Science Syllabus
Lower Secondary
Normal (Technical)

Year of implementation: from 2008

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CONTENTS

PREAMBLE

This Lower Secondary Science Normal (Technical) Syllabus covers the first two-years of a four-year syllabus designed to provide secondary school students in the Normal (Technical) Course with the necessary foundation in science for post-secondary technical courses.

This syllabus is also a further development of the Primary Science Syllabus. Based on the notion of a spiral curriculum, fundamental concepts introduced at the primary school level are built upon and treated in greater depth at the lower secondary level. The content knowledge and the learning approach of this subject consolidate and build on what the student has acquired through science in the primary school. A student who has completed primary school education in any of the streams will be adequately prepared to study this subject.

This syllabus is based on the *Science Curriculum Framework* and emphasises the need for a balance between the acquisition of science knowledge, skills and attitudes. In addition, the knowledge and skills to be acquired in this subject have direct relevance to technical courses. Many of these skills and much of this knowledge are in the physical sciences. Topics which are aimed at developing an interest in and a positive appreciation of science and technology have also been included. In addition, some topics on the human body and healthy lifestyles have been included to prepare the students for adult life.

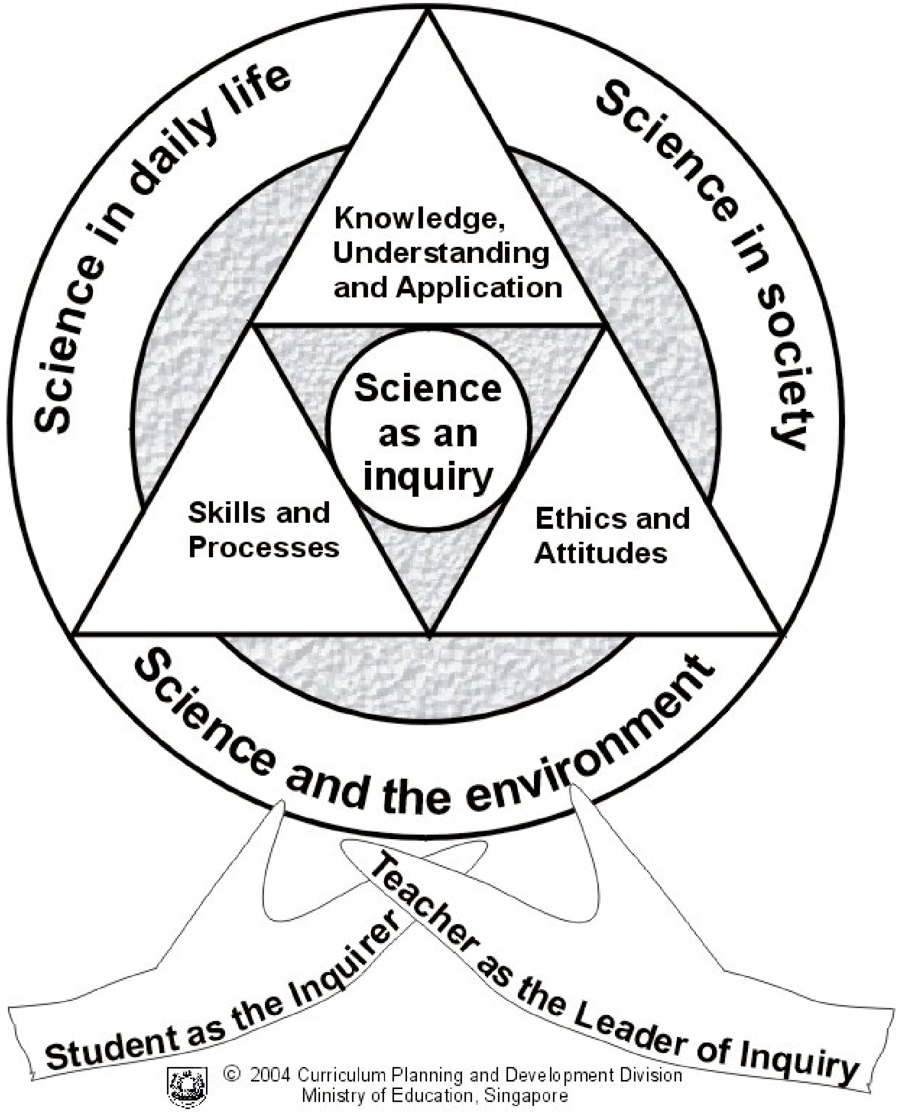
The aims spelt out in the syllabus provide the guiding principles for the suggested teaching approaches and evaluation methods.

Teachers are advised not to follow the syllabus too rigidly but to exercise their professional judgement in implementing it. Schemes of work should be developed with the interests and abilities of the students uppermost in mind. Teachers are encouraged to use a variety of approaches in their teaching and to incorporate ideas and materials from various sources, in order to enhance the learning of science.

SCIENCE CURRICULUM FRAMEWORK

The *Science Curriculum Framework* is derived from the *Policy Framework for the Teaching and Learning of Science*. It encapsulates the thrust of science education in Singapore to prepare our students to be sufficiently adept as effective citizens, able to function in and contribute to an increasingly technologically-driven world.

Central to the curriculum framework is the inculcation of the spirit of scientific inquiry. The conduct of inquiry is founded on three integral domains of (a) Knowledge, Understanding and Application, (b) Skills and Processes and (c) Ethics and Attitudes. These domains are essential to the practice of science. The curriculum design seeks to enable students to view the pursuit of science as meaningful and useful. Inquiry is thus grounded in knowledge, issues and questions that relate to the roles played by science in daily life, society and the environment.



