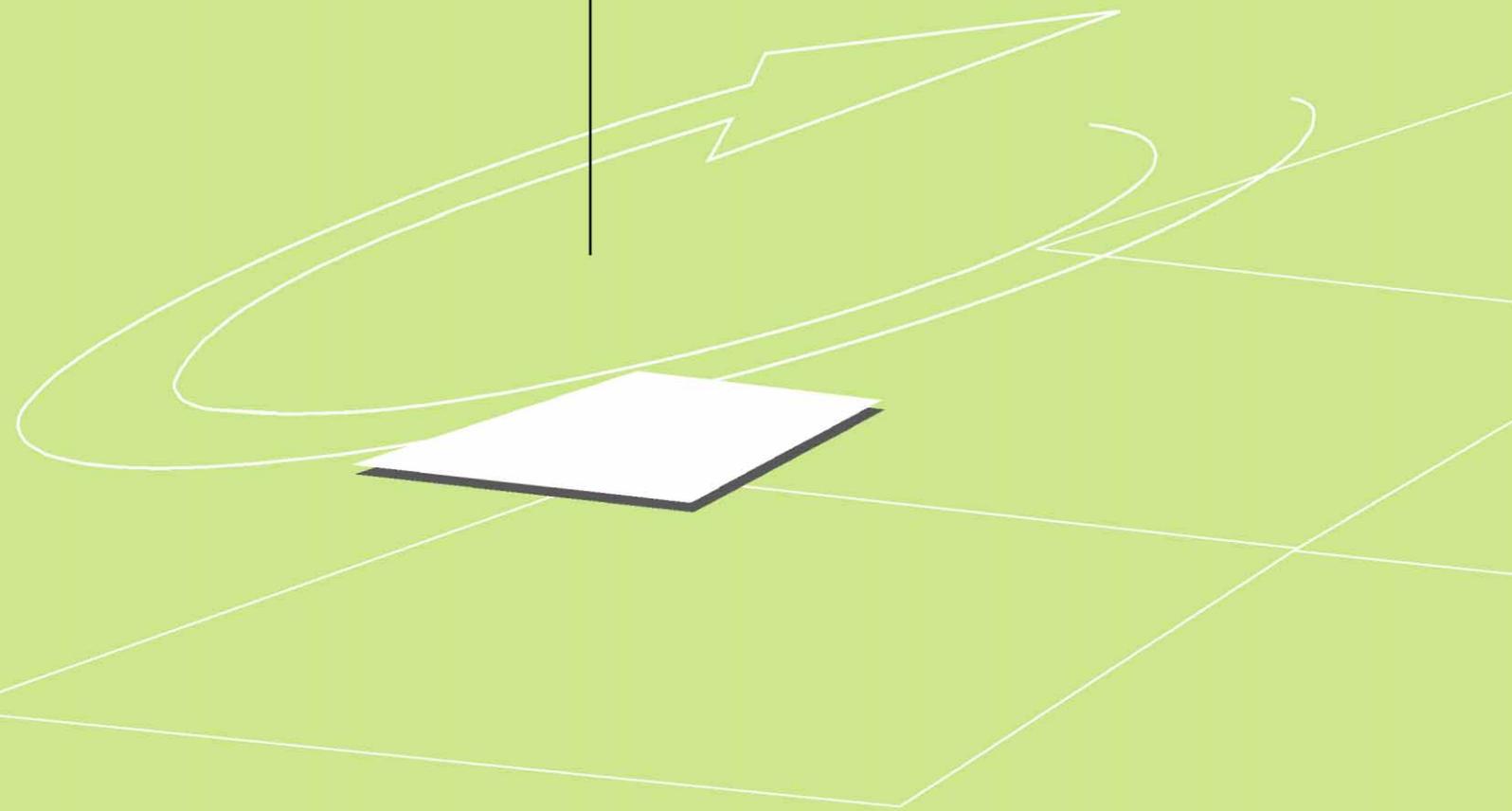
**A FRAMEWORK OF SCHOOL ASSESSMENT PRACTICES**



(Adapted from Shirley Clarke)

## Chapter 6

# Learning and Teaching Resources



## 6 Learning and Teaching Resources

A diversity of learning and teaching resources should be used to enhance the effectiveness of learning. Learning resource materials that provide students with experiences of the world beyond the school and give support to students in developing abstract ideas and concepts are particularly useful for facilitating independent learning. Resources on the Internet provide learning opportunities to keep students abreast of the latest scientific and technological development. Teachers are encouraged to make use of various types of resources in their lessons and students may also use these resources for independent study under the guidance of their teachers.

### 6.1 Subject Curriculum Guides

To further support learning and teaching of science, subject curriculum guides are issued in addition to this Guide.

- ❖ *General Studies for Primary Schools Curriculum Guide (Primary 1-6) (2002)*
- ❖ *Syllabus for Science (Secondary 1-3) (1998)*
- ❖ *Biology Curriculum Guide (Secondary 4-5) (2002)*
- ❖ *Chemistry Curriculum Guide (Secondary 4-5) (2002)*
- ❖ *Physics Curriculum Guide (Secondary 4-5) (2002)*

### 6.2 Quality Textbooks/Learning and Teaching Materials

It is crucial to have quality textbooks/resource materials selected or developed for use in the classroom. Textbooks have a major role to play in helping students learn key ideas. A satisfactory textbook should:

- ❖ provide a sense of purpose and direction for learning;
- ❖ alert teachers to students' prior knowledge;
- ❖ provide students with a variety of phenomena and help them understand how the phenomena relate to scientific ideas;
- ❖ guide students' interpretation and reasoning;
- ❖ provide practice in using scientific ideas;

- ❖ provide assessment tasks and criteria for monitoring student progress; and
- ❖ encourage students to explore beyond the classroom.

Schools should choose science textbooks that will enhance the motivation and learning effectiveness of students. Schools should consider the following:

- ❖ the approach and coverage of the textbooks - whether they facilitate the development of the knowledge, skills, values and attitudes promoted in the curriculum;
- ❖ the suitability of the teaching content;
- ❖ the quality of the language used in the textbooks;
- ❖ the appropriateness of the learning activities;
- ❖ the use of examples and illustrations - whether they are appropriate and help learning or cause distraction; and
- ❖ the safety aspects of the practical work.

<i>Exemplar (4) for illustration: "Selection of Quality Science Textbooks"</i>
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Teachers should apply their judgement and use science textbooks flexibly according to the needs, abilities and interests of their students. Teachers should not feel obliged to use a textbook from cover to cover. They should feel free to select and/or adapt relevant parts and to modify the sequence of topics to suit their teaching purposes. They may consider the following when using textbooks:

- ❖ keeping the learning targets and objectives of a key stage in mind and identifying the focus of each unit;
- ❖ matching the content with the science curriculum of the school and making sure that there is a balanced coverage of the learning targets and objectives;
- ❖ omitting certain parts - the more able learners may skip the easy parts and the less able learners may skip the more difficult parts; and
- ❖ adapting the content or the activities to make them more challenging so as to initiate critical thinking and bring about creativity in their students.

As alternatives to textbooks on the recommended lists, schools are encouraged to:

- ❖ develop their own learning and teaching materials to meet learner needs, if necessary; and
- ❖ adopt a wide variety of suitable learning resource materials (e.g. school-based curriculum projects, useful information from the Internet, the media, relevant learning packages and educational software).

**Schools may refer to Booklet 7 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on quality learning and teaching resources.**

### **6.3 Resource Development in Support of Science Education**

For GS, a series of projects have been conducted by CDI to explore various ways of enhancing scientific investigation in primary schools. These projects resulted in a number of resource packages, which serve as useful reference for learning and teaching. One example is the report of the Primary Science Project Competition published by the Hong Kong Institute of Education. The report contains details of the winning entries of students' work in scientific investigation, science toys and science inventions. Students report on the products of exploratory activities as well as on the process of project learning. They also reflect on what they have learned during the Competition. Articles to illustrate how to conduct effective science learning activities in primary school classrooms are also included.

Resources related to other science activities, such as science day and Young Scientist Award Scheme, have also been published. Teachers may either take part in the activities or design their own teaching materials based on the available resources. When the textbooks are to be revised for the new GS curriculum, publishers may make reference to these resources and include an adequate amount of science activities in their textbooks. This will provide teachers with stronger support for conducting science activities.

A number of printed and electronic resource materials have been developed and disseminated to schools to support the learning and teaching of science. They are listed in Appendix 6.

#### **6.4 Research and Development Projects (“Seed” Projects)**

The purpose of collaborative research and development (“seed”) projects in the Science Education KLA is to:

- ❖ generate useful experiences for the reference of schools, teachers and the community;
- ❖ develop a critical mass of curriculum change agents and leaders (e.g. teachers and school heads) to enhance the capacity for curriculum reform; and
- ❖ act as an impetus to school-based curriculum development.

All projects are geared towards promoting the learning capabilities of students to achieve the learning targets of the Science Education KLA. Below are some suggested themes, which can either stand alone as separate projects or act as an integral part of projects. They are in line with the key emphases of the curriculum reform and the focuses for science education curriculum development:

- ❖ Process and thinking skills
- ❖ Catering for student diversity
- ❖ Assessment for learning
- ❖ Four key tasks - moral and civic education, reading to learn, project learning, and IT for interactive learning
- ❖ School-based curriculum development
- ❖ Curriculum organization and learning and teaching strategies

Each project:

- ❖ begins with practical issues (e.g. enhancing students’ capability to learn science, assessment needs) in the natural setting of schools and the community in Hong Kong;
- ❖ is based on principles/theories and puts them into practice;
- ❖ is evidence-based, evaluative, adaptable to other situations, and

- suggests actions for improvement;
- ❖ is collaborative, involving the participation of schools, curriculum developers, tertiary institutions, and local and overseas experts;
  - ❖ empowers teachers and schools;
  - ❖ varies in size and objectives (e.g. a single lesson, an activity, a unit, a 3-year longitudinal study), and in the way development and research components interact;
  - ❖ may build on some earlier success that has worked to the benefits of students, for example:
    - ▶ innovations initiated by the schools themselves
    - ▶ consultancy studies on student diversity
    - ▶ action research projects in schools undertaken by the CDI and tertiary institutions;
  - ❖ translates basic research into practice to serve the immediate needs of schools;
  - ❖ is evaluated and improved on the basis of experience at the end of each year in terms of impact on learning, teacher empowerment, change management and continuous professional development; and
  - ❖ develops experience which will be disseminated through effective channels such as seminars/sharing sessions, reports, learning and teaching resource materials.

In science education, the following R&D projects have been launched:

<b>R&amp;D Projects for Science Education</b>		
<b>Theme</b>	<b>Level</b>	<b>Purpose</b>
Enhancing Scientific Investigation in General Studies (2000-02)	Primary	To explore various modes of curriculum organization for introducing hands-on and minds-on activities in General Studies. The purpose is to nurture students' curiosity and interest in science through inquiry learning.

<b>Theme</b>	<b>Level</b>	<b>Purpose</b>
Infusing Process and Thinking Skills into Science Lessons (2000-02)	Secondary	To explore and develop strategies for infusing science process skills and thinking skills into science lessons. The focus is on the development and try-out of resource materials, created by innovative teachers who act as change agents, through peer review of lesson observation and sharing of experiences.
Informed Decisions in Science Education (2001-03)	Secondary	To develop and try out methodologies which engage students in applying scientific knowledge and developing critical thinking and problem-solving skills in informed decision-making activities. The outcome of this project will serve as reference for the development of strategies for enhancing STS elements in the revised subject curricula of Biology, Chemistry and Physics at S4-5 level.
Assessment for Learning in Science (2001-04)	Secondary	To develop and try out quality criteria and modes of assessment that promote assessment for learning in science. The project will also serve as reference for refining and validating quality criteria for assessment in science.
Enriching the Science Curriculum through School-based Curriculum Development (2002-03)	Secondary	To explore and try out various modes of curriculum organization to enrich students' learning experiences in science. Based on the core and extension parts of the science subject curricula, schools will develop their own curriculum to address issues in line with students' needs.

