SCIENCE
SYLLABUS
Lower Secondary
Normal (Technical) Course

Implementation starting with
2021 Secondary One Cohort

Ministry of Education
SINGAPORE

PREAMBLE

The Lower Secondary Science Normal (Technical) Syllabus is based on the ***Science Curriculum Framework***. The syllabus is for a two-year course that is designed to provide students with an understanding of the natural and physical world around them and to equip them with a basic level of scientific knowledge and practices. Together with embedded values and ethics, the syllabus guides students to apply scientific knowledge and practices to make informed decisions and take responsible actions in their everyday lives. It is also a foundation for the learning of science at Upper Secondary levels.

When implementing the syllabus, teachers are encouraged to emphasise the development of students' 21st Century Competencies (21CC) and draw on the components of the Singapore Teaching Practice (STP) – namely the Singapore Curriculum Philosophy, Knowledge Bases and Pedagogical Practices. Bearing in mind the learning needs of their students, teachers can employ appropriate Teaching Areas from the STP, draw reference from the Teaching in Educational Support (TiES) professional development package and various sources to make learning of science meaningful and engaging to their students. Teachers are encouraged to use Information and Communications Technology (ICT), for both pedagogical and assessment purposes, to enrich and deepen students' learning.

CONTENTS

SECTION 1: INTRODUCTION

Science Curriculum Framework
21st Century Competencies Framework

1. INTRODUCTION

1.1 Science Curriculum Framework

The *Science Curriculum Framework* (see **Figure 1**) encapsulates the thrust of Science education in Singapore to provide students with strong fundamentals in Science for life, learning, citizenry and work.

The tagline **Science for Life and Society** at the core of the curriculum framework captures the essence of the goals of Science education.

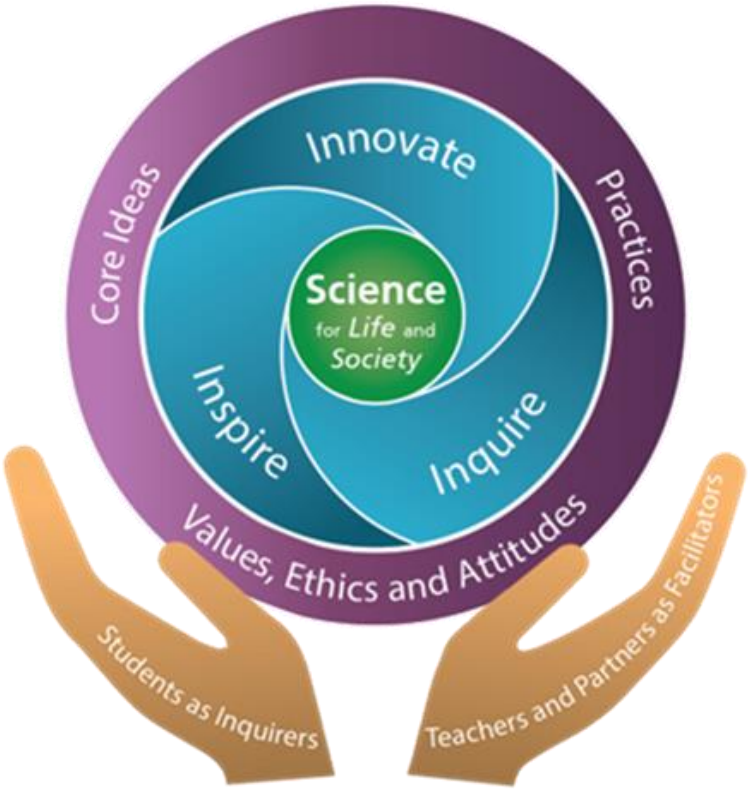

Figure 1: *Science Curriculum Framework*

Our Science students are diverse, with different needs, interests and aptitudes for Science. Given the diversity of our Science students and the needs of Singapore, the twin goals of Science education are to:

- Enthuse and nurture all students to be scientifically literate, so that they are able to make informed decisions and take responsible actions in their daily lives; and

- Provide strong Science fundamentals for students to innovate and pursue STEM for future learning and work.

Surrounding the core of the framework are the 3 **In**s, *Inspire*, *Inquire* and *Innovate,* which articulates the vision of Science education. It encapsulates the desired overall experience of our students in Science education:

- Inspired by Science. Students enjoy learning Science, and are fascinated by how everyday phenomena have scientific connections and how Science helps solve many of our global challenges. They regard Science as relevant and meaningful, and appreciate how Science and Technology have transformed the world and improved our lives. Students are open to the possibility of pursuing Science-related careers to serve the good of society.