The science curriculum seeks to nurture the <u>student as an inquirer</u>. The starting point is that children are curious about and want to explore the things around them. The science curriculum leverages on and seeks to fuel this spirit of curiosity. The end goal is students who enjoy science and value science as an important tool in helping them explore their natural and physical world.

The <u>teacher is the leader of inquiry</u> in the science classroom. Teachers of science impart the excitement and value of science to their students. They are facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Teaching and learning approaches centre around the student as an inquirer.

The following table shows the description of each domain which frames the practice of science:

Knowledge, Understanding and Application of	Skills and Processes	Ethics and Attitudes
• Scientific phenomena, facts, concepts and principles • Scientific vocabulary, terminology and conventions (including symbols, quantities and units) • Scientific instruments and apparatus including techniques of operation and aspects of safety • Scientific quantities and their determinations	<u>Skills</u> • Using apparatus and equipment • Posing questions • Observing • Classifying • Comparing • Communicating • Inferring • Formulating hypothesis • Predicting • Analysing • Elaborating • Verifying • Generating possibilities • Defining the problem <u>Processes</u> • Planning investigation • Creative problem solving	• Curiosity • Creativity • Objectivity • Integrity • Open-mindedness • Perseverance • Responsibility

The domains are contextually linked to the roles played by science to establish its relevance and relationship to modern-day living:

Science in daily life - Personal perspective focusing on the individual	**Science in society** - Social perspective focusing on human interactions	**Science and the environment** - Naturalistic perspective focusing on man-nature relationship
• Showing curiosity, interest and enjoyment in science • Applying scientific concepts and skills to daily life • Making informed decisions that are related to the social, environmental, economic and technological aspects of science, e.g. lifestyle choices that affect personal health	• Becoming confident, responsible and productive citizens in a technological world • Showing awareness of science and technology on society, industry, business, home and leisure, e.g. sensitivity to the benefits and abuses of the applications of science	• Demonstrating safety consciousness and safe practices, e.g. when using apparatus and equipment • Showing care and concern for the environment, e.g. importance of conserving energy, reducing pollution

AIMS

The Lower Secondary Science Normal (Technical) Syllabus aims are to:

(i) enable students to acquire knowledge and understanding so as to
- be suitably prepared for post-secondary technical courses;
- become confident citizens in a technological world.

(ii) enable students to develop abilities and skills that
- will be relevant and useful in the workplace and daily life;
- encourage safety consciousness and safe practices.

(iii) develop attitudes which
- are relevant to the study of science such as concern for accuracy and precision;
- will enable the students to be responsible and productive citizens.

(iv) stimulate
- curiosity, interest, and enjoyment in science;
- care and concern for the environment.

(v) promote an awareness of the impact of science and technology on society, industry, business, home and leisure.

(vi) promote an awareness of the importance of the use of IT for communications and as a tool for data collection and analysis of experimental results.

It is hoped that teachers will incorporate the social, environmental, economic and technological aspects of science wherever possible throughout the syllabus (see Aims (iv) and (v)). Where appropriate, students should also have opportunities to discuss the ethical implications of science and technology.

SYLLABUS FRAMEWORK

The Lower Secondary Science Normal (Technical) Syllabus comprises:

- The knowledge, skills and attitudes that all students should acquire, which are designed for 85% of the curriculum time.

- The 15% freed up curriculum time, known as the white space, to enable teachers to use more interactive and engaging teaching and learning approaches, and/or to implement school-based curriculum. This flexibility enables teachers to better cater for the range of abilities, interests and needs of their students, so long as the aims of the syllabus are met.

A Knowledge, Understanding and Application

The syllabus is organised around big ideas that students can relate to in their everyday experiences and the commonly observed phenomena in nature.

The big ideas are presented as six Core Units in the syllabus. They are **Introducing Science and Technology, Investigating Life Processes, Investigating Matter, Investigating Forces, Investigating Electricity and Investigating Heat.** These units have been chosen because they provide a broad-based introduction to both the life and physical sciences. The topics under each unit are not to be viewed as compartmentalised blocks of knowledge.

To help teachers and students appreciate and understand the units, some key inquiry questions[1] are included for each unit. These questions can guide teachers and engage students in uncovering the important ideas at the heart of each unit. They can also use these questions to raise more specific questions for the respective topics under each unit.

For example, in the unit on **Introducing Science and Technology**, students are introduced to the essence of science, its measurement, and the impact of science and technology on society. Another central concept in science that students learn about in this unit is energy. Our life depends a lot on energy as energy is needed to make things work. In doing work, energy is changed from one form into one or more forms. For this unit, the key inquiry questions are:

- What is science and how does it work?
- Why do we need to measure things?
- What are the different forms of energy?

*The six Core Units are compulsory for all students. Other than the unit on **Introducing Science and Technology** which is to be taught first, there is no particular order in which the units are to be taught. Teachers are encouraged to determine the order based on the abilities and current interests of the students.*

[1] Reference: Wiggins, J and McTighe, J. (1998). *Understanding by Design.* Alexandria, Va.: Association for Supervision and Curriculum Development.

B Skills and Processes

In this syllabus, teachers are encouraged to provide opportunities for students to use concepts and integrate skills and processes to inquire about science around them.

Skills

Using apparatus and equipment
This is the skill of knowing the functions and limitations of various equipment and apparatus, and being able to select and handle them appropriately for various tasks.

Posing questions
This is the skill involving the clarification of issues and meaning through inquiry. Good questions focus attention on important information and are designed to generate new information.

Observing
This is the skill of using our senses to gather qualitative as well as quantitative information about a particular object, event or phenomenon. This also includes the use of instruments to extend the range of our senses.

Classifying
This is the skill of grouping objects or events according to common attributes or properties.

Comparing
This is the skill of identifying the similarities and differences between or among objects or entities.

Communicating
This is the skill of transmitting and receiving information presented in various forms - verbal, tabular, graphical or pictorial.