The expected outcomes of the “seed” projects may include:

- ❖ research reports including exemplary teaching ideas, materials and practices;
- ❖ resource materials for enriching students' learning experiences;

- ❖ professional development of primary and secondary school teachers involved in the projects; and
- ❖ stronger links between schools, tertiary institutions and the Education Department.

## 6.5 Community Resources for Science Education

To facilitate life-wide learning in science, different government departments, non-government agencies and educational institutions, etc. can make contributions. They are partners who can provide students with real-life learning experiences as well as up-to-date information and professional services.

A number of community resources have been identified and provided in Appendix 7 for teachers' reference. They are by no means exhaustive. Teachers are encouraged to explore further learning opportunities available in the community and make good use of them to make science learning and teaching interesting, authentic and meaningful.

**Schools may refer to Booklet 11 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on the above.**

## 6.6 Resource Management in Schools

With the implementation of the school-based management starting from 2000, schools are accorded the autonomy and flexibility for the allocation of government funding to meet the operating expenses to achieve their school-based objectives. Schools can make use of the funding available from the Operating Expenses Block Grant (OEBG) and the Composite Furniture and Equipment Grant (CFEG) to meet the expenses required for the development of science education. The following table gives an overview of the objectives and ambit of the grants and examples of how they can be employed to meet schools' needs. An annual plan should also be drawn up to solicit funds from school management committee for science activities such as field trips and visits to museums.

<b>Financial Resources in Supporting Science Education</b>		
<b>Grant / Resource</b>	<b>Objectives &amp; Usage</b>	<b>Remark</b>
Composite Furniture and Equipment Grant (CFEG)	<ul style="list-style-type: none"> <li>• Purchase of furniture and equipment (F&amp;E) items (new ones and replacement);</li> <li>• Maintenance / repairs for F&amp;E items; and</li> <li>• Insurance premium for non-standard F&amp;E items.</li> </ul>	<ul style="list-style-type: none"> <li>• Circular On "Composite Furniture and Equipment Grant and Transition Furniture and Equipment Grant for Aided Schools"</li> <li>• F&amp;E list for science subjects are available from the website of the Education Department</li> <li>• Release of Grant: August</li> </ul>
Operating Expenses Block Grant (OEBG) (Grants for science subjects under the general domain)	<ul style="list-style-type: none"> <li>• Operating expenses, e.g. purchase of consumables for experimental use</li> </ul>	<ul style="list-style-type: none"> <li>• Circulars on "Operating Expenses Block Grant (OEBG) for Aided Schools" and "Subject and Curriculum Block Grant for Government Schools "</li> <li>• Release of Grant: August/April</li> </ul>
Non-recurrent Grants: Major Repairs / Alternations	<ul style="list-style-type: none"> <li>• Costs for major repairs and alternations, e.g. laboratory renovation</li> </ul>	<ul style="list-style-type: none"> <li>• Circular on "Applications for Non-Recurrent Grants: Major Repairs/ Alterations"</li> <li>• Application is usually made in May/June</li> </ul>
Arrangement for Emergency Repairs	<ul style="list-style-type: none"> <li>• Emergency repairs of damages, e.g. fume cupboard repair</li> </ul>	<ul style="list-style-type: none"> <li>• Circular on "Streamlined Arrangement on Processing Emergency Repairs"</li> </ul>

Details of the circulars and F&E lists can be downloaded from the following websites:

- ❖ Circulars - [http://www.ed.gov.hk/ednewhp/flash\\_circulars.htm](http://www.ed.gov.hk/ednewhp/flash_circulars.htm)
- ❖ F&E Lists - <http://www.ed.gov.hk/building/>

In addition, schools may also look for funding from other sources, e.g. the Quality Education Fund, the Hong Kong Jockey Club Fund for Summer Youth Programme and school sponsoring bodies to enhance the effectiveness of learning and teaching for science education.

## 6.7 Support to Teachers

For successful realization of the recommendations for science education, the following types of teacher development are needed:

- ❖ Curriculum leadership courses to familiarize science panel heads with the recommendations for development in the Science Education KLA and with strategies for school-based curriculum development
- ❖ Seminars and workshops for teachers to share experiences on good practices in the planning of school-based curriculum, design of learning activities and conducting hands-on and exploratory activities
- ❖ Web-supported courses with practical sessions to update teachers on new developments in science and technology

The assistance of laboratory technicians in the conduction of practical work and project work is essential. Laboratory technicians should also be familiarized with the new developments of the science curriculum. Both the teacher development programmes and training for laboratory technicians can be arranged by schools, sponsoring bodies, Education Department, tertiary institutions or professional organizations.

In addition, the Education Department will

- ❖ support schools through the Science Section, school-based curriculum development teams and Regional Education Offices; and
- ❖ build up a resource repository related to the proposed changes in the curriculum on the Internet to support teachers.

**Schools may refer to Booklet 10 of the *Basic Education Curriculum Guide - Building on Strengths* (2002) for more ideas on the above.**

# EXEMPLARS

## **Exemplar (1)**

### **Thematic Science Day in Primary Schools**

**Level: Primary**

**Curriculum: General Studies**

**Emphasis: Promoting science at primary level**

Schools are recommended to create curriculum space by spending about 80% of the total learning time for GS on core elements and flexibly arranging the remaining 20% to cater for the interests and needs of students. The following is a description of how a school runs a thematic science day making use of part of this 20% curriculum time:

- Theme-based science exploratory activities are run in the school campus for 1-2 days to provide an extended science learning experience for the students.
- These activities are generated from the GS curriculum with ideas contributed by scientists of the Hong Kong University of Science and Technology (HKUST).
- The occasion allows students to learn in an informal setting at their own pace and exercising their imagination and creativity. They are allowed to have trial-and-error during the exploratory activities. They could seek solutions through peer collaboration, and at the same time developing responsibility and ownership for their learning.
- Teachers and parents take part as tutors or group leaders in the programme. Training sessions are provided by the HKUST to familiarize them with the running of the programme and the underpinning scientific theories. Secondary students also participate as helpers. It is reported that the bringing together of such effort and expertise not only contributes to the success of the programme, but also provides opportunities for the sharing of ideas and experiences among the various parties.
- Some schools have modified the activities and tried to run their own thematic science days with the help of secondary students from neighbouring schools. It is hoped that in the long run, scientists from tertiary institutes will provide assistance in the development of the activities, and each school can conduct their science days on its own. Primary schools can share their experiences through networking.

## Exemplar (2)

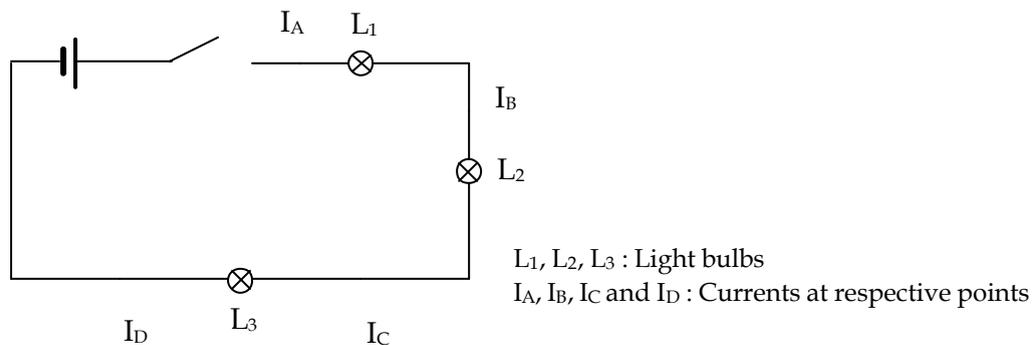
### Quality Feedback in the Teaching, Learning and Assessment Cycle