- Inquire like Scientists. Students have strong fundamentals in Science, and possess the spirit of scientific inquiry. They are able to engage confidently in the *Practices of Science* grounded in the knowledge, issues and questions that relate to the roles played by Science in daily life, society and the environment. They can discern, weigh alternatives and evaluate claims and ideas critically, based on logical scientific evidence and arguments, and yet are able to suspend judgement where there is lack of evidence.

- Innovate using Science. Students apply Science to generate creative solutions to solve real-world problems, ranging from those affecting everyday lives to complex problems affecting humanity. It is envisaged that there will be a strong pipeline of students who can contribute towards STEM research, innovation and enterprise.

The outer ring represents the domains that make up the strong Science fundamentals: Core Ideas of Science, *Practices of Science*, and *Values, Ethics and Attitudes* in Science.

- *Core Ideas* (CI) of Science. To make Science learning coherent and meaningful, the Science curriculum is organised around *Core Ideas*, which are the distilled ideas central to Science. The *Core Ideas* help students see the coherence and conceptual links *within* and *across* the different sub-disciplines of Science (i.e. Biology, Chemistry and Physics). The *Core Ideas* also provide a framework to make visible students' progression in Science understanding across the different levels of education. Teachers will be able to pitch their lessons according to the students' stage of readiness to help them gradually develop understanding of Science concepts with increasing complexity.

- *Practices of Science* (POS). The *Practices* consist of three components:
  (a) Demonstrating *Ways of Thinking and Doing* in Science (WOTD);
  (b) Understanding the Nature of Scientific Knowledge (NOS); and
  (c) Relating Science, Technology, Society and Environment (STSE).

  They represent the set of established procedures and practices associated with scientific inquiry, what scientific knowledge is and how it is generated and established, and how Science is applied in society respectively. The *Practices* serve to highlight that the discipline of Science is more than the acquisition of a *body of knowledge* (e.g.

scientific facts, concepts, laws, and theories); it is also a *way of thinking and doing*[1]. In particular, it is important to appreciate that the three components representing the cognitive, epistemic and social aspects of the *Practices* are intricately related. For example, observation of events can lead to the generation of scientific knowledge which is, simultaneously, shaped by the beliefs about scientific knowledge. In addition, scientists develop models to construct theories, based on the assumption that there is order and consistency in natural systems. The practice of theory-making, in turn, reinforces the explanatory power of scientific knowledge. The scientific endeavour is embedded in the wider ethical, social, economic and environmental contexts.

- *Values, Ethics and Attitudes* (VEA) in Science. Although Science uses objective methods to arrive at evidence-based conclusions, it is in fact a human enterprise conducted in particular social contexts which involves consideration of values and ethics. The intent of fostering an awareness and appreciation of these values in the curriculum is to sensitise our students to the ethical implications of the application of Science in society. The challenges that humanity will face in the upcoming centuries will not be overcome by scientific and technological solutions alone. There is a need to consider the impact of these solutions in terms of their benefits to humanity and the ethical issues involved. Thus, Science education needs to equip students with the ability to articulate their ethical stance as they participate in discussions about socio-scientific issues that involve ethical dilemmas, with no single right answer.

The pair of hands in the *Science Curriculum Framework* represents the roles of students *as inquirers* in their learning and pursuit of Science, supported by *teachers and partners as facilitators* of the students' learning experiences, to impart the excitement and value of Science to the students. The partnership of learning and teaching goes beyond the students and teachers to include other partners who can facilitate learning in various contexts to help fuel students' sense of inquiry and innovation, to inspire them and to help them appreciate the application of Science in their daily lives, society and the environment.

[1] Ways of Thinking, Ways of Doing (2012). Stanford University. Retrieved from: https://stanford.app.box.com/s/2448dpj26j4c7buzansz.

1.2 21st Century Competencies Framework

The *Framework for 21st Century Competencies and Student Outcomes* (see **Figure 2**) helps guide us to prepare our students to be confident people, self-directed learners, concerned citizens and active contributors – attributes we strive to develop in students to thrive in and contribute to a fast-changing and globalised world of the 21st century.