Inferring
This is the skill of interpreting and explaining observations, data or information gathered.

Formulating hypothesis
This is the skill of making a general explanation for a related set of observations or events. It is an extension of inferring.

Predicting
This is the skill of assessing the likelihood of an outcome based on prior knowledge of how things usually turn out.

Analysing
This is the skill of clarifying information by examining parts and relationships contained in the information.

Elaborating
This is the skill of providing details, examples and other relevant information so as to make one's ideas more comprehensible to others.

Verifying
This is the skill of confirming or proving the truth of an idea, using specific standards or criteria of evaluation.

Generating possibilities
This is the skill of exploring all the alternatives, possibilities and choices beyond the obvious or preferred one.

Defining the problem
This is the skill where one makes conscious effort to clarify situations that are puzzling in some way. The extent, scope and nature of the problem are identified and clarified.

Processes

Processes are complex operations which call upon the use of several skills.

Planning Investigation
This process involves formulating questions or hypotheses for investigating and devising ways to find answers. It also involves deciding on the type of equipment required, and measurements to be made, as well as identifying the variables involved and manipulating the variables so that the effect of only one variable can be observed in any one experiment.

Creative problem solving
This is the process of thinking through a problem and choosing an innovative solution that meets the requirements. This thinking process is used whenever one faces obstacles and wishes to overcome them so as to arrive at a practical and workable solution.

It must be pointed out that there is also no one definite sequence of priority among the skills and processes listed above. For example, observation may lead to hypothesising but at other times a hypothesis can lead to observation. All the skills and processes listed above are seen as part of the total process of scientific inquiry.

In science teaching and learning, effort should initially be directed at teaching explicitly each of the skills through the use of appropriate activities. Later, effort should be directed to helping students integrate some or all of the skills in scientific inquiry.

C Ethics and Attitudes

In scientific inquiry, the adoption of certain mental attitudes such as *curiosity, creativity, objectivity, integrity, open-mindedness, perseverance and responsibility* is advocated. Attempts should also be made to promote safety consciousness among students and to encourage students to adopt safe practices.

Curiosity
This is the attitude of desiring to explore the environment and question what they find.

Creativity
This is the attitude of seeking innovative and relevant ways to solve problems.

Objectivity
This is the attitude of seeking data and information to validate observations and explanations objectively.

Integrity
This is the attitude of handling and communicating data and information with integrity.

Open-mindedness
This is the attitude of accepting all knowledge as tentative and the willingness to change our views if the evidence is convincing.

Perseverance
This is the attitude of pursuing a problem until a satisfactory solution is found.

Responsibility
This is the attitude of showing care and concern for living things and awareness of our responsibility for the sustainability of the environment.

Opportunities should be provided in the classroom for students to ask questions. Students should be encouraged to ask both closed and open questions. From the type of questions asked by the students, teachers could gather information on their 'frame of mind' and the quality of their understanding.

Table 1 shows an overview of the Lower Secondary Science Normal (Technical) Syllabus.

Table 1: Overview of Lower Secondary Science Normal (Technical) Syllabus

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Designed for 85% of the curriculum time.[2]			White Space
1 Introducing Science and Technology ▪ What is science and technology? ▪ Physical quantities and measurement ▪ Energy as a resource	**2 Investigating Life Processes** ▪ Digestion ▪ Reproduction ▪ Other life processes ▪ Abuses to life	**3 Investigating Matter** ▪ Properties of matter ▪ Solids, liquids and gases ▪ Water, solutions and suspensions ▪ Air pollution ▪ Water pollution	The 15% freed up curriculum time is to enable teachers to use more interactive and engaging teaching and learning approaches, and/or to implement school-based curriculum. This flexibility enables teachers to better cater for the range of abilities, interests and needs of their students, so long as the aims of the syllabus are met.
4 Investigating Forces ▪ Force ▪ Machines	**5 Investigating Electricity** ▪ What is electricity? ▪ Currents and circuits ▪ Sources of electricity ▪ Conductors and insulators ▪ Electrical safety	**6 Investigating Heat** ▪ Temperature and thermometer ▪ Heating and cooling matter	

[2] There is no change in the recommended curriculum time, which remains as 4 periods per week (each period is 35-40 minutes).

TEACHING AND LEARNING THROUGH INQUIRY

What is scientific inquiry?

Scientific inquiry may be defined as the activities and processes which scientists and students engage in to study the natural and physical world around us. In its simplest form, scientific inquiry may be seen as consisting of two critical aspects: the what (content) and the how (process) of understanding the world we live in[3].

Teaching science as inquiry must therefore go beyond merely presenting the facts and the outcomes of scientific investigations. Students need to be shown how the products of scientific investigations were derived by scientists and be provided opportunities to: ask questions about knowledge and issues that relate to their daily lives, society and the environment; be actively engaged in the collection and use of evidence; formulate and communicate explanations based on scientific knowledge.

Through inquiry learning, students will be able to acquire knowledge and understanding of their natural and physical world based on their own investigations, apply the skills and processes of inquiry and develop attitudes and values that are essential to the practice of science.

What are some characteristics of teaching and learning of science as inquiry?

Inquiry-based learning may be characterised by the degree of responsibility students have in posing and responding to questions, designing investigations, and evaluating and communicating their learning (student-directed inquiry) compared to the degree of responsibility the teacher takes (teacher-guided inquiry). Students will best benefit from experiences that vary between these two inquiry approaches.