Level: Junior Secondary

Curriculum: Science

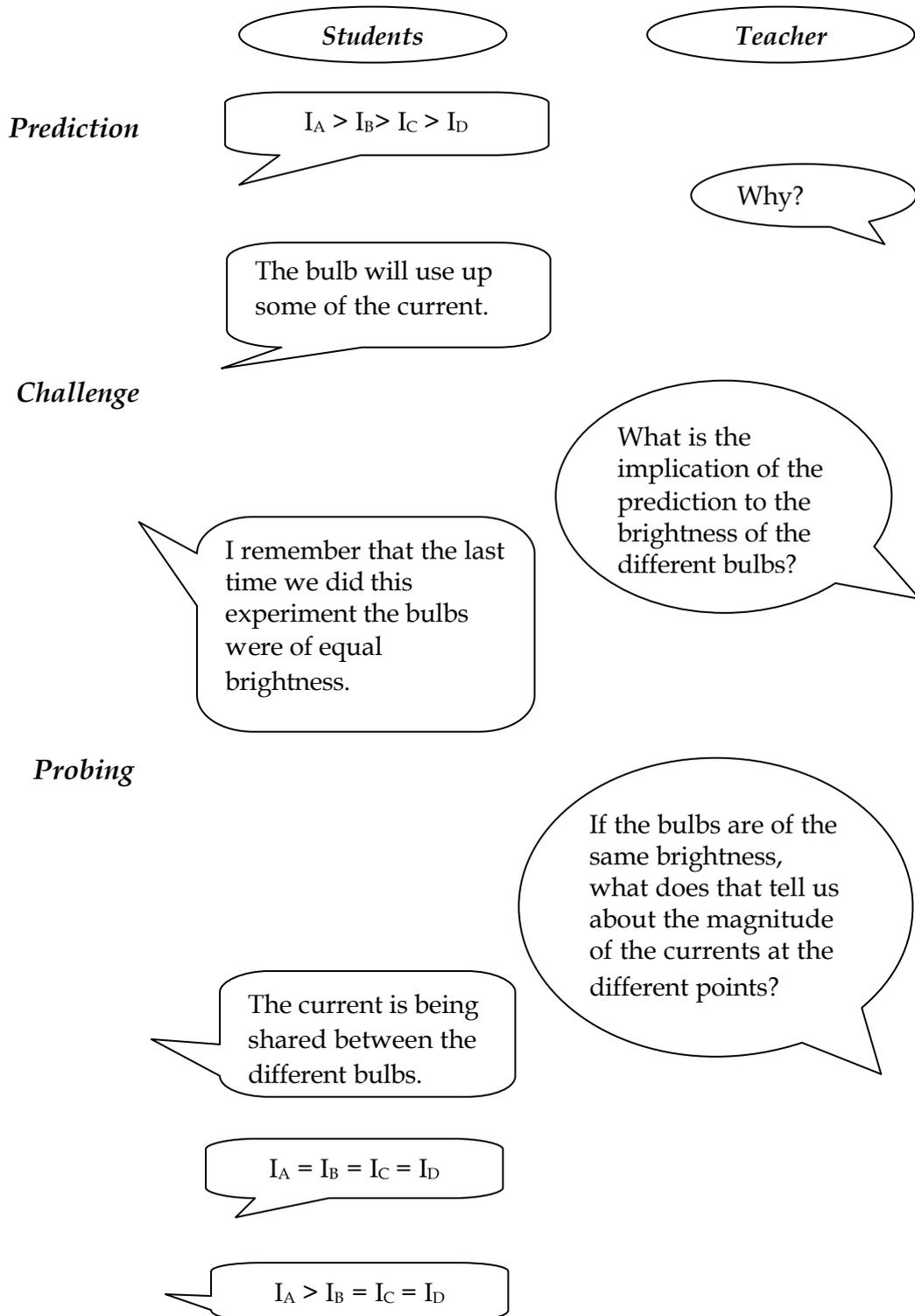
Emphasis: Assessment for learning

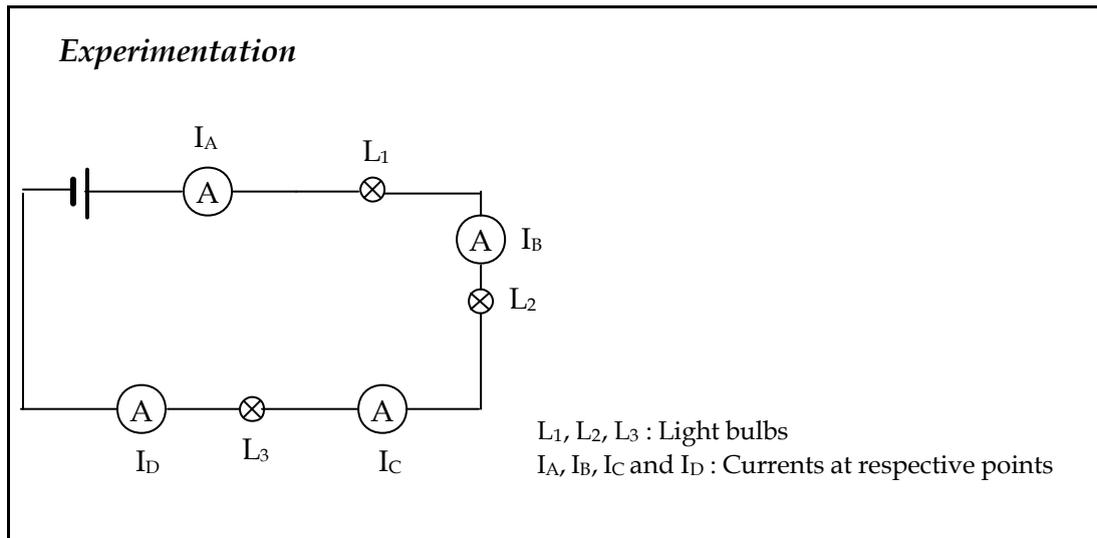
Students are involved in a predict-observe-explain task during a science lesson. They are presented with a circuit with three light bulbs and a cell connected in series. Students are asked to predict the magnitude of current at different parts of the circuit when the switch is closed. They are then given four ammeters to measure the current at the different parts simultaneously. Students then proceed to the stage of making sense of their observations.



- The above predict-observe-explain task is presented to groups of students in a science laboratory.
- Students are first invited to discuss amongst themselves and come up with their own predictions of the magnitude of the current at the different points before the switch is closed.

To evoke thoughtful, active reflection, the teacher must be open-minded and a neutral and intelligent listener:





- Based on the experimental result, the students are then asked to come up with an explanatory model to explain what is happening in the circuit.
- The groups are invited to present their model and how the phenomenon observed can be explained using their model. It is important that the presenters speak on behalf of the groups. The groups challenge the proposals of other groups and defend their own proposal. Students are allowed to modify their models and put their final proposals on the board. They then vote on the options presented. It is important that the dialogue should evoke thoughtful active reflection in which all students are encouraged to take part.
- The students' performances in explanation and discourse are evaluated publicly. Scores are awarded to the different groups. The teacher guides the students to see why some groups are awarded higher scores than others, thus helping them to reflect on their models and re-evaluate their explanations.
- The group scores gained during lessons contribute to the final grades of individual students. The scores also give an indication of the quality of collaborative learning in the groups.
- The quality of teacher-student interaction during the prediction, explanation and scoring process is the major factor contributing to the success of raising standards (student achievements) and helping students to take active responsibility for their own learning.

**Exemplar (3)**  
**Assessing Science Practical Work**

**Level: Junior Secondary**

**Curriculum: Science**

**Emphasis: Assessment for improving students' learning in science**

- Practical work is the vehicle for the construction of science knowledge through hands-on activities. Proper mastery of practical skills enhances safe and efficient exploration of phenomena around us.
- Practical assessments that are aligned with the learning objectives provide useful information on science learning and teaching. For example, students can be asked to heat a beaker of water to 80 °C with a Bunsen burner, or be asked to design and draw the circuit diagram for an alarm system. The assessment of process and product provide information about students' competency in manipulating apparatus and instruments, as well as their understanding of the underlying scientific principles.
- Practical assessments also help to identify problems students may have with practical work.
- It may not be possible to assess the skills and attitudes of all the students in one single assessment. The teacher could assess one or two skills at one time or assess the same skill over a few occasions using different activities. Attitudes, on the other hand, should be assessed over a period of time.
- A practical assessment can be organized in different ways. When there are sufficient apparatus or materials available, all the students can carry out the same task at the same time. Otherwise, different groups of students could be engaged in different tasks at one time and move from one 'station' to another until they have completed all the tasks.
- Well-designed practical assessment provides opportunities for students to develop problem-solving and thinking skills. Students' perseverance, confidence, creativity and participatory attitudes are also cultivated.

The following is an example of a record providing information on students' progress in practical work.

### Record of Progress in Practical Work

Name: XXX      Class: XX      Overall Grade: 2.5

Items:

Process Skills / Attitude	Excellent (4 Marks)	Very Good (3 Marks)	Good (2 Marks)	Satisfactory (1 Mark)	Needs Improvement
Observing	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Predicting	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Controlling variables	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Measuring	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Interpreting data	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Communicating	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Responsibility	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cooperativeness	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment:

- ♦ *Can describe objects and events in terms of obvious features and uses some scientific ideas in deciding on the relevant things to describe.*
- ♦ *Need improvement in finding pattern from a set of data and interpreting the meaning from the pattern.*

The items to be assessed may vary according to the teacher's major concerns. The assessment criteria for each item should be made known to students. The record can be given to students at a regular interval e.g. at the end of a term, or every two months.

**Exemplar (4)**  
**Selection of Quality Science Textbooks**

**Level: Junior Secondary**

**Curriculum: Science**

**Emphasis: Quality science textbooks**

- In selecting science textbook, schools may prepare checklists with reference to the aims and objectives of the Science (S1-3) Curriculum, ED circulars on selection of textbooks and learning resources the handbook Safety in Science Laboratories (2002).
- A sample of such kind of checklist developed by a school is provided below:

**ABC Secondary School**  
**Science (S1-3) Textbook Selection Board**  
**Quality Textbook / Learning Resources Criteria Checklist**

Please rate each of the following items on a scale of 1 to 10 with “10” being the maximum. Please give reason(s) for ratings of below 4 and above 7.

Item	Publisher				
1. Content selected is aligned with the learning targets and objectives of the curriculum					
2. Well-structured organization of content that renders reading easy					
3. Facilitates progressive development of concepts and science process skills					
4. Fosters learning to learn through developing students' skills in critical thinking, communication, collaboration, problem-solving, etc.					
5. Accurate and appropriate language used					
6. Accurate and effective use of illustrations					
7. Provision of purposeful and diversified learning activities					
8. Due emphasis on safety precautions whenever appropriate					

Item	Publisher			
9. Impartiality				
10. Appropriate weight, layout and print font size				

Other comments:

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Name of teacher: \_\_\_\_\_

Date: \_\_\_\_\_

## Exemplar (5)

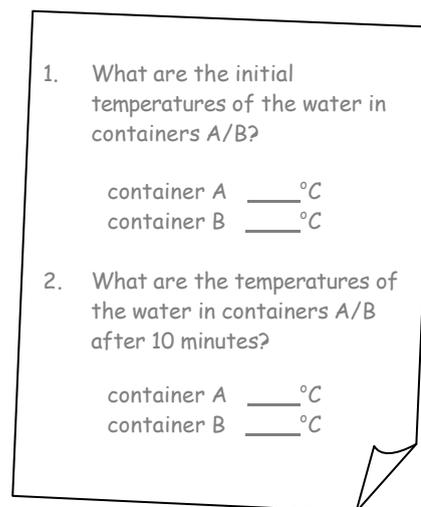
### Developing Critical Thinking and Problem-solving Skills Through Design of Experiments

Level: Junior Secondary

Curriculum: Science

Emphasis: Critical thinking and problem-solving skills

Traditionally, science textbooks usually introduce the concept of energy gain and loss with an experiment on comparing the temperature change of water in containers of different materials over a period of time. The experimental setup and procedures involved are given in detail. Students only need to follow the procedures step by step to perform the experiment and complete a worksheet by answering superficial questions which require little independent thinking. Instead of following the textbook passively, the science teacher can develop students' critical thinking and problem-solving skills through carefully designed activities that are more meaningful and relevant to their daily life, thereby fostering active learning.



1. What are the initial temperatures of the water in containers A/B?

container A \_\_\_\_\_°C  
container B \_\_\_\_\_°C

2. What are the temperatures of the water in containers A/B after 10 minutes?

container A \_\_\_\_\_°C  
container B \_\_\_\_\_°C

**At the end, the teacher might also get students to compare their work with the textbook – showing how students learn more if they explore and do things for themselves!**

- Energy gain and loss is introduced under the topic “Life in space” in the S1-3 Science curriculum. In discussing the life of astronauts in space, students come to realize the need to maintain body temperature in space. As an introduction to the study of the design of a space suit, the teacher asks students to design and make a thermo-cup in groups. This serves the purpose of illustrating the idea of preventing energy loss.
- Students are asked to consider how to choose materials and how the design of their thermo-cups would affect its effectiveness in retaining warmth. They hand in their proposals, describing and explaining their designs in detail.

- Based on students' proposals, the teacher gives written feedback to individual groups, challenging their ideas and helping students to reflect on their designs. As long as safety issues are observed, the teacher encourages students to proceed with their proposals and make their own thermo-cups.
- Different groups of students then present and explain their designs before the class. Students are guided to evaluate the feasibility of each design based on their scientific knowledge.
- After different groups have made their thermo-cups, the teacher leads the whole class to design a fair test to test for the effectiveness of their thermo-cups. The whole class has to decide what measurements to make, what variables to keep unchanged, and how to improve the reliability of the results. Finally, the effectiveness of each thermo-cup is tested according to the criteria the whole class has agreed upon.

*"How should we make the comparison?"*

*"We should use the same amount of water for each trial."*

*"... and start with the same temperature too!"*

*"What should we measure? Would an alcohol thermometer be precise enough for the test?"*

*"Let's use a data logger for the test and see how the temperature of the water in each thermo-cup changes over time."*

A snapshot of the class discussion

- The whole exercise reduces students' reliance on traditional experimental workbooks in science learning. Students go through the process of critically analyzing a problem and proposing the "best solution". The designs are then evaluated scientifically. In the process, students are led to focus on a problem and through the problem-solving activities, their critical thinking, communication, collaboration and study skills are developed.

**Exemplar (6)**  
**Developing Generic Skills, Values and Attitudes**  
**through Projects in Science**

**Level: Junior Secondary**

**Curriculum: Science**

**Emphasis: Generic skills, values and attitudes**

- The teacher arranges a boat trip in the school picnic to various sites of the Hong Kong waters (Victoria Harbour, Tolo Harbour, beaches), and asks the students to look at the urban development of the harbour.
- Before the trip, students are asked to formulate their own problem, define their scope of work, find out what tests they would carry out, how to carry out and what the tests mean. The method of collection, the storage of samples etc. should be well thought of.
- Students are asked to look at the water pollutants and refuse and try to classify them according to the type, estimated weight, volume and source at the spot.
- Students are asked to collect water samples for testing water quality.
- Students are encouraged to approach their problems from different perspectives, integrating knowledge (e.g. science, geography, mathematics, IT and languages), skills (collaboration, problem-solving etc.), values and attitudes (perseverance, cooperativeness etc.) as they tackle their problems.
- Students are asked to keep learning journals which they record their thoughts and ideas and their supporting evidences. The teacher acts as a facilitator in the progress by giving continuous feedback to students, especially with regard to their development in terms of generic skills.
- A detail description of the running of the project is provided below:

**Title:** Marine pollution in Hong Kong

**Objectives:**

This project aims to provide learning experiences for students to:

1. develop a deeper understanding of effects of pollutants to water quality.
2. be aware of the issues related to marine pollution in Hong Kong.
3. propose strategies and measures to control the water quality.