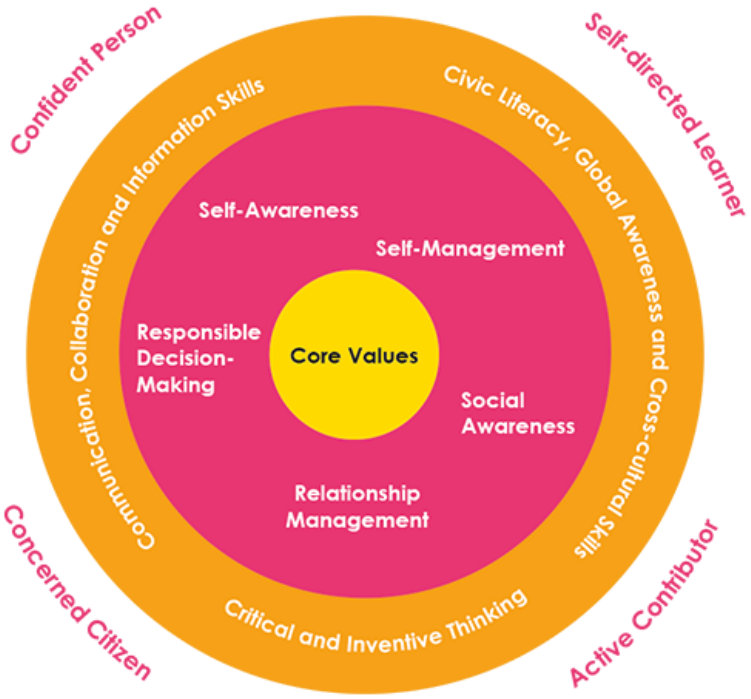

Figure 2: Framework for 21st Century Competencies and Student Outcomes

This framework identifies the core values, social and emotional competencies, as well as competencies necessary for the globalised world we live in. In totality, these are referred to as 21st Century Competencies (21CC).

<u>Supporting the Development of 21CC through Science</u>

Science education plays an important role in helping our students understand and address many of the local and global challenges we face in the 21st century. These challenges include climate change, depletion of natural resources, disruptive innovations in technology (e.g. artificial intelligence), and feeding an increasing population. To navigate these challenges, we need to develop scientifically literate citizens who

- possess mind-sets and practical knowledge of Science and its applications to make informed decisions and responsible actions in their daily lives.

- appreciate Science as humanity's intellectual and cultural heritage, the beauty and power of its ideas, as well as participate in socio-scientific issues ethically and in an informed manner.

- are able to apply scientific knowledge and skills, as well as adopt scientific attitudes and mind-sets to innovate and push new frontiers.

In this respect, the development of scientific literacy supports MOE's efforts on the development of students' 21CC. As discussed in **Section 1.1**, the development of scientific literacy is necessary to equip students with strong Science fundamentals in the three domains of *Core Ideas*, *Practices* and *Values, Ethics and Attitudes*. The subsequent paragraphs illustrate ideas on how 21CC can be developed through the Science curriculum.

Civic Literacy, Global Awareness and Cross-Cultural Skills

For students to actively contribute to the community and nation, and develop an awareness of and the ability to analyse global issues and trends, they could be given opportunities to

- explore how Science and Technology contribute to society, in Singapore and globally, (e.g. how applications of new scientific discoveries inspire technological advancements) and motivate scientists to ask new questions in their inquiry.

- participate in ethical discussions that require them to be open-minded when weighing multiple perspectives and develop in them a sense of responsibility for the environment.

Critical and Inventive Thinking

For students to generate novel ideas to address issues and solve problems, exercise sound reasoning, use metacognition to make good decisions, and manage complexities and ambiguities, they could be given opportunities to

- engage in the process of inquiry. Students could raise divergent questions about the natural world, develop multiple ways to observe and collect evidence, and explore more than one explanation from their evidence. At the same time, students should exercise healthy scepticism in questioning the assumptions and uncertainties in their evidence and evaluate how these assumptions could influence their explanations.

- recognise that Science is an evidence-based, model-building enterprise to understand the natural world through exploring how and why scientific models evolve over time in light of new evidence.

Communication, Collaboration and Information Skills

For students to be able to communicate information and ideas clearly, collaborate effectively and manage information thoughtfully and responsibly, they could be given opportunities to

- communicate their ideas clearly and persuasively using the language of Science. Students could engage in activities that allow them to express their appreciation for the need and importance of having scientific standards and terminology.

- understand how Science is presented in various forms (e.g. oral, written, visual) and media (e.g. print media, social media) and evaluate the effect these forms of communication have on the audience (e.g. identifying false statements of fact).

- collaborate with other students in knowledge construction. Students should present their work and ideas to others, and have healthy discussions and critique. Through collaborative discussions, students could develop social awareness as they are required to discern different perspectives, recognise and appreciate diversity, and empathise with and respect others.