Essential features of science as inquiry	**More** ← **Amount of Student Self-Direction** → **Less** **Less** ← **Amount of Guidance from Teacher or Material** → **More**			
Question Students engage with an event, phenomenon or problem when they …	pose a question	select among questions	sharpen or clarify question provided	accept given question
Evidence Students give priority to evidence when they …	determine what constitutes evidence and collects it	are directed to collect certain data	are given data and asked to analyse	are given data and told how to analyse

[3] Reference: Chiappetta, E. L., Koballa, T., Collette, A. T. (2002). *Science instruction in the middle and secondary schools.* Upper Saddle River, NJ: Merrill/Prentice Hall.

Essential features of science as inquiry	More ← Amount of Student Self-Direction → Less Less ← Amount of Guidance from Teacher or Material → More			
Explanation Students construct explanations when they …	formulate their own explanation after summarising evidence	are guided in process of formulating explanation from evidence	are given possible ways to use evidence to formulate explanation	are provided with evidence
Connections Students evaluate their explanations when they …	examine other resources and form links to explanations	are directed toward sources of knowledge	are given possible connections	are provided with connections
Communication Students communicate and justify their explanations when they …	form reasonable and logical argument to communicate explanations	are coached in development of communication	are provided guidelines for communication	are given steps and procedures for communication

Adapted from *Inquiry and the National Science Education Standards*, National Research Council (2000).

What are some strategies for conducting inquiry-based learning and teaching?

A primary purpose for inquiry-based instruction is for students to learn fundamental science concepts, principles, and theories as well as to develop science process skills and attitudes that are essential for scientific inquiry. Science teachers are already using a variety of teaching strategies in their lessons.

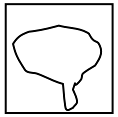
To further emphasise the learning of science as inquiry, teachers can incorporate in these strategies the essential features of **Question, Evidence, Explanation, Connections and Communication** and provide students with experiences that varies between guided (partial) and open (full) inquiry.

To meet the learning styles of the students, teachers should carry out the inquiry-based approach through *hands-on learning*[4]. Hands-on learning experiences should also be situated in *realistic contexts*, so that students can make connections with their own lives and the environment in which they live. In this way, students become engaged and excited about what they are studying, and they then become motivated to learn.

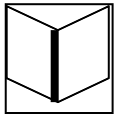
Teachers are also encouraged to use a variety of strategies to facilitate the inquiry process. Selected strategies are highlighted below to help teachers plan and deliver lessons

[4] Inquiry-based approach and hands-on learning are not synonymous. Hands-on learning is any educational experience that actively involves students in handling, manipulating or observing a scientific process to gain knowledge or understanding.

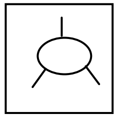
that will engage students in meaningful learning experiences and cultivate their interest and curiosity in science. These strategies can be mixed and matched. A brief description of each of these strategies is also given below:



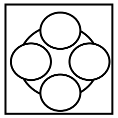
Brainstorming
Brainstorming is a strategy for generating creative ideas and solutions.



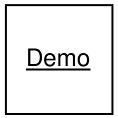
Case Study
The case study approach is a strategy which uses real and hypothetical cases to help students develop critical skills such as analysing, inferring and communicating.



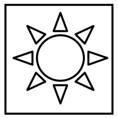
Concept Mapping
Concept mapping is a strategy to present meaningful relationships among concepts. Concept maps are useful in organising and linking concepts or ideas.



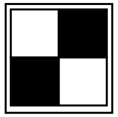
Cooperative Learning
In cooperative learning, activities are structured such that each student assumes certain responsibilities and contributes to the completion of tasks. In working with others, students are exposed to different points of views and solutions in accomplishing a common goal.



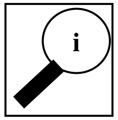
Demonstration
Demonstration is commonly used to scaffold the learning process. This approach is recommended when the learning activity is not safe or too complex for students to set up on their own.



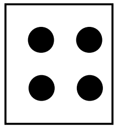
Field Trip
A field trip is any learning activity outside the school. It provides opportunities for students to explore, discover and experience science in everyday life.



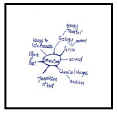
Games
Games engage students in play or simulations for the learning of concepts or skills. This is useful in helping students to visualise or illustrate objects or processes in the real world.



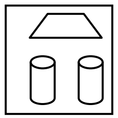
Investigation
In scientific investigation, students engage in activities that mirror how scientists think and what they do in a decision making process, such as asking or posing questions and planning or designing investigations.



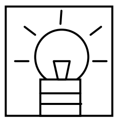
Learning Centres
Learning centres are various stations at which individuals or groups of students carry out selected activities. The activities may be designed to accommodate a variety of learning styles and challenge multiple intelligences.



Mindmapping
A mind map radiates from a central image or key word. The branches connect related concepts and ideas to the central image. Every word and image is itself a potential sub-centre of ideas or concepts. The visual presentation of related information enhances understanding. The association would be to facts as well as relationship between the facts.



Model Building
Model building is an activity in which students design and construct a representation of a concept or object.



Problem Solving
Problem solving engages students in finding solutions to problems by applying scientific knowledge and skills.

Projects
Projects are learning activities that require students to find out about an object, event, process or phenomenon over a few weeks or even months.

Questioning
Questions are useful tools in the scientific inquiry process. Both teachers and students should engage in cycles of questions-answers-questions throughout the learning process.

Role Play, Drama, Dance and Movement
Role play, drama, dance and movement allow students to express their understanding of scientific concepts and processes in a creative way.

Strategies for Active and Independent Learning (SAIL)
The SAIL approach emphasises learning as a formative and developmental process in which instruction and assessment point the way for students to continuously learn and improve. Learning expectations and rubrics are used to describe what students should know and be able to do. This would help students know where they are in the learning process and how they can improve.

Teachers are also encouraged to leverage on the planned learning activities to infuse Information Technology and National Education.