The following generic skills, values and attitudes can be developed:

1. Informed decision-making
2. Problem-solving
3. Information handling
4. Collaboration
5. Critical thinking
6. Communication
7. Commitment
8. Perseverance
9. Responsibility

### **Step 1: Preparation phase**

- Brainstorm to explore the main theme. Students are encouraged to suggest ideas and at the same time comment or criticize others' ideas in a constructive way.
- Lead students to think of any idea they are interested, and ask them to suggest questions around these ideas. For example:
  - Is water pollution a problem in Hong Kong? What are the evidences?
  - What are the possible sources of pollutants and effects on water quality?
  - What are the possible measures in controlling water pollution?
  - What are the roles of government and individual citizens in water pollution control?
  - Is water pollution a local issue or global issue?
  - Should restaurants pay the sewage discharge fee?

Help students to decide the types of project according to the questions set. It could be a survey, an information search or an investigation.

### **Step 2: Planning phase**

- Explain the requirement of the project.
- Help students to make an implementation plan based on the problem suggested.
- Ask students to include the division of work and responsibility and work schedule in the implementation plan.

### **Step 3: Implementation phase**

- Allow sufficient time for students to:
  - search and handle information.
  - interpret information and analyze data.
  - write the project report and prepare the presentation.
  
- Ask students to keep a record/journal for:
  - keeping track of the progress.
  - facilitating self-reflection.
  - assessment.

### **Step 4: Final phase**

#### ***Written report***

Students are required to submit a group project report including the aim of the project, any hypotheses, experimental method, ways to collect data, analysis of data, conclusions and comments.

#### ***Oral presentation***

1. Oral presentation helps assessing the efforts, collaborative work and communication skills of the students.
2. Oral presentation can be in a variety of ways, e.g. PowerPoint presentation, role-play, dialogue, interview or speech.
3. Students are encouraged to challenge the ideas, findings and conclusions of each other in equal status. These would facilitate the exchange of knowledge in a non-judgemental manner, hence creating a culture of dialogue and self-learning.

#### ***Use of learning journals***

The use of learning journal enables students to critically reflect on their own learning process and revise their goals and learning strategies accordingly. This will foster in them a sense of ownership of their learning.

The following questions may help the students to reflect:

1. How did I explore the various topics for my project work?
2. How and why did I select the topic for my project work?
3. What are the unique features of my work?
4. How did I overcome problems that I encountered?
5. What were some of the interesting ways I used to conduct my work?

6. What have I learnt in this project, in terms of scientific knowledge, social issues, skills, values and attitudes?
7. Have I become more concerned about our environment? In what way can I be more contributive to the protection of our environment?

### Exemplar (7)

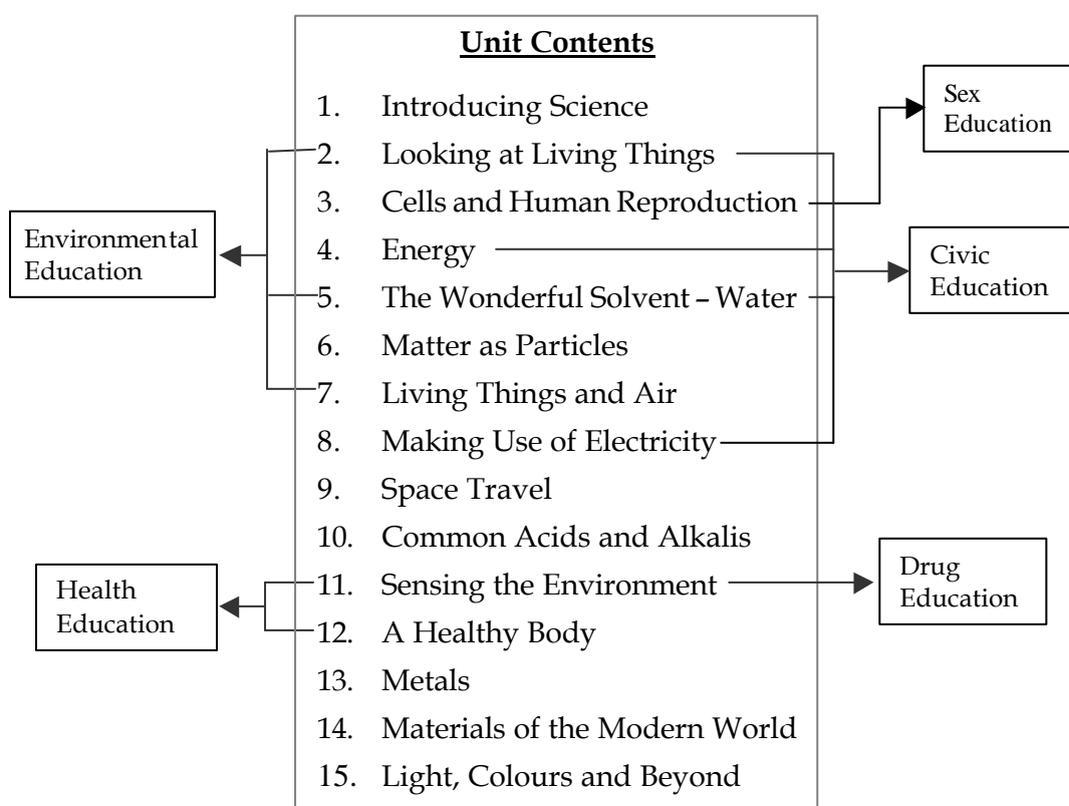
#### Extending the Science Curriculum to Cover Cross-curricular Issues

Level: Junior Secondary

Curriculum: Science

Emphasis: Cross-curricular issues

In the learning of science, students should be led to view an issue with multiple perspectives and make connections between their learning experiences in different areas. The diagram below illustrates how the Science (S1-3) Curriculum can be extended to link with some cross-curricular issues.



Cross-curricular Issues	References
Civic Education	<a href="http://www.greenpower.org.hk/">http://www.greenpower.org.hk/</a> <a href="http://www.chinalightandpower.com.hk">http://www.chinalightandpower.com.hk</a> <a href="http://www.info.gov.hk/wsd/">http://www.info.gov.hk/wsd/</a>
Drug Education	Life Education Activity Programme, Hong Kong Jockey Club Drug InfoCentre
Environmental Education	<a href="http://www.info.gov.hk/epd/">http://www.info.gov.hk/epd/</a>
Health Education	Health InfoWorld, Hospital Authority
Sex Education	"Implementing Sex Education through the Junior Secondary Science Curriculum", Guidelines on Sex Education in Schools

## **Exemplar (8)**

### **Assessment in an Inquiry Classroom**

**Level:** Upper Primary

**Curriculum:** General Studies

**Emphasis:** Assessing scientific investigations

#### **Characteristics of an Inquiry Classroom**

Below are some features we value in an inquiry classroom and the list will help teachers focus on what needs to be assessed:

- Students formulate their own questions and devise ways to answer them.
- Students collect data, decide how to represent them, and test the reliability of the knowledge they have generated.
- Students learn to evaluate their own work and the work of others.
- Students react to challenges regarding their conclusions and the limitations of their work.
- Students make presentations to others and are willing to receive constructive criticism.

#### **A scene in an Inquiry Classroom**

In studying the patterns and phenomena related to sound, a P.6 class is trying to investigate how sound is produced and how we hear it. Groups of students are provided with different musical instruments including some that can be tuned and others that cannot. The students are asked to find out how to make a loud sound, a soft sound, a high-pitched sound, and a low-pitched sound. They are also asked how to stop themselves from hearing the sound from the instrument. The students discuss their findings and prepare to present what they have done and their ideas about it.

#### **What the teacher does during the lesson**

- Moves around and listens to student discussion.
- Encourages students to think by asking questions.
- Encourages them to ask questions that can be explored through further investigations.
- Observes how systematically they investigate and how thoroughly they notice and record effects.
- Facilitates discussion among group members

- Observes how students communicate and how they explain what they did during group presentations.
- Listens to the vocabulary they use.
- Asks each student to select one instrument and suggest how it makes sound, and how he or she hears it by a piece of writing with illustrations.
- Collects students' work and studies them for information about their understanding of sound, their use of evidence, and their reasoning process.
- Decides on the next steps for the students – whether they are ready to move on to other investigations of sound or they need to consolidate ideas about how sound is created and how it travels to our ears.

### **What to assess**

Assessment in an inquiry classroom must be concerned with process skills, attitudes to science and the understanding of scientific ideas.

Process skills developed include:

- Observing – watching carefully, taking notes, comparing and contrasting  
e.g. A student watches carefully which parts of the musical instrument are vibrating.
- Questioning – generating questions from observations that can lead to investigations  
e.g. Why do I stop hearing the sound when I put my hand on the vibrating string?
- Hypothesizing – providing explanations consistent with available observations  
e.g. I think sound is produced because the string is vibrating.
- Predicting – suggesting an event in the future, based on observations  
e.g. I think loud sound can be produced when the strings of an instrument vibrate more vigorously.

The attitudes include:

- Maintaining curiosity and interest in science  
e.g. Students are eager to find out how to produce a loud sound and a soft sound using the instrument.
- Developing personal integrity through honest recording of experimental

data

e.g. A student writes down his observation that the body of the instrument also vibrates, instead of just recording that the string vibrates, which he knows beforehand.

- Willing to contribute and to work with others with diverse backgrounds  
e.g. A group of students works in collaboration and shares ideas
- Willing to change ideas in the light of evidence  
e.g. A student accepts the idea that sound is not just coming out from the opening in the body of a guitar but from all the vibrating parts of the instrument, including the body of it, after he has listened to other groups' presentation and discussion.

The understanding of scientific ideas includes:

- Production of sound
- Pitch of sound
- Transmission of sound

### **How to assess**

The teacher gathers information about students' learning through observing, questioning and looking closely at products.

Observing:

Much can be learned about students' skills by observing them at work.

e.g. Observes how systematically they investigate and how thoroughly they notice and record effects.

e.g. Listens to the vocabulary they use and how they communicate with each other.

Questioning:

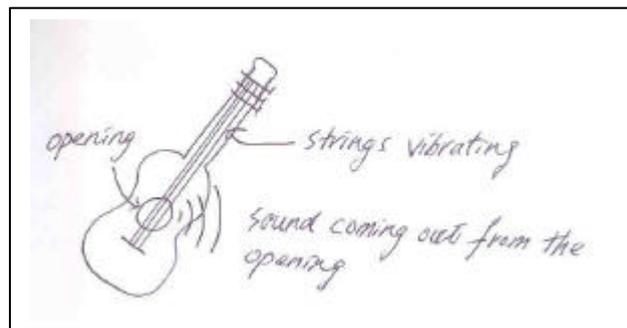
The most useful kinds of question are open, as opposed to closed, and learner-centered.

e.g. "What do you notice about the body of the guitar when sound is produced?" Vs "Do you see the vibration of the strings when sound is produced?"

Looking closely at products:

The products of students' inquiry, whether they are drawings, constructions, or pieces of writing, give clues to their thinking and are especially useful in assessing their understanding of scientific ideas. In the lesson, the teacher asks each student to select one instrument and to suggest how it makes sound, and how he or she hears it.

e.g. The diagram below shows a student's response to the teacher's questions.



The diagram shows that the student has developed the idea that sound is produced when the strings of the guitar vibrate. But the student considered that sound could only travel through air and so sound comes only from the opening in the body of the guitar.