SECTION 2: CONTENT

Aims of Lower Secondary Science Normal (Technical) Syllabus
Syllabus Framework
Guide to the Syllabus
Syllabus Content

2. CONTENT

2.1 Aims of Lower Secondary Science Normal (Technical) Syllabus

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

(i) develop 21st century competencies in students which would enable them to
- apply critical and inventive thinking to identify and solve problems;
- communicate and collaborate with others effectively; and
- show care and concern for people and the environment.

(ii) guide students in acquiring knowledge, skills and values for application in their daily lives such that they
- are motivated to learn Science through contextualised and hands-on learning;
- become confident citizens who are able to make sound decisions tapping on Science and Technology;
- develop safe and ethical practices; and
- understand the use of ICT and appropriate tools for scientific inquiry and analysis of issues.

(iii) prepare students for future learning and work such that they
- become lifelong and motivated learners; and
- develop skills which are useful and relevant for them to be contributing citizens.

2.2 Syllabus Framework

Our fraternity believes that every child wants to and can learn. When children find meaning in learning, they are motivated to take ownership of their own learning. Based on this set of beliefs, the Lower Secondary Normal (Technical) Science syllabus is structured into an introductory topic on *Laboratory Measurements and Procedures* and three modules, namely *Machines Around Us (I)*, *Our Environment*, and *Our Body and Health (I),* that are situated in authentic contexts students can relate to. The contexts draw students into asking questions and seeking knowledge that can help them gain a deeper understanding of the content in each module.

The content in each of the modules is anchored on key inquiry questions. These questions provide an overarching frame to guide instruction and learning of the content. Teachers could use the key inquiry questions as a starting base to delve further into a series of related questions, to facilitate students' understanding of the interconnections of the scientific concepts. **Table 1** provides the key inquiry questions of each module.

Table 1: Key inquiry questions for all topics and modules

Topic/ Module	**Key Inquiry Question**
Laboratory Measurements and Procedures	Why is it important to observe laboratory safety guidelines? Why is measurement important?
Machines Around Us (I)	How do we use forces and energy conversions to make our lives better? Why is it important to reduce energy wastage? How does electricity work and how can we use it safely? How do the effects of heat affect our lives?
Our Environment	How can matter be classified? What impact do our activities have on the environment?
Our Body and Health (I)	What are the basic building blocks of living things? How do we get the energy from food to live, work and play? How do we reproduce? How can we take good care of our body?

Table 2 provides an overview of the syllabus content.

Table 2: Overview of syllabus content

Laboratory Measurements and Procedures			
Module	**Machines Around Us (I)**	**Our Environment**	**Our Body and Health (I)**
Topic	• Force • Energy • Electricity • Heat	• Matter • Water Pollution • Air Pollution	• Cells • Getting Energy and Nutrients from Food • Human Reproduction • Taking Good Care of My Body

The teaching and learning of the topics within a module should be viewed as interlinked and not as compartmentalised blocks of knowledge.

2.2.1 Core Ideas of Science

Core Ideas allow students to appreciate the interconnections of scientific concepts across topics, making Science more meaningful for students.

In the syllabus, students would have the opportunity to appreciate the following eight *Core Ideas* (see **Figure 3**).