Information Technology (IT)
When used as a tool to support appropriate teaching strategies, IT can enhance the teaching and learning process and lead to engaged learning. For example, teachers can tap on the Internet for alternative resources which can be used to support inquiry-based learning activities. Appropriate IT devices such as datagloggers and other hand-held devices can be used to enhance data collection and speed up data analysis. Abstract concepts in science can also be made more comprehensible with the use of simulations, scenarios and animations.

National Education (NE)
National Education is infused into the curriculum to allow students see how scientific phenomenon and developments can contribute to or affect the nation.

Where appropriate, students should have opportunities to develop attitudes which are relevant to the study of science. Teachers are also encouraged to incorporate the ethical aspect of science wherever possible throughout the syllabus.

Ethics and Attitudes
In scientific inquiry, the adoption of certain mental attitudes such as curiosity, creativity, objectivity, integrity, open-mindedness, Perseverance and Responsibility is advocated. Students can also discuss the ethical implications of science and technology.

What are some features of an inquiry classroom?

An inquiry classroom is visibly different from a traditional classroom in the following ways:

Traditional	Inquiry
Students often work alone	Students often work in groups
Emphasis on mastery of facts	Emphasis on understanding of key concepts
Follows a fixed curriculum closely	Allows for pursuit of student questions
Activities rely mainly on textbooks and workbook materials	Activities rely on primary sources
Students are viewed as "blank slates"	Students are viewed as thinkers with their own theories about the world
Teachers tend to disseminate information to students	Teachers facilitate an interactive learning environment
Teachers tend to seek correct answers	Teachers seek to understand student learning
Assessment tends to be separate from teaching	Assessment is interwoven with teaching

Adapted from *In search of understanding: the case for constructivist classrooms*, Brooks & Brooks (1993).

What are some misconceptions about inquiry-based learning and teaching?

1: *All science subject matter should be taught through student-directed inquiry*.
Whereas student-directed inquiry will provide the best opportunities for cognitive development and scientific reasoning, teacher-guided inquiry can best focus learning on the development of particular science concepts. Thus, students will best benefit from experiences that vary between these two inquiry approaches.

2: *Inquiry cannot be carried out by students effectively as they will not be able to discover anything worthwhile.*
Although it is important that students are provided with opportunities to pursue their own questions and discover some things for themselves, scientists and students often engage in inquiry to solve problems or understand events by reading relevant materials such as science magazines /journals and online scientific literature, and seeking advice from experts in the specific field. They may be engaged in inquiry without actually making their own discoveries.

3: *Inquiry teaching occurs whenever students are provided with hands-on activities*.
Although participation by students in hands-on activities is desirable, it is equally important that they are mentally engaged with scientific reasoning and methods. Research indicates that science process skills are best learnt when used to understand specific scientific content. Understanding content without process or vice versa is insufficient to nurture students as inquirers.

ASSESSING TEACHING AND LEARNING

Assessment is an integral part of the teaching and learning process. It involves gathering information through various assessment techniques and making sound decisions. Assessment provides information to the teacher about students' achievement in relation to the learning objectives. With this information, the teacher makes informed decisions about what should be done to improve teaching methods and enhance the learning of the students.

Why Assess?

Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. While it complements the teaching and learning process, it also provides formative and summative feedback to teachers, students, schools and parents.

- Assessment provides feedback to *students,* allows them to understand their strengths and weaknesses. Through assessment, students can monitor their own performance and progress. It also points them in the direction they should go to improve further.

- Assessment provides feedback to *teachers,* enables them to understand the strengths and weaknesses of their students. It provides information about students' achievement of learning outcomes as well as the effectiveness of their teaching.

- Assessment provides feedback to *schools.* The information gathered facilitates the placement of students in the appropriate stream or course, and the promotion of students from one level to the next. It also allows the schools to review the effectiveness of their instructional programme.

- Assessment provides feedback to *parents,* allows them to monitor their children's progress and achievement through the information obtained.

What to Assess?

The aims of the Lower Secondary Science Normal (Technical) Syllabus deal with the acquisition of knowledge, understanding and application of the science concepts, the ability to use process skills, and the development of attitudes important to the practice of science. The assessment objectives of the syllabus are aligned to the three domains in the *Science Curriculum Framework* as shown below:

i. Assessment of Knowledge, Understanding and Application of Science Concepts
ii. Assessment of Skills and Process
iii. Assessment of Ethics and Attitudes

How to Assess?

Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. As it serves many purposes, it is important to match the type of assessment to the specific purpose for which it is intended. Before making an assessment about a certain aspect of students' performance, the teacher should ensure that the assessment mode used will generate information that reflect accurately the particular aspect of performance the teacher intends to assess.

In an inquiry-based classroom, the assessment can take many forms. In addition to the written tests, teachers can also conduct performance based assessment using the following modes:

- Practicals
- Projects
- Teacher observations
- Checklists
- Reflections / Journals
- Model-making
- Posters
- Games and quizzes
- Debates
- Drama / Show and Tell
- Learning Trails

Teachers can also assess students through the use of portfolio. It is a systematic collection of students' work and provides a comprehensive picture of their achievement. The work collected provides a continuous record of the students' development and progress in the acquisition of knowledge, understanding of scientific concepts, application of process skills, and development of attitudes. It also provides opportunity for the students to have self-evaluation and reflections by revisiting their own portfolio.

The assessment modes listed above are by no means exhaustive. Adopting a variety of assessment modes enables the teachers to assess different aspects of teaching and learning.

Guidelines for Assessment

It is essential for assessment to be aligned to the teaching and learning process. School-based assessment, both formative and summative in nature, should be used to provide a complete picture of the students' performance and progress, and the effectiveness of the teaching and learning process.