By carefully analyzing students' works, teachers will be able to identify the different understandings about sound exist in the class and decide on what issues should be addressed in the lessons that follow.

### **Giving Feedback to Students**

For feedback to have a positive effect, it should be focused on the work in hand and how it can be improved. For example, the teacher might comment, "You have made an interesting observation that sound comes from the opening of the guitar. Are you quite sure it is only coming from the opening? Why don't you check your idea by covering up the opening with your hand and seeing whether the result is the same or different?" This is more likely to promote learning than commenting that the result was wrong, or indeed, just saying, "fine" and not showing the student how to improve it.

# APPENDICES

## Generic Skills and Science Education

To further illustrate the development of the four focused generic skills, namely communications skills, creativity, critical thinking skills and problem-solving skills, the following tables provide the descriptors of expected achievement across the school curriculum and exemplars of implementation in science education at each key stage.

### Communication Skills

Communication is a dynamic and ongoing process in which two or more people interact in order to achieve a desired outcome or goal. In learning to communicate effectively, learners should learn to speak, listen, read and write effectively. They should learn to select the most appropriate means to convey a message in accordance with the purpose and context of the communication. They should use accurate and relevant information and organize it systematically and coherently for their audience. They should also evaluate the effectiveness of their communication and identify areas of improvement for action.

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Key Stage 1 (Junior Primary)</b> Learners will learn to</p> <ul style="list-style-type: none"> <li>• comprehend and act appropriately on spoken instructions</li> <li>• use clear and appropriate means of communication, both verbal and non-verbal, to express meaning and feelings</li> <li>• read and write simple texts</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• comprehend and follow instructions in carrying out experiments (e.g. seed germination)</li> <li>• use appropriate units (e.g. kg, cm) in measurements</li> <li>• use appropriate language in discussion and when reporting observations (e.g. colour change) or findings of experimental investigation</li> <li>• write simple sentences to report observations or findings of experiments</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Key Stage 2 (Senior Primary)</b> <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• comprehend and respond to different types of text</li> <li>• use spoken, written, graphic and other non-verbal means of expression to convey information and opinions, and to explain ideas</li> <li>• work and negotiate with others to develop ideas and achieve goals</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• present experimental findings through careful observation in oral and written forms (e.g. describe objects and events in terms of obvious features)</li> <li>• write simple reports using texts or diagrams on experimental findings</li> <li>• collaborate in groups to accomplish science project work</li> </ul>
<p><b>Key Stage 3 (Junior Secondary)</b> <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• understand, analyze, evaluate and respond to a range of different types of texts</li> <li>• use appropriate language and/or other forms of communication to present information and different points of view, and to express feelings</li> <li>• reflect and improve on the effectiveness of their own communication</li> <li>• work and negotiate with others to solve problems and accomplish tasks</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• extract useful information from a variety of sources (e.g. libraries, the Internet) and forms (e.g. texts, graphs, tables, charts)</li> <li>• use appropriate scientific terminology to present one's point of view and argument in oral and written modes</li> <li>• discuss experimental results among students in a group</li> </ul>
<p><b>Key Stage 4 (Senior Secondary)</b> <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• listen and read critically, and speak and write fluently for a range of purposes and audiences</li> <li>• use appropriate means of communication to inform, persuade, argue and entertain and achieve expected outcomes</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• use a wide range of scientific terminology and technical terms to communicate information and to develop an argument</li> <li>• write simple articles on contemporary science issues</li> <li>• understand and appreciate the viewpoints of people with different interests, and resolve conflicts to solve problems concerning Science, Technology and Society (STS) issues</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<ul style="list-style-type: none"> <li>critically evaluate the effectiveness of their communication</li> <li>resolve conflicts and solve problems with others to accomplish tasks</li> </ul>	<ul style="list-style-type: none"> <li>choose and use an appropriate means (e.g. graphs to show trends; tables/ charts to organize numerical data) to present their findings/viewpoints/ arguments and are able to evaluate the effectiveness of such means</li> </ul>

### Creativity

<p>Creativity is an important but elusive concept. It has been defined in a variety of ways. Some people define it as an ability to produce original ideas and solve problems, others see it as a process, and yet others take it as a set of personal qualities. In fact, creativity is a complex and multifaceted construct. Within the individual, creative behaviour is the result of a complex of cognitive skills/abilities, personality factors, motivation, strategies, and metacognitive skills. A person's creative performance may not correspond to his/her developmental stage.</p> <p>General Principles: Although the demanding process of teaching for creativity is hard to make routine, some principles apply in general. To develop students' creativity, we ask them to go beyond the given information, allow them time to think, strengthen their creative abilities, reward their creative efforts, value their creative attributes, teach them creative thinking techniques and the Creative Problem-solving model, and create a climate conducive to creativity. These principles can be employed in all key learning areas (KLAs).</p>
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(The expected achievement of the learners in this generic skill cannot be suitably classified according to key stages)

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>to strengthen creative abilities: fluency, flexibility, originality, elaboration, sensitivity to problems, problem defining,</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>do creative writing (e.g. a science fiction, a story of a foam cup) to develop imagination, originality</li> <li>ask relevant questions, suggest ideas and</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p>visualization, imagination, analogical thinking, analysis, synthesis, evaluation, transformation, intuition, logical thinking, etc.</p> <ul style="list-style-type: none"> <li>• to develop creative attitudes and attributes: imagination, curiosity, self-confidence, independent judgement, persistence and commitment, tolerance for ambiguity, openness to new and unusual ideas/methods/approaches, deferment of judgement, adaptability, willingness to take sensible risks, etc.</li> <li>• use and apply the Creative Problem Solving (CPS) Model and creative thinking techniques: brainstorming, 6W thinking technique, 6 hats method, attribute listing, idea checklists, synectics, mind mapping, etc.</li> </ul>	<p>make predictions in science experiments and project work (e.g. ask why leaves have different shapes)</p> <ul style="list-style-type: none"> <li>• formulate hypotheses and devise methods for testing them in scientific investigations (e.g. propose a hypothesis about the effect of detergents on living organisms)</li> <li>• propose and develop alternative solutions to a scientific problem and evaluate the appropriateness of these methods</li> <li>• be willing to try new approaches or methods in solving science problems</li> <li>• be willing to explore innovative ideas before making solution plans or decisions on Science, Technology and Society (STS) issues (e.g. considering ideas for alternative energy resources)</li> <li>• participate in fun science competitions/open day/science events</li> <li>• make improvisations (e.g. using a ruler and pieces of string to replace a beam balance)</li> <li>• design a poster/slogan/model or compose a song/lyric with a science theme</li> <li>• adopt a variety of presentation methods (e.g. through role play, drama or use of PowerPoint)</li> <li>• use and apply the Creative Problem Solving Model in science projects</li> <li>• use brainstorming to generate suggestions on the best ways to conduct a scientific investigation and experiment, or the best solution to an STS problem</li> </ul>

## Critical Thinking Skills

Critical Thinking involves drawing out meaning from given data or statements. It is concerned with the accuracy of given statements. It aims at generating and evaluating arguments. Critical thinking is the questioning and inquiry we engage in to judge what to believe and what not to.

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Key Stage 1 (Junior Primary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• extract, classify and organize information from a source</li> <li>• identify and express main idea, problem or central issues</li> <li>• understand straight-forward cause and effect relationships</li> <li>• distinguish between obvious fact and opinion</li> <li>• recognize obvious stereotypes, assumptions, inconsistencies and contradictions</li> <li>• formulate questions, make predictions / estimations and hypotheses</li> <li>• draw simple but logical conclusions not contradictory to given evidence and data</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• identify obvious characteristics (e.g. colour, size, hotness etc.) of objects directly related to their senses</li> <li>• classify objects (e.g. living and non-living things) according to their observable features</li> <li>• raise questions to observed scientific phenomena</li> </ul>
<p><b>Key Stage 2 (Senior Primary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• understand and make deductions/ inferences from sources</li> <li>• cross reference other sources to determine the reliability of a source</li> <li>• understand the concepts of relevance and irrelevance</li> <li>• distinguish fact and opinion as well as source and evidence</li> <li>• question obvious bias, propaganda, omissions, and the</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• identify patterns and changes in a set of data collected.</li> <li>• compare and contrast objects or phenomena of a similar or different nature (e.g. compare animals and plants)</li> <li>• organize and analyze data to generate meaningful information (e.g. from examining pictures of reproduction of different animals to generalize the reproduction methods of animals)</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p>less obvious fallacies</p> <ul style="list-style-type: none"> <li>• formulate appropriate questions, make reasonable predictions and hypotheses</li> <li>• draw logical conclusions based on adequate data and evidence, and make predictions about consequences</li> </ul>	<ul style="list-style-type: none"> <li>• infer from observation and experimental results (e.g. what products are formed in photosynthesis)</li> <li>• ask for logical reasoning and scientific explanation (e.g. We can see the Moon because it reflects sunlight to our eyes.)</li> </ul>
<p><b>Key Stage 3 (Junior Secondary)</b> <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• compare different sources, note contrasts and similarities, and determine their reliability</li> <li>• distinguish fact, opinion and reasoned judgement</li> <li>• be aware that value orientations and ideologies can affect people's perspective</li> <li>• recognize and challenge stereotypes, inconsistencies, emotional factors, and propaganda</li> <li>• draw and test conclusions as well as hypotheses, identify reasonable alternatives and predict probable consequences</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• identify the chain of arguments related to a science problem (e.g. energy changes in a power plant)</li> <li>• identify dependent and independent variables of a science investigation</li> <li>• examine theories and concepts through logical reasoning and experimentation</li> <li>• recognize preconceptions or misconceptions based on experimental evidence (e.g. recognize through experiment that a filter does not add colour but subtract colour from white light)</li> <li>• group and organize knowledge and concepts and apply to a new situation (e.g. apply scientific knowledge to explain the application of salt in defrosting)</li> <li>• predict trends from observed patterns and changes (e.g. change of states of matter, rate of change etc.)</li> <li>• distinguish between scientific facts, myths, conjectures and legends</li> <li>• examine evidence and argument based on their own knowledge and value before arriving at a judgement (e.g. make informed judgement on the use of nuclear energy)</li> </ul>
<p><b>Key Stage 4 (Senior Secondary)</b> <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• distinguish real and stated issues, false and accurate images, and relevant and irrelevant evidence</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• discard invalid models based on scientific facts and reasoning, and suggest valid models to explain phenomena</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<ul style="list-style-type: none"> <li>• recognize and challenge subtle consistencies and inconsistencies, unstated fundamental assumptions, permeating value orientations and ideologies</li> <li>• distinguish among sophisticated fact, opinion and reasoned judgement</li> <li>• aware that the selection and deployment of information/ facts is affected by personal perspective</li> <li>• draw warranted conclusions, predict and assess probable consequences and make reasoned judgement in reading, writing, and speech</li> </ul>	<ul style="list-style-type: none"> <li>• recognize the limitation of scientific models and the temporary nature of scientific theories</li> <li>• justify an assumption in an experiment and estimate the discrepancies that would be produced if they do not hold</li> <li>• justify the validity of a logical argument(e.g. an argument which embodies scientific principles to explain a phenomenon)</li> <li>• make inferences to predict trends and patterns from a limited range of evidence and justify their validity</li> </ul>

### Problem-solving Skills

Problem-solving involves using thinking skills to resolve a difficulty. Problem-solvers assemble facts about a problem and determine the best course of action.