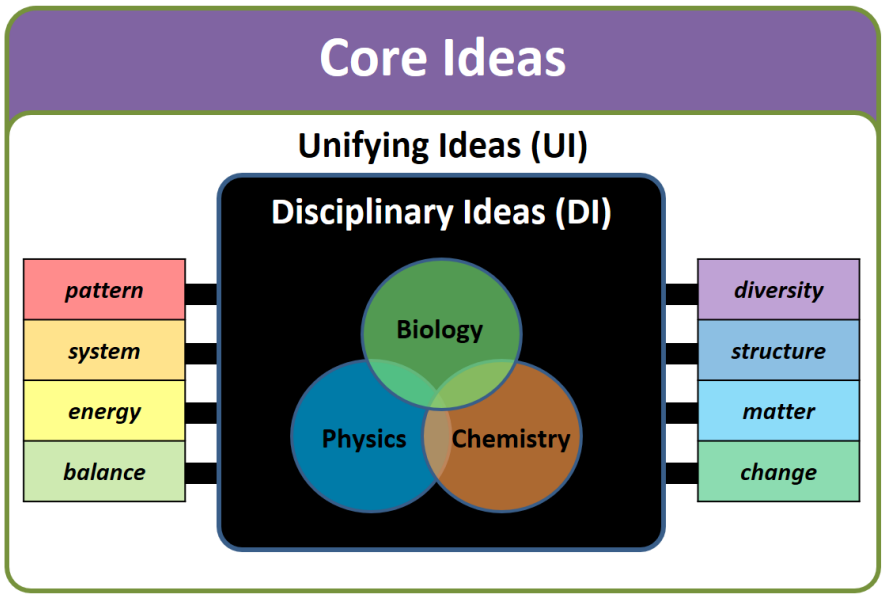

Figure 3: Core Ideas in the Science Curriculum Framework

2.2.2 Practices of Science

Teachers are encouraged to provide opportunities (e.g. hands-on activities, case studies) for students to develop *Practices of Science* (see **Figure 4**). It is important to appreciate that the three components of the *Practices* are related.

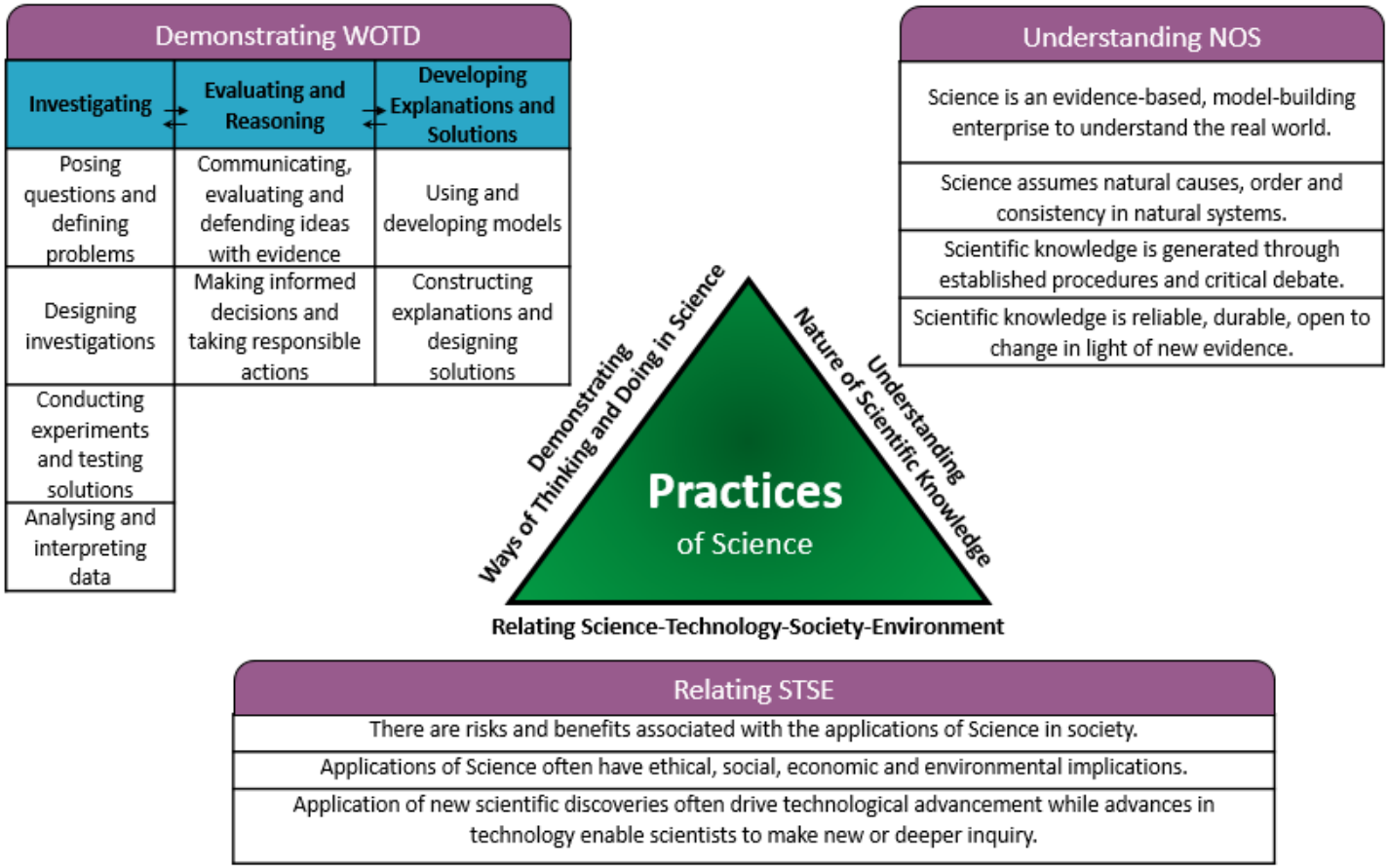

Figure 4: Practices of Science

In the N(T) Science classroom, students should be actively engaged in hands-on activities and 'making' projects which require them to work on real-world problems.