SYLLABUS CONTENT

CORE UNIT 1: INTRODUCING SCIENCE AND TECHNOLOGY	OVERVIEW	KEY INQUIRY QUESTIONS
▪ What is science and technology? ▪ Physical quantities and measurement ▪ Energy as a resource	In this unit, students are introduced to the essence of science, its measurement, and the impact of science and technology on society. Another central concept in science that students learn about in this unit is energy. Our life depends a lot on energy as energy is needed to make things work. In doing work, energy is changed from one form into one or more forms. It is recommended that this unit be taught first, as it contains basic concepts that will have to be mastered by students to facilitate learning in other units.	• What is science and how does it work? • Why do we need to measure things? • What are the different forms of energy?

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
What is science and technology? ▪ science is the study of nature and how it affects us and the environment ▪ technology is the application of scientific knowledge	▪ discuss the uses and benefits of science and technology to society	▪ acquire the skills of conducting simple investigations	▪ recognise that the study and practice of science involve three major elements: attitudes, processes or methods, and products ▪ develop an awareness that science is not confined to the laboratory, but is manifested in all aspects of the world ▪ develop sensitivity to the benefits and abuses of the applications of science

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Physical quantities and measurement ▪ A physical quantity is made up of two parts: a number or quantity and a unit ▪ Accurate measurements of physical quantities form the basis of scientific knowledge		▪ use the appropriate units for length, mass and time ▪ interpret and use the appropriate prefixes milli-, centi- or kilo- in relation to the units of length and mass ▪ determine appropriate derived units for area and volume ▪ acquire, during appropriate activities throughout the course, the following skills: - use of common laboratory apparatus correctly with due consideration to safety (especially in relation to heating of solids and liquids) - use of the following measuring instruments: measuring cylinder, metre rule and measuring tape, spring balance, electronic balance, stop clock or stop watch, thermometers, voltmeters, ammeters, multimeters - estimation of and measurement of length, area, volume, mass and time (excluding the volume	▪ value teamwork and individual effort

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
		and mass of gases)	
Energy as a resource ▪ energy is needed to make things work ▪ there are different forms of energy	▪ outline the utilisation of energy in society, e.g. in home, work, industry, leisure and transport ▪ give examples of devices and processes in everyday life which use energy and describe the change in the form of energy	▪ compare the different sources of usable energy viz. biomass, fuel cells, solar energy, fossil fuels (e.g. coal, oil and natural gas), and their limitations	▪ appreciate that fossil fuels are exhaustible and the need and ways to reduce energy wastage ▪ appreciate the importance of conserving energy because Singapore is totally dependent on imported fossil fuels to meet its energy needs

CORE UNIT 2: INVESTIGATING LIFE PROCESSES ▪ Digestion ▪ Reproduction ▪ Other life processes ▪ Abuses to life	**OVERVIEW** In this unit, the study of the human body focuses on the maintenance of good health. Students learn about the major body systems that carry out various life processes, such as digestion, reproduction, breathing, respiration, transport and excretion, and their role in the healthy functioning of the body. Students also learn that unhealthy lifestyles can lead to diseases which prevent the body systems from carrying out life processes. This helps students appreciate how lifestyle choices can affect personal health.	**KEY INQUIRY QUESTIONS** • How does the body keep itself healthy? • What can I do to keep my body healthy?

Topic/ Key Concepts	**Learning Outcomes**		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Digestion ▪ food must be digested before our body can make use of it	▪ explain what is meant by digestion ▪ explain why a digestive system is necessary ▪ describe briefly how the different parts of a digestive system helps in the digestion of food	▪ investigate the role played by enzymes in the digestion of food (names of enzymes are not required) and communicate findings	▪ value science for its usefulness in providing an understanding of everyday phenomena ▪ value teamwork and individual effort
Reproduction ▪ reproduction is an essential life process for the continuity of the human species ▪ lifestyle choices can affect personal health	▪ describe the functions of the various parts of the human male and female reproductive systems ▪ describe briefly the menstrual cycle and fertilisation ▪ show an awareness of some forms of facilitated reproduction in humans, e.g.	▪ interpret and communicate data on the physical changes that occur during puberty and early adolescence ▪ compare a temporary and a permanent method of birth control	▪ appreciate the importance of sample size in obtaining reliable evidence ▪ appreciate the harmful consequences of sexually transmitted infections like syphilis, gonorrhoea and AIDS ▪ appreciate the consequences relating to abortion and pre-

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
	in-vitro fertilisation and artificial insemination		marital sex
Other life processes ▪ the human body systems work together to maintain the health of the individual	▪ describe briefly the following processes: - breathing and respiration - transport - excretion and state their importance in the maintenance of the body ▪ state briefly that malfunctions of vital organs can be caused by various factors (e.g. unhealthy lifestyles, diseases, heredity; unhealthy lifestyles include lack of exercise, lack of sleep and unbalanced diet)		▪ appreciate the ways that technology can remedy malfunctions of vital organs (e.g. drugs, transplants, artificial organs, life support systems) ▪ value teamwork and individual effort
Abuses to life ▪ lifestyle choices can affect personal health	▪ list some drugs and inhalants that are commonly abused ▪ list some harmful substances in tobacco smoke e.g. nicotine, carbon monoxide gas, tar and other cancer-causing substances	▪ investigate how lifestyle choices, i.e. drug abuse, consumption of alcohol and smoking, can affect personal health and communicate findings	▪ appreciate the harmful effects and consequences of drug abuse such as depression, hallucination, addiction and related social problems like crimes and transmission of AIDS ▪ appreciate the possible harmful effects of consumption of alcohol on the individual, his family and society

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
			▪ appreciate the possible harmful effects of smoking or passive smoking on a person's health such as bronchitis, lung cancer and heart disease ▪ appreciate ways to avoid being addicted to drugs, alcohol and smoking

CORE UNIT 3: INVESTIGATING MATTER ▪ Properties of matter ▪ Solids, liquids and gases ▪ Water, solutions and suspensions ▪ Air pollution ▪ Water pollution	**OVERVIEW** This unit presents the common physical properties of matter. Knowledge of properties of matter and its composition helps students understand matter's varied uses, availability, and limitations in our world, such as air and water pollution. Because everyone has experience with matter in a variety of forms, matter is a topic that is amenable for basic exploration and for bringing out students' prior knowledge about the physical world. The most successful way we can explore concepts about matter is therefore through concrete examples, direct experience and simple investigations that students can carry out.	**KEY INQUIRY QUESTIONS** • What is matter? • How can matter be classified? • What impact do humans have on the environment?