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Key Stage 1 (Junior Primary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• develop ideas about the problem and identify sources of information and help</li> <li>• identify, under guidance, different ways of tackling the problem</li> <li>• choose and implement a solution plan, using support and advice given</li> <li>• follow the given step-by-step methods to check and describe the outcomes</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• ask relevant questions (e.g. what should I find out?) in a simple scientific investigation</li> <li>• follow instructions to carry out experiments to find out some simple science facts (e.g. find out what kind of materials can be attracted by magnets)</li> </ul>

Descriptors of Expected Achievements across the School Curriculum	Exemplars of Implementation in Science Education
<p><b>Key Stage 2 (Junior Secondary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• identify the problem and describe its main features</li> <li>• propose alternative courses of action for solving it</li> <li>• plan and try out selected option, obtain support and make changes when needed</li> <li>• develop an appropriate method to measure the outcomes and examine the approach chosen</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• select and apply facts and science concepts to solve simple problems (e.g. identify conditions needed for burning)</li> <li>• propose hypotheses (e.g. oxygen is needed for rusting) for some simple scientific phenomena and devise methods for testing them</li> <li>• select methods and apparatus to carry out scientific investigations</li> </ul>
<p><b>Key Stage 3 (Senior Primary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• explore the problem and identify the issue(s) at stake</li> <li>• suggest and compare the possible outcomes of each alternative course of action and justify the option selected</li> <li>• execute the planned strategy, monitor progress and revise the approach when necessary</li> <li>• evaluate the quality of outcomes against established criteria, and review the effectiveness of the solution process</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• devise plans and procedures to carry out scientific investigations</li> <li>• try out different solution methods and identify the strengths and weaknesses of these methods (e.g. compare the use of pH paper and pH meter in measuring the pH of a solution)</li> <li>• analyze data, draw conclusions and make further predictions in science experiments</li> </ul>
<p><b>Key Stage 4 (Senior Secondary)</b>  <b>Learners will learn to</b></p> <ul style="list-style-type: none"> <li>• recognize the complexity of the problem and search for appropriate information required to solve it</li> <li>• formulate feasible strategies to achieve optimal results, considering both long term as well as short term objectives</li> <li>• monitor and critically reflect on the progress in solving the problem</li> <li>• evaluate the overall strategy and anticipate possible future problems related to the solution</li> </ul>	<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• propose solution plans for scientific problems and evaluate the appropriateness of these plans (e.g. make proposals to improve the air quality of Hong Kong)</li> <li>• evaluate the quality of the experimental results and identify the factors affecting its quality (e.g. estimate errors)</li> </ul>

## Values and Attitudes in Science Education

The following is an outline of the values and attitudes advocated in the school curriculum:

Personal		Social	
Core Values	Sustaining Values	Core Values	Sustaining Values
<ul style="list-style-type: none"> <li>• sanctity of life</li> <li>• truth</li> <li>• aesthetics</li> <li>• honesty</li> <li>• human dignity</li> <li>• rationality</li> <li>• creativity</li> <li>• courage</li> <li>• liberty</li> <li>• affectivity</li> <li>• individuality</li> </ul>	<ul style="list-style-type: none"> <li>• self-esteem</li> <li>• self-reflection</li> <li>• self-discipline</li> <li>• self-cultivation</li> <li>• principled morality</li> <li>• self-determination</li> <li>• openness</li> <li>• independence</li> <li>• enterprise</li> <li>• integrity</li> <li>• simplicity</li> <li>• sensitivity</li> <li>• modesty</li> <li>• perseverance</li> </ul>	<ul style="list-style-type: none"> <li>• equality</li> <li>• kindness</li> <li>• benevolence</li> <li>• love</li> <li>• freedom</li> <li>• common good</li> <li>• mutuality</li> <li>• justice</li> <li>• trust</li> <li>• interdependence</li> <li>• sustainability</li> <li>• betterment of human kind</li> </ul>	<ul style="list-style-type: none"> <li>• plurality</li> <li>• due process of law</li> <li>• democracy</li> <li>• freedom and liberty</li> <li>• common will</li> <li>• patriotism</li> <li>• tolerance</li> <li>• equal opportunities</li> <li>• culture and civilization heritage</li> <li>• human rights and responsibilities</li> <li>• rationality</li> <li>• sense of belonging</li> <li>• solidarity</li> </ul>

Attitudes	
<ul style="list-style-type: none"> <li>• optimistic</li> <li>• participatory</li> <li>• critical</li> <li>• creative</li> <li>• appreciative</li> <li>• empathetic</li> <li>• caring and concern</li> <li>• positive</li> <li>• confident</li> <li>• cooperative</li> <li>• responsible</li> <li>• adaptable to changes</li> <li>• open-minded</li> </ul>	<ul style="list-style-type: none"> <li>• with a respect for               <ul style="list-style-type: none"> <li>- self</li> <li>- life</li> <li>- quality and excellence</li> <li>- evidence</li> <li>- fair play</li> <li>- rule of law</li> <li>- different ways of life, beliefs and opinions</li> <li>- the environment</li> </ul> </li> <li>• with a desire to learn</li> <li>• diligent</li> <li>• committed to core and sustaining values</li> </ul>

It is believed that the development of the above values and attitudes, together with the strengthening of students' self-management and interpersonal skills, should enable them to make wise decisions on emerging issues in society and cope with stress and negative influences from various sources. The Science Education KLA has, in its contexts, included a range of learning objectives contributing to the development of these values and attitudes. They are illustrated below to facilitate the planning of relevant learning experiences in the Science Education KLA.

Development of values and attitudes in science education are illustrated below:

<b>Developing Values and Attitudes in Science Education</b>
<p><b>Learners</b></p> <ul style="list-style-type: none"> <li>• maintain curiosity and continued interest in science</li> <li>• be aware of the importance of the safety of oneself and others in the laboratory and be committed to safe practices in daily life</li> <li>• develop personal integrity through observation and honest recording of experimental data and analyzing experimental evidence</li> <li>• show an awareness that the body of scientific knowledge is not static; and that experimental and investigatory work are important for its advancement</li> <li>• develop an awareness of scientific advancement and its social, economic, environmental and technological implications</li> <li>• be willing to communicate and comment on issues related to science, value the suggestions and respect the decisions of others</li> <li>• develop a positive attitude in enhancing personal and community health</li> <li>• appreciate the wonders of Nature and show respect and care for all forms of life</li> <li>• appreciate the imminent need for conservation and act responsibly in conserving the environment.</li> <li>• demonstrate a continued interest and enjoyment in the pursuit of scientific knowledge</li> <li>• be critical towards evidence, hypotheses and experiments</li> <li>• show an awareness of the evolutionary nature of scientific knowledge, and that experimental and investigative work are important for its advancement</li> <li>• develop open-mindedness, be able to show tolerance and respect towards different opinions, viewpoints, and people with different beliefs and value systems</li>   <li>• reflect on ways that scientific and technological developments influence the society</li> <li>• be committed and show continued effort to support activities contributing to the personal and community health, protection of the environment,</li> </ul>

**Developing Values and Attitudes in Science Education**

- conservation of natural heritage, both locally and globally
- develop positive attitudes and values towards sex on matters related to the role of sexuality, parenthood, marriage, etc.
  - show concern for the local, national and global scientific issues and ethics arising from the conflicting use of places, environment, animal-testing, use of materials and related consequences etc.
  - make informed and responsible decisions on matters related to their health based on scientific knowledge, evidence and objectivity
  - be able to tolerate ambiguity, different opinions and people with different value systems
  - be willing to contribute to the betterment of mankind in local, national and global perspectives based on the acquired scientific knowledge

## **New Approaches for the General Studies Curriculum**

The aims of school education, as stated in the Education Commission's Reform Proposals, are "to motivate students to construct a core of basic knowledge and develop their basic abilities and attitudes to prepare them for the building of a learning and civilized society". To prepare students to face their future challenges in the 21st century, the General Studies (GS) curriculum bears the notions of developing students' understanding about themselves, society and the world, maintaining healthy personal development, cultivating positive personal and social values and attitudes, developing an interest and curiosity in natural phenomena and the physical world, cultivating care and concern for environmental conservation, and developing the ability to inquire and solve problems with special reference to those related to the impact of science and technology on society.

The GS curriculum is designed in the belief that students' learning experiences are connected and not compartmentalized. The curriculum integrates core elements of learning in the Key Learning Areas of Personal, Social and Humanities Education (PSHE), Science Education (SE) and Technology Education (TE). The learning elements are integrated into various topics relating to students' daily experiences, so as to help them develop a holistic view of themselves as individuals in the community, their place in the natural world, and the interaction between human beings and the environment. Six strands of learning are identified:

- Health and Living
- People and Environment
- Science and Technology in Everyday Life
- Community and Citizenship
- National Identity and the Chinese Culture
- Global Understanding and the Information Era

Details of the proposed core elements of these areas can be found in the GS Curriculum Guide.

Students will gain diversified learning experiences through active participation in learning activities such as project learning, service learning,

scientific investigation and hands-on activities related to science and technology. Resources from community establishments, such as museums, community organizations, public and private bodies, will be utilized to promote life-wide learning.

## Characteristics of the Science (S1-3) Curriculum

### Background

The present Science (S1-3) Curriculum was implemented in September 2000.

### Special features

The curriculum emphasizes a balanced approach towards the acquisition of scientific knowledge, attitudes and skills through carefully organized activities. The investigative approach, which involves students in defining problems, designing experiments to find solutions, carrying out practical work and interpreting the results, should be employed. Such investigations enhance the acquisition of scientific knowledge and process skills as well as contribute towards other educational goals such as cultivation of citizenship, development of appropriate personal and social values and appreciation and respect for life.

Many activities suggested in the curriculum provide opportunities for developing students' generic skills as well as values and attitudes. Exemplars (2), (5), (6), (7) illustrate how learning experiences in science can foster the development of generic skills by engaging students in investigative activities; while exemplars (6) and (7) propose scenarios in which important values and attitudes such as integrity, diligence, fairness, curiosity, imagination, caring and concern and respect for life can be developed through science activities.