2.2.3 Values, Ethics and Attitudes

In learning Science, the adoption of certain values, ethics and attitudes such as curiosity, creativity, integrity, objectivity, open-mindedness, resilience, responsibility and healthy scepticism is advocated. **Table 3** gives a description of each of the value, ethic and attitude.

Table 3: Values, Ethics and Attitudes in Science

Values, Ethics and Attitudes	**Description**
Curiosity	Desiring to explore the environment and question what is found.
Creativity	Seeking innovative and relevant ways to solve problems.
Integrity	Handling and communicating data and information with complete honesty.
Objectivity	Seeking data and information to validate observations and explanations without bias.
Open-mindedness	Accepting all knowledge as tentative and suspending judgment. Tolerance for ambiguity. Willingness to change views if the evidence is convincing.
Resilience	Not giving up on the pursuit for answers/solutions. Willingness to take risks and embrace failure as part of the learning process.
Responsibility	Showing care and concern for living things and awareness of our responsibility for the quality of the environment.
Healthy Scepticism	Questioning the observations, methods, processes and data, as well as trying to review one's own ideas.

The use of authentic and familiar contexts in the syllabus allow students to have discussions on social and ethical issues grounded in scientific knowledge.

2.3 Guide to the Syllabus

This section provides brief descriptions of the features of the syllabus found in **Section 2.4**.

Module 1
MACHINES AROUND US (I)

Overview

Machines around us help to make our lives easier. For example, we use an inclined plane, which is a simple machine, to reduce the amount of force required to push a luggage or a wheelchair.

When machines are used, energy conversions usually occur. Many machines operate on electricity. It is important for us to understand how various sources of energy can be tapped to generate electricity for machines to run and how we can use electricity safely. Some of the electrical energy supplied to machines may generate heat. The effects due to the heat may be positive or negative to us.

As machines play an important role in our lives, it is important to understand how and why they work, and appreciate the importance of reducing energy wastage, especially in Singapore.

Key Inquiry Questions

- How do we use forces and energy conversions to make our lives better?
- Why is it important to reduce energy wastage?
- How does electricity work and how can we use it safely?
- How do the effects of heat affect our lives?

Overview

Describe the "why" behind studying the module. The narrative facilitates students' appreciation of why studying the module is relevant and important, and how through the learning, students will be able to make informed decisions and take responsible actions in their daily lives. It also highlights the interconnections between the topics in the module.

Key Inquiry Questions

Frame the study of the context and key concepts covered in the module. The use of these questions serves to facilitate the inquiry process in the teaching and learning of the topics in the module. It allows students to be inspired and to inquire about Science in their daily lives.

Topic Description
Highlight some key concepts and Key Inquiry Questions

1. LABORATORY MEASUREMENTS AND PROCEDURES

Topic Description

Scientific investigation is an integral part of learning science. To ensure the safety of ourselves and others working in the science laboratory, we must always observe the safety guidelines and learn the correct techniques of handling laboratory apparatus and instruments.

Measurements provide objective evidence for scientific investigation. They are also important for our daily lives. For example, we should take the correct volume of liquid medicine prescribed by our doctors when we are unwell.

Appropriate instruments should be used to take measurements of the physical quantities. However, there are some instances where an estimation of the quantity is sufficient for the intended purpose. To facilitate communication of quantities, both measurement and estimation should be recorded with appropriate units.

Key Inquiry Questions

- Why is it important to observe laboratory safety guidelines?
- Why is measurement important?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) appreciate the importance of observing safety guidelines when working in the science laboratory
(b) show responsibility for the safety of oneself and others working in the science laboratory by observing the safety guidelines
(c) identify the hazard symbol for the following hazards: corrosive, flammable, irritant, and toxic to environment
(d) use Bunsen burner safely and correctly in experiments
(e) measure length, mass, temperature, time interval and volume of liquids/solids using appropriate instruments such as ruler, measuring tape, electronic balance, laboratory thermometer, digital stopwatch and measuring cylinder
(f) record measurements of length, mass, temperature, time and volume using appropriate units
(g) estimate length between 1 mm and 1 m
(h) appreciate the importance of measurements in our daily lives and for scientific investigations
(i) recognise that different instruments are used to measure different physical quantities

2.4 Syllabus Content

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As machines play an important role in our lives, it is important to understand how and why they work, and appreciate the importance of reducing energy wastage, especially in Singapore.