Topic/ Key Concepts	**Learning Outcomes**		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Properties of matter ▪ materials can be classified in a variety of ways according to their properties ▪ the physical properties of a material determine how we can make use of it	▪ describe materials in terms of physical properties such as hardness, elasticity, solubility, density, boiling/melting point, electrical and thermal conductivities ▪ relate knowledge of the properties of materials to their everyday use	▪ compare materials in terms of their physical properties ▪ classify materials into different groups (e.g. metals and non-metals; ceramics, plastics and fibres)	▪ appreciate the need to organise scientific knowledge in a systematic manner
Solids, liquids and gases	▪ distinguish between the three states of matter in terms of	▪ observe and record the changes that take place when	▪ appreciate the need to organise scientific knowledge

Topic/ Key Concepts	Learning Outcomes Knowledge, Understanding and Application	 Skills and Processes	 Ethics and Attitudes
▪ matter can exist in three states	properties, e.g. density, compressibility, maintenance of shape and volume	matter is heated/cooled	in a systematic manner
Water, solutions and suspensions ▪ to make a solution, we need a solute and a solvent ▪ solvents and solutions are useful substances	▪ explain what is meant by the terms solute, solvent and solution ▪ recognise that water dissolves many substances ▪ give examples of uses of solvents and solutions in the home, industry and medicine	▪ deduce the nature of solutions and suspensions by simple laboratory test (e.g. passing a beam of light, filtering using filter paper) ▪ investigate the factors that affect the solubility of materials (e.g. type of solute/solvent, temperature) and communicate findings ▪ investigate the factors that affect the rate of dissolving (e.g. temperature, surface area, stirring) and communicate findings	▪ appreciate that science and technology have contributed to the development of a variety of products that we depend on and use each day
Air pollution ▪ air pollution harms both plants and animals ▪ air pollution can be prevented or reduced	▪ state the names and sources of common air pollutants (carbon monoxide, sulphur dioxide and oxides of nitrogen) ▪ list the possible harmful effects of air pollutants introduced into the atmosphere through human activities (acid rain, greenhouse effect and smoke haze from	▪ investigate the effects of acid rain on the environment and communicate findings	▪ appreciate that air is an important type of matter that can be polluted as a result of Man's activities ▪ appreciate that clean air is important for Singapore to be a good home to four million people who have to live, work and play in the same small

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
	forest fires) ▪ discuss some ways to reduce air pollution		space
Water pollution ▪ fresh water is limited in supply and can be depleted or polluted, becoming unavailable or unsuitable for life ▪ water pollution can be prevented or reduced	▪ state common types and sources of water pollution ▪ discuss some methods of water pollution control ▪ state that used water can be converted into drinkable water, e.g. NEWater	▪ investigate the effects of water pollution on living things and communicate findings	▪ appreciate that water is an important type of matter that can be polluted as a result of Man's activities ▪ appreciate that controlling water pollution is essential if Singapore is to have a clean supply of water in the future ▪ value teamwork and individual effort

CORE UNIT 4: INVESTIGATING FORCES ▪ Force ▪ Machines	**OVERVIEW** In this unit, students learn about forces and their effects. There are many forces acting around us. (Forces are generally classified as a push or a pull; some common forces around us are gravitational, frictional and magnetic forces.) Forces are needed for objects to start moving and stop moving, to move faster or slower, and to change the direction of motion. We cannot see forces but we can see and feel the effects of forces. Students then increase their understanding of forces by studying simple machines. Emphasis is placed on investigating a variety of simple machines and recognising that simple machines are examples of technologies that help humans make work easier, thereby developing positive attitudes towards technology uses that increase productivity.	**KEY INQUIRY QUESTIONS** ▪ What are the effects of a force? ▪ How can machines help us make work easier?

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Force ▪ a force can be a push or a pull ▪ a force can change the shape, size, state of rest, and motion of a body	▪ give examples of different forces: pushing, lifting, stretching, twisting, pressing, gravitational, frictional and magnetic forces ▪ use newton as the unit of force	▪ infer the effects of forces such as: - change in state of rest or motion of a body - change in size and/or shape of a body ▪ predict changes in movement of a body as a result of the application of two or more forces in a straight line ▪ use a forcemeter or spring balance to measure force	▪ value science for its usefulness in providing an understanding of everyday phenomena

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<tr><th rowspan="2">Topic/
Key Concepts</th><th colspan="3">Learning Outcomes</th></tr>
<tr><th>Knowledge, Understanding and Application</th><th>Skills and Processes</th><th>Ethics and Attitudes</th></tr>
<tr><td>Machines
▪ simple machines make work easier</td><td>▪ list the advantages of using simple machines (levers, inclined planes, pulleys, wheel and axle, and gears) and give everyday examples of their use</td><td>▪ investigate the effort used when the following is used to raise a load and communicate findings:
- lever
- inclined plane
- pulley
▪ investigate how the following works to make objects move and communicate findings:
- wheel and axle
- gears</td><td>▪ appreciate that technology develops in response to human needs and wants
▪ value teamwork and individual effort</td></tr>
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CORE UNIT 5: INVESTIGATING ELECTRICITY	**OVERVIEW**	**KEY INQUIRY QUESTIONS**
▪ What is electricity? ▪ Currents and circuits ▪ Sources of electricity ▪ Conductors and insulators ▪ Electrical safety	Electricity is one of the most useful forms of energy. It is very important in our daily life. Our homes have many appliances that use electricity. However, electricity can be very dangerous if it is not used properly. We cannot see electricity but we know it is present from the work that it does. In this unit, students explore current electricity, investigate series and parallel circuits, and make connections to daily life. In the process, students appreciate the importance of electricity in everyday life, recognise the importance of energy conservation, and understand the need for safe practices when using electricity.	▪ How is electricity helpful and harmful? ▪ How many different ways can we make a circuit to light a bulb? ▪ What safety features are designed into electric circuits?