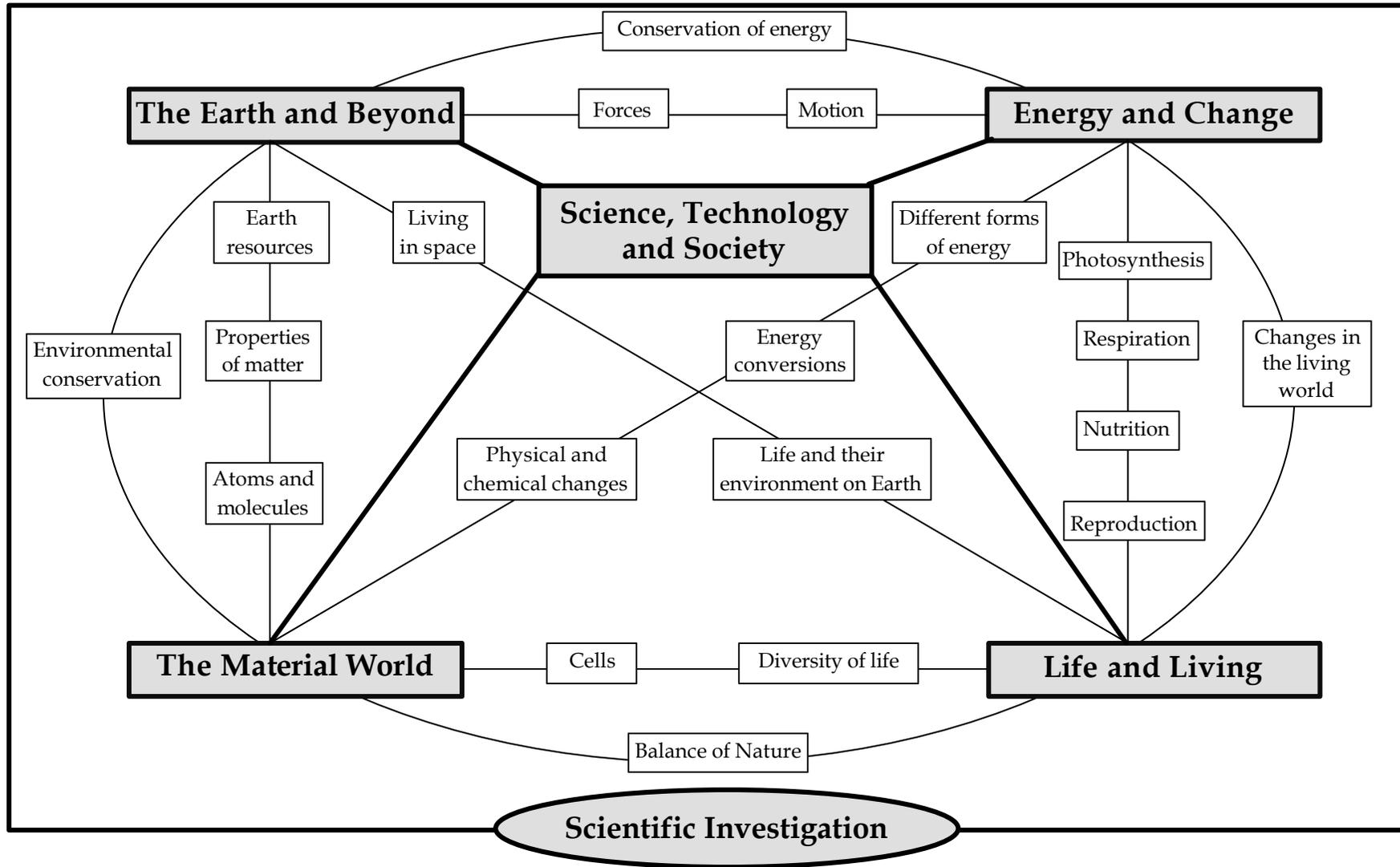
As a means to cater for individual differences, the content of the curriculum is organized into core and extension parts (please refer to the *CDC Syllabus for Science (Secondary 1-3) (1998)*) to allow for flexibility in the organization of school-based science curriculum. The core represents the basic components of science that all students should learn. The extension constitutes additional learning for different students. The level of attainment for each topic within the extension would vary from school to school and within a school from class to class. Apart from the core, teachers are expected to select materials from the extension to suit the needs, interests and abilities of their students. **It must be emphasized that an average student is not expected to learn all the materials in the extension parts.**

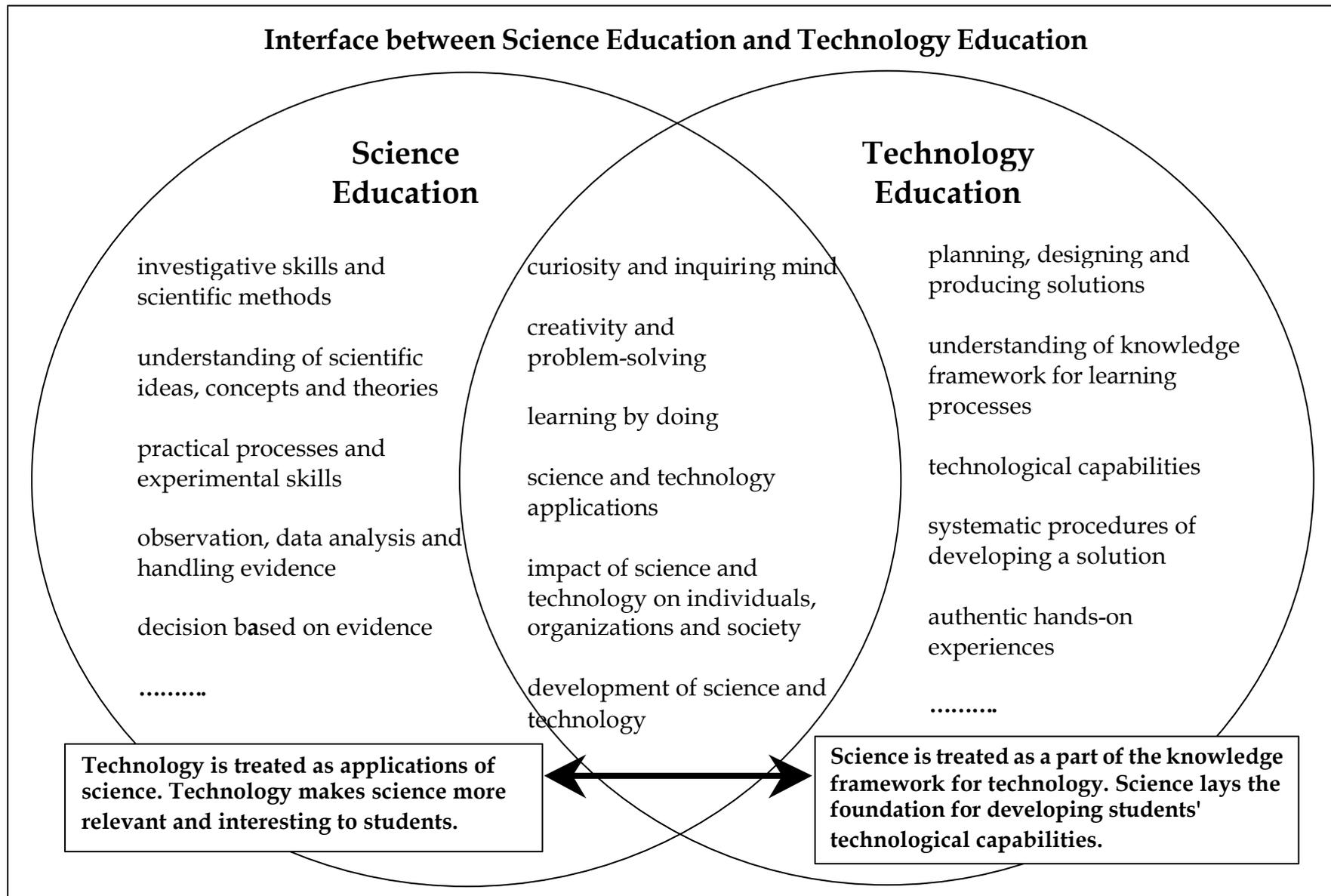
### **Further development**

During the development of this curriculum guide, the conceptual framework of the Science (S1-3) Curriculum (*CDC Syllabus for Science (Secondary 1-3)*, p.7) has been revised to align with the six strands in the school science curriculum (see 2.2.1) and a diagrammatic presentation is provided on the next page to illustrate how the learning elements in the 15 units of the Science (S1-3) Curriculum are organized and linked into a unifying conceptual whole.

To upkeep with recent developments in science and technology, an Ad Hoc Committee has been set up to identify new developments in science and technology suitable for inclusion into the Science (S1-3) Curriculum as extension topics. Relevant supporting resources will be developed in due course.

### Conceptual Framework of the Science (S1-3) Curriculum





**List of Curriculum Support Materials for Science Education**  
(as at June 2002)

	<b>Title</b>	<b>Year</b>	<b>Level</b>	<b>Format</b>
1.	Science Section, ED 教育署科學組 (URL: <a href="http://cd.ed.gov.hk/sci">http://cd.ed.gov.hk/sci</a> )	Updated timely	S1-S7	Web-based
2.	HKeducationCity.net: Resources 香港資訊教育城：資源中心 資源庫>初中>科學教育 政府資源>科學教育 教學影片庫>科學(教育電視系列) (URL: <a href="http://www.hkedcity.net/">http://www.hkedcity.net/</a> )	Updated timely	P1-S7	Web-based
3.	ETV guide 教育電視 資源庫>教育電視教師參考資料>科學科 (URL: <a href="http://www.cdc.org.hk/etv">http://www.cdc.org.hk/etv</a> )	Updated timely	P1-S7	Web-based, TV
4.	eTV Online eTV 直播室 (URL: <a href="http://www.etvonline.tv">http://www.etvonline.tv</a> )	Updated timely	P1-S7	Web-based, On-line ETV Programme
5.	Safety in Science Laboratories 科學實驗室安全手冊	2002	S1-S7	CD-ROM, Book
6.	Safety Corner (URL: <a href="http://cd.ed.gov.hk/sci/laboratory/safety_corner.htm">http://cd.ed.gov.hk/sci/laboratory/safety_corner.htm</a> )	2001	S1-S7	Web-based
7.	Standard Equipment and Furniture List for Chemistry/ Physics/ Biology/ Integrated Science (URL: <a href="http://www.ed.gov.hk/building/">http://www.ed.gov.hk/building/</a> )	2000	S1-S7	Web-based
8.	Laboratory Safety Posters 實驗室安全海報	1996	S1-S7	Poster
9.	Science Laboratories – Fixtures & Furniture	1995	S1-S7	Book
10.	Guidelines on the Prevention of Blood-borne Diseases in Schools 血液傳染病在校內預防指引	2001	P1-S7	Book
11.	'Implementing Sex Education through the Junior Secondary Science Curriculum' 「透過初中科學科課程推行性教育」 教材套	2002	S1-S3	CD-ROM, Resource Package

	Title	Year	Level	Format
12.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Science (S.1-3) 中學科學科(中一至中三)常用英漢辭彙	2001	S1-S3	Book
13.	「豬肺呼吸」及「太空之旅」 實驗儀器製作	2001	S1-S3	CD-ROM (Chinese Version Only)
14.	「科學探究」與「學會學習」 <物質的粒子觀>	2001	S1-S3	CD-ROM (Chinese Version Only)
15.	「科學探究」與「學會學習」 <太空之旅、生物與空氣>	2001	S1-S3	CD-ROM (Chinese Version Only)
16.	小學科學探究活動 <常識百搭>	2001	P4-P6	CD-ROM (Chinese Version Only)
17.	小小科學家獎勵計劃	2001	P5-P6	Booklet (Chinese Version Only)
18.	Secondary 1 Science IT-based Resource Package 中一科學科<教學資源> (URL: <a href="http://resources.ed.gov.hk/s1science">http://resources.ed.gov.hk/s1science</a> )	2000	S1-S3	CD-ROM, Web-based Teaching Resources
19.	Electrical Safety 用電安全	2000	S1-S7	CD-ROM
20.	能量	2000	S1-S3	CD-ROM, Book (Chinese Version Only)
21.	Be Friends with Nature 親親大自然	1999	S1-S3	Resource Folder, CD-ROM
22.	Safety Precautions in Integrated Science Experiments 綜合科學科實驗安全措施	1999	S1-S3	Book
23.	Stages in an Investigation 科學探究的步驟	1998	S1-S3	Booklet
24.	Physics World 物理園 (URL: <a href="http://www.hk-phy.org/">http://www.hk-phy.org/</a> )	Updated timely	S1-S5	Web-based
25.	Experiments for Advanced Level Physics	2001	S6-S7	CD-ROM

	Title	Year	Level	Format
26.	調幅與調頻模擬實驗	2000	S4-S5	CD-ROM (Chinese Version Only)
27.	Sixth Form Physics Practical Assessment 中六物理科實驗技能評估	2000	S6-S7	CD-ROM
28.	趣味物理實驗 (第一輯及第二輯)	1999	S4-S5	CD-ROM (Chinese Version Only)
29.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Physics in Secondary Schools 中學物理科常用英漢辭彙	1991	S1-S7	Book
30.	Modern Chemical Techniques - web version 現代化學分析技術 - 網上版 (URL: <a href="http://resources.ed.gov.hk/chemtech">http://resources.ed.gov.hk/chemtech</a> )	2000	S6-S7	Web-based
31.	Modern Chemical Techniques 現代化學分析技術	2000	S6-S7	CD-ROM, Book
32.	Chemistry Collection 2000 化學資源集 2000	2000	S4-S7	CD-ROM
33.	Experimental Techniques in Chemistry	1999	S6-S7	CD-ROM
34.	Air Pollution and Environmental Protection 空氣污染和環境保護	1999	S6-S7	CD-ROM
35.	Resource Materials on Infrared Spectroscopy 紅外光譜學教學資料冊	1999	S6-S7	Resource Folder
36.	Chemical Safety 化學品安全	1999	S1-S7	CD-ROM
37.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Chemistry in Secondary Schools 中學化學科常用英漢辭彙	1999	S1-S7	Book
38.	OHT Resources for A-level Chemistry 高級程度化學科投影片資料冊	1998	S6-S7	Resource Folder
39.	Chemistry Clipart 化學繪圖集	1997	S1-S7	Resource Folder
40.	HK Bioweb 香港生物網 (URL: <a href="http://resources.ed.gov.hk/biology/">http://resources.ed.gov.hk/biology/</a> )	2002	S1-S7	Web-based