Key Inquiry Questions

- How do we use forces and energy conversions to make our lives better?
- Why is it important to reduce energy wastage?
- How does electricity work and how can we use it safely?
- How do the effects of heat affect our lives?

2. FORCE

Topic Description

A force is a push or a pull. There are different types of forces, such as frictional and gravitational force. Although forces cannot be seen, many of their effects are observed in our daily lives. For example, a box moving down a rough inclined plane experiences frictional force, and slows down. Hence, the box may change its state of motion when a force is exerted on it.

Our understanding of forces has enabled us to use machines to make our lives better. For instance, we can use a small force to lift a heavy load with the help of simple machines (e.g. lever).

Key Inquiry Question

- How do we use forces to make our lives better?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) identify the following actions of forces: lifting, pressing, stretching and twisting (b) identify and give examples of the following types of forces: elastic force, frictional force, gravitational force and magnetic force (c) state that the weight of an object is the gravitational force acting on the object (d) use newton as the unit of force (e) use spring balance to measure force (f) investigate and describe the following effects of force: (i) change in shape and/or size of an object (ii) change the state of rest or motion of an object (including change in speed and/or direction) (g) show an understanding of how frictional force depends on the texture of the two surfaces in contact and on the size of the forces exerted on the two surfaces (h) describe the effects of frictional force on an object (i) identify and give everyday examples of the following types of simple machines: inclined plane, lever (classes of lever are not required) and pulley (j) investigate how simple machines (inclined plane, lever and pulley) can make lifting a load easier (k) appreciate science for its usefulness in improving quality of life: knowledge of forces helps us understand how machines work

3. ENERGY

Topic Description

Energy is the ability to do work and it takes different forms. When machines are in use, energy may change from one form to another. For example, a bus converts potential energy of diesel to kinetic, heat and sound energy.

As energy cannot be created, we need to tap on various sources of energy to power our machines. Fossil fuel is currently a common primary energy source. However, it will be depleted one day and burning of fuels produces carbon dioxide, which may contribute to global warming. Thus, we should reduce energy wastage and explore renewable sources of energy.

Key Inquiry Questions

- How do we use energy conversions to make our lives better?
- Why is it important to reduce energy wastage?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) identify and give everyday examples of the following forms of energy: electrical energy, heat energy, kinetic energy, light energy, potential energy (specific terms, such as gravitational potential energy, are not required) and sound energy
(b) state that energy cannot be created or destroyed and can be converted from one form to another
(c) describe energy conversions in everyday situations
(d) name fossil fuels (coal, crude oil and natural gas) as non-renewable sources of energy
(e) name biomass, hydropower, sun and wind as renewable sources of energy
(f) state advantages and disadvantages of using non-renewable sources of energy (coal, crude oil and natural gas) and renewable sources of energy (biomass, hydropower, sun and wind)
(g) state that carbon dioxide is a greenhouse gas and may contribute to global warming
(h) recognise ways and appreciate the need to reduce energy wastage
(i) show care and concern for the environment by reducing energy wastage in daily life
(j) appreciate science for its usefulness in improving quality of life: knowledge of energy helps us understand how machines work

4. ELECTRICITY

Topic Description

Electricity can be used to perform many tasks in our daily lives. Many machines are designed to convert electrical energy to other forms of energy to make our lives better. To explain how electrical systems work, we need to recognise that the flow of electric charges, which have electrical energy, results in a current and that the size of the current is affected by the arrangement of components in the circuit.

Electricity is usually generated at power stations and transmitted over long distances to our machines. As the voltage of the mains supply is high, improper use of electricity can pose danger to our lives. It is hence important to take precautionary measures and use safety features to avoid the hazards of using electricity.