Topic/ Key Concepts	**Learning Outcomes**		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
What is electricity? ▪ electricity is a useful form of energy that should not be wasted	▪ describe electricity as a useful form of energy in our life ▪ state the importance of reducing electrical energy wastage		▪ appreciate the importance of conserving energy because Singapore is totally dependent on imported fossil fuels to meet its energy needs ▪ value teamwork and individual effort
Currents and circuits ▪ electrical components can be connected in	▪ explain what is meant by current, voltage and resistance and state their units ▪ identify series and parallel circuits	▪ use voltmeter/ ammeter/multimeter for electrical measurements ▪ draw and interpret circuit diagrams and set up circuits	▪ value science for its usefulness in providing an understanding of everyday phenomena

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
series or parallel circuits	▪ explain why parallel circuits are widely used in household while series circuits are not	comprising electrical sources (cell and battery), switches, lamps, resistors (fixed), ammeters and voltmeters ▪ compare different types of lamps/bulbs and their energy consumption	
Sources of electricity ▪ electricity is generated at power stations ▪ batteries are portable sources of electricity	▪ outline the process from the production of electricity to using it in our home with reference to the energy conversions that take place ▪ state the importance of batteries as a source of electricity, giving some examples of their use		▪ appreciate the importance of conserving energy because Singapore is totally dependent on imported fossil fuels to meet its energy needs
Conductors and insulators ▪ both conductors and insulators are usually present in electrical appliances	▪ relate the conducting properties of materials to their use in the various parts of electrical appliances/circuits	▪ investigate to classify a variety of materials as insulators or conductors and communicate findings	▪ appreciate the need to organise scientific knowledge in a systematic manner

Topic/ Key Concepts	Learning Outcomes		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Electrical safety ▪ it is always important to observe electrical safety precautions when using electricity	▪ state the hazards of: - damaged insulation - overloaded circuit - damp conditions ▪ identify a fuse and its rating ▪ state how a fuse works and the effect or danger of using one of incorrect rating ▪ identify a circuit breaker and state its function ▪ list some precautionary measures to ensure the safe use of electricity		▪ appreciate the importance of observing electrical safety precautions when using electricity

CORE UNIT 6: INVESTIGATING HEAT ▪ Temperature and thermometer ▪ Heating and cooling matter	**OVERVIEW** Heat is very important to life. Heat is a form of energy. When energy transformation takes place, it usually involves the gain or loss of heat. In fact, other forms of energy can be converted into heat energy. Interactions between energy and matter account for changes observed in everyday events. Understanding how heat energy and matter interact helps students understand a wide variety of physical changes.	**KEY INQUIRY QUESTIONS** ▪ What is temperature and how is it measured? ▪ How does heat change matter?

Topic/ Key Concepts	**Learning Outcomes**		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Temperature and thermometer ▪ temperature is a measure of how hot or how cold an object is ▪ a thermometer is used to measure temperature accurately	▪ explain what temperature is ▪ show an awareness that there are other types of thermometers, e.g. digital thermometer, temperature sensor	▪ use liquid-in-glass laboratory and clinical thermometers (Six's thermometer is excluded)	
Heating and cooling matter ▪ heat is a form of energy ▪ solids, liquids and gases expand when	▪ explain that heat is a form of energy, giving some examples of the sources and the energy conversions that take place ▪ state the importance of heat energy in our life ▪ describe some common	▪ infer that generally, solids, liquids and gases expand when heated and contract when cooled ▪ infer that a change of state is brought about by adding or removing heat energy without any change in temperature	▪ value science for its usefulness in providing an understanding of everyday phenomena

Topic/ Key Concepts	**Learning Outcomes**		
	Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
heated and contract when cooled	situations and applications to illustrate when too much heat is undesirable and how the excess heat is removed ▪ recognise that when the temperature of a substance increases, the substance has absorbed heat; when the temperature of a substance decreases, the substance has lost heat ▪ describe some everyday examples/applications involving the removal/addition of heat energy in the change of state ▪ describe some consequences and applications of expansion and contraction in everyday life		

GLOSSARY OF TERMS

S/No	Term	Description of term
1.	appreciate	to recognise the value of a concept or situation
2.	describe	to state in words (using diagrams where appropriate) the main points of a topic
3.	discuss	to give a critical account of the points involved in the topics
4.	distinguish	to identify and understand the differences between objects, concepts and processes
5.	explain	to give reasons or make some reference to theory
6.	identify	to select and/or name the object, event, concept or process
7.	investigate	to find out by carrying out experiments
8.	list	to give a number of points or items without elaboration
9.	outline	to give the main or essential points of the concepts, processes
10.	recognise	to identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon
11.	relate	to identify and explain the relationships between objects, concepts or processes
12.	show an awareness	to have superficial knowledge of the concepts or processes
13.	show an understanding	to recall, explain and apply information
14.	state	to give a concise answer with little or no supporting argument
15.	suggest	to provide ideas to a problem or a situation, or apply knowledge to a 'novel' situation (there is no unique answer)

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