	<b>Title</b>	<b>Year</b>	<b>Level</b>	<b>Format</b>
41.	Resources for Teaching of Biology 2: Photomicrographs 生物科教學資源 2: 顯微照片	2001	S4-S7	CD-ROM
42.	Resources for Teaching of Biology 生物科教學資源	2000	S4-S7	CD-ROM
43.	IT-Based Resource Package for Secondary Schools in Hong Kong: Biotechnology 資訊科技為本中學資源教材套： 生物科技	1999	S4-S7	CD-ROM
44.	Biology/Human Biology Newspaper Clipping CD-ROM 生物學/人類生物學剪報光碟	1999	S1-S7	CD-ROM
45.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Human Biology in Secondary Schools 中學人類生物科常用英漢辭彙	1998	S4-S5	Book
46.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Biology in Secondary Schools 中學生物科常用英漢辭彙	1991	S1-S7	Book

## Community Resources for Science Education

Organizer	Activity	Telephone Number
Agriculture, Fisheries and Conservation Department	<p>Endangered Species Resources Centre</p> <ul style="list-style-type: none"> <li>• The Centre has some 500 specimens of about 100 endangered species on display.</li> <li>• Guided tours are available and advanced booking is required.</li> </ul>	2150 6974
	<p>The Hong Kong Herbarium</p> <ul style="list-style-type: none"> <li>• The Hong Kong Herbarium is the most comprehensive herbarium in Hong Kong. There are approximately 38,000 plant specimens for examination.</li> </ul> <p>(Website: <a href="http://www.afcd.gov.hk/con_new/homepage.htm">http://www.afcd.gov.hk/con_new/homepage.htm</a>)</p>	2150 6900
	<p>Hong Kong Wetland Park</p> <ul style="list-style-type: none"> <li>• Wetland Tour is a guided visit programme and serves as one of the conservation education programmes of the Hong Kong Wetland Park. It aims to arouse public awareness on the wetland ecosystem in Hong Kong.</li> <li>• The content of the tour will be tailor-made to suit the needs and age profile of individual schools/groups around three major wetland themes: Wetland Conservation, Adaptation of Wetland Plants and Adaptation of Wetland Birds.</li> </ul> <p>(Website: <a href="http://www.afcd.gov.hk/wetlandpark/">http://www.afcd.gov.hk/wetlandpark/</a>)</p>	3152 2666
	<p>Conservation Camps</p> <ul style="list-style-type: none"> <li>• Conservation camps involve summer outdoor activities to provide opportunities for students to engage in maintenance work for trees and country in parks.</li> </ul> <p>(Website: <a href="http://parks.afcd.gov.hk/">http://parks.afcd.gov.hk/</a>)</p>	2422 9431

Organizer	Activity	Telephone Number
Anthropological Survival Out-Reach - "Little Seal" marine ecological tour	<ul style="list-style-type: none"> <li>"Little Seal" is a marine mobile school, which aims at providing special marine tours for Hong Kong primary and secondary students.</li> </ul> (Website: <a href="http://www.asomf.org.hk/daycamp.htm">http://www.asomf.org.hk/daycamp.htm</a> )	2473 0738
Education Department	<ul style="list-style-type: none"> <li>Various sciences related activities and competitions for students will be held each year. Schools can get the information through circulars issued by the Education Department.</li> </ul> (Website: <a href="http://www.ed.gov.hk">http://www.ed.gov.hk</a> )	2891 0088
Food and Environmental Hygiene Department	Health Education Exhibition and Resource Centre <ul style="list-style-type: none"> <li>A permanent exhibition on the theme of "Food Safety, Environmental Hygiene and You" is staged at the Centre. It features world class exhibition facilities with utilization of advanced multi-media presentation technologies.</li> </ul> (Website: <a href="http://www.info.gov.hk/fehd">http://www.info.gov.hk/fehd</a> )	2377 9275
Friends of the Earth	School Talk & Workshop <ul style="list-style-type: none"> <li>Talks and workshops on environmental issues can be provided.</li> </ul> Nature Guided Eco-Walk <ul style="list-style-type: none"> <li>Guided eco-walks will show you the beautiful side of Hong Kong.</li> </ul> (Website: <a href="http://www.foe.org.hk/">http://www.foe.org.hk/</a> )	2528 5588
Hong Kong Observatory	<ul style="list-style-type: none"> <li>Introduces the work of the Hong Kong Observatory</li> <li>Displays - instruments for weather observation and environmental radiation.</li> </ul> (Website: <a href="http://www.weather.gov.hk">http://www.weather.gov.hk</a> )	2926 8215

Organizer	Activity	Telephone Number
Hong Kong Science Museum	<ul style="list-style-type: none"> <li>• The Hong Kong Science Museum was opened on 18 April 1991. It offers a fascinating opportunity for you to discover the mystery of science.</li> <li>• The four-storey museum occupies a site of 12,000 square metres while its exhibition halls cover a total floor area of 6 500 square metres.</li> <li>• There are about 500 exhibits, 60% of which are hands-on exhibits.</li> <li>• Guided Tour Services for schools are available</li> </ul> <p>(Website: <a href="http://www.lcsd.gov.hk/CE/Museum/Science/">http://www.lcsd.gov.hk/CE/Museum/Science/</a>)</p>	2732 3232
Hong Kong Space Museum	<ul style="list-style-type: none"> <li>• Hong Kong Space Museum has two thematic exhibition halls: the Hall of Space Science and the Hall of Astronomy on the ground and first floors respectively. The exhibits, predominately interactive, enable visitors to learn through a series of entertaining and educational experiences.</li> <li>• Teacher' s Corner: Self-Learning Astronomy Course, Space Race Board Game</li> </ul> <p>(Website: <a href="http://www.lcsd.gov.hk/CE/Museum/Space/">http://www.lcsd.gov.hk/CE/Museum/Space/</a>)</p>	2721 0226
Hospital Authority	<p>Health InfoWorld</p> <ul style="list-style-type: none"> <li>• Health InfoWorld's interesting, interactive and user-friendly exhibits feature six disease groups which between them form the biggest threat to the health of Hong Kong people today. Apart from illustrating the causes, prevention and treatment of these diseases, the exhibits also dispel common misconceptions about them. Interactive computer kiosks challenge visitors to test their knowledge on health, and to explore its important connection with our daily lifestyle.</li> </ul> <p>(Website: <a href="http://www.ha.org.hk">http://www.ha.org.hk</a>)</p>	2230 7733

Organizer	Activity	Telephone Number
Kadoorie Farm and Botanic Garden	<ul style="list-style-type: none"> <li>• Educational programme to stimulate students' appreciation of nature and to arouse their support for environmental conservation.</li> <li>• Through learning in nature and studying local environmental issues, students can better understand our responsibility to environmental conservation.</li> </ul> <p>(Website: <a href="http://www.kfbg.org.hk/">http://www.kfbg.org.hk/</a>)</p>	2488 0166
LIONS Nature Education Centre	<ul style="list-style-type: none"> <li>• LIONS Nature Education Centre aims at encouraging the public to experience the beauty of nature and promotes the message of conservation.</li> <li>• The facilities include Countryside Hall, Agriculture Hall, Fisheries Hall, Insectarium, Shell House, Dragonfly Pond, Specimen Orchard, Medicinal Herbal Garden, Interesting Plants, Arboretum, Field Corps and Mineral Corner.</li> </ul> <p>(Website: <a href="http://www.lnec.net/eng/index.htm">http://www.lnec.net/eng/index.htm</a>)</p>	2792 2234
Ocean Park	<ul style="list-style-type: none"> <li>• Secondary Education Trail</li> <li>• Outward Education Activities</li> <li>• Teacher Education Trail</li> </ul> <p>(Website: <a href="http://www.oceanpark.com.hk/">http://www.oceanpark.com.hk/</a>)</p>	2873 8679
Ocean Park Conservation Foundation	<p>“Hand-in-Hand, Save the Whales and Dolphins” Award Scheme</p> <ul style="list-style-type: none"> <li>• To educate students on the current situation of the marine mammals and our environment through participation in various kinds of activity.</li> <li>• To motivate and encourage students to support and promote marine conservation to the community.</li> </ul> <p>(Website: <a href="http://www.opcf.org.hk/part4.html">http://www.opcf.org.hk/part4.html</a>)</p>	2873 8679

Organizer	Activity	Telephone Number
Tai Po Kau Interactive Nature Centre	<ul style="list-style-type: none"> <li>• Introduction with an entirely new concept in leisure life and education, the Tai Po Kau Interactive Nature Centre aims to provide healthy and educational leisure activities to the Hong Kong public of every age and background, from toddlers to senior citizens, from school children to working adults.</li> <li>• A variety of innovative programmes have been designed for different groups of people               <ul style="list-style-type: none"> <li>- families, centers for elderly, corporations and schools.</li> </ul> </li> </ul> <p>(Website: <a href="http://www.taipokau.org">http://www.taipokau.org</a>)</p>	2657 6657
World Wide Fund For Nature Hong Kong	<p>Island House Conservation Studies Centre</p> <ul style="list-style-type: none"> <li>• The grounds of Island House cover an area of 1.75 hectares and are a mixture of formal gardens and lawns in the English style, with over 140 identified species of plants. It is an outdoor classroom for organising plant-themed environmental education activities to help students discover the 'secrets' of plants through a fun-filled learning experience.</li> </ul> <p>Mai Po Marshes Wildlife Education Centre</p> <ul style="list-style-type: none"> <li>• Tailor-made educational programmes are organised for primary and secondary students. Four hundred school groups each year take part in special visits to Mai Po Nature Reserve guided by WWF HK Education Officers. In order to promote Education and Public Awareness at Mai Po, a number of visitor facilities have been established, such as birdwatching hides, nature trails, boardwalks, Education and Field Studies Centres, a museum showing the history of <i>gei wai</i> shrimp farming and a Waterfowl Collection.</li> </ul> <p>(Website: <a href="http://www.wwf.org.hk">http://www.wwf.org.hk</a>)</p>	2652 0285

### Exemplars and Recommendations in Science Education

	<b>Exemplar</b>	Scientific Investigating	STS Connection	Communication	Creativity	Critical Thinking	Problem-solving	Values and Attitude	Curriculum Organization	Assessment for Learning	Reading to Learn	Project Learning	Lifewide Learning	Catering for Differences	IT for Interactive Learning
1	Thematic Science Day in Primary Schools	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
2	Quality Feedback in the Teaching, Learning and Assessment Cycle	✓		✓	✓	✓	✓	✓		✓				✓	
3	Assessing Science Practical Work	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
4	Selection of Quality Science Textbooks							✓	✓	✓	✓			✓	
5	Developing Critical Thinking and Problem-solving Skills Through Design of Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓
6	Developing Generic Skills, Values and Attitudes through Projects in Science	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓
7	Extending the Science Curriculum to Cover Cross-curricular Issues	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	Assessment in an Inquiry Classroom	✓		✓	✓	✓		✓		✓				✓	

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