Key Inquiry Question

- How does electricity work and how can we use it safely?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) describe electrical energy as a useful form of energy in our daily lives (b) state that the flow of electrical charges in a closed circuit gives rise to a current (c) state that voltage is required for current (d) state that resistance opposes current (e) use the following units for electrical quantities: (i) ampere for current (ii) volt for voltage (iii) ohm for resistance (f) identify series and parallel circuits (g) use ammeter to measure current and voltmeter to measure voltage (h) draw and interpret circuit diagrams, and set up circuits, with power sources (cell or battery), switches, lamps, fixed resistors, ammeters and voltmeters (i) investigate how the number of cells (arranged in series) and the number of lamps (arranged in series/parallel) affect the current in a circuit (j) describe the generation and transmission of electricity with reference to the energy conversions that take place in power stations (k) state that voltage supplied to homes in Singapore is 230 V (l) state the hazards of using electricity and precautionary measures in the following situations: (i) damaged insulation

(ii) damp conditions
(iii) overloaded circuits
(iv) using appliances with voltage ratings lower than the voltage of mains supply

(m) name the following safety features in our household electrical systems: circuit breakers, fuses and earth wire
(n) explain the use of circuit breakers and fuses in electrical circuits
(o) describe the wiring in a mains plug (live, neutral and earth wires)
(p) show care and concern for the safety of oneself and others by avoiding hazards of using electricity
(q) show care and concern for the environment by using electricity responsibly to reduce wastage
(r) appreciate science for its usefulness in improving quality of life: knowledge of electricity helps us power machines

5. HEAT

Topic Description

Heat and its effects are often encountered in our daily lives. Some of the energy supplied to machines (e.g. electric kettle) is usually converted to heat, which flows from the hotter region (e.g. heating element of the kettle) to the colder region of the machine (e.g. outer casing of the kettle). As a result, the colder region gains heat, becomes hotter and expands while the hotter region loses heat, becomes colder and contracts. Depending on the types of machines, these changes due to the flow of heat energy might be useful or undesirable to us. It is hence important to consider heat and its effects when using machines to ensure our safety, and when designing machines to ensure they function effectively.

Key Inquiry Question

- How do the effects of heat affect our lives?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) show an understanding that temperature is a measure of the degree of hotness of an object
(b) use laboratory thermometer or data logger with temperature sensor to measure temperature
(c) show an understanding that heat is a form of energy that flows from a region of higher temperature to a region of lower temperature until both regions reach the same temperature
(d) relate the change in temperature of an object to heat gain/loss by the object
(e) describe some everyday effects and applications of expansion and contraction (e.g. buckling of railway track, use of bimetallic strip in a thermostat - details of the construction and operation of a thermostat are not required)
(f) state that the function of a thermostat is to maintain temperature
(g) describe the importance of heat in our daily lives
(h) appreciate science for its usefulness in improving quality of life: knowledge of heat helps us tap on its usefulness and reduce its harmful effects

Module 2
OUR ENVIRONMENT

Overview

In our daily lives, we interact with our environment, which includes matter (e.g. mixtures) that we use, the water that we drink and the air that we breathe. Knowing the properties of matter has many uses. For example, the knowledge that oil is less dense than water helps us decide what to do during oil spills; knowing the acidity of rain can inform us of the air quality.

Water and air are important matter in our environment. Without clean water and air, our survival will be threatened. We should therefore consider the effects of water and air pollution on the environment and our health. To reduce pollution, we will need to know the sources of pollution and how we can play a part to have clean water and air.

Key Inquiry Questions

- How can matter be classified?
- What impact do our activities have on the environment?

6. MATTER

Topic Description

Matter is anything that has mass and occupies space. Matter can be described according to their properties, such as density, acidity/alkalinity and solubility. The different properties of matter allow us to distinguish and use them for different purposes. Despite the great diversity of matter, we can identify patterns in their properties and use the patterns to classify them (e.g. soluble or insoluble solids; acids or alkalis).

Due to interactions between matter, it is common to find mixtures in our environment. By knowing the properties of matter and interactions between matter, we can change and separate a mixture to get specific substances.

Key Inquiry Question

- How can matter be classified?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) show an understanding of how matter changes from one state to another: (i) melting (solid to liquid) (ii) boiling/evaporation (liquid to gas) (iii) condensation (gas to liquid) (iv) freezing (liquid to solid) (b) investigate and show an understanding of how the density of an object depends on its mass and volume (formula for density is not required) (c) deduce whether an object will float or sink by comparing its density with that of its surrounding medium (d) describe acidity, neutrality and alkalinity using the pH scale (whole number only) (e) show an understanding that indicators change colour when added to an acid or alkali (f) investigate the effect of acidic, neutral and alkaline solutions on indicators (litmus paper and universal indicator) (g) show an understanding that a mixture is made up of two or more substances and each of these substances can be obtained by separation techniques (h) distinguish among solute, solvent and solution (i) give examples of uses of solvents and solutions (j) investigate how solubility of substances depends on: (i) temperature (ii) type of solute

(iii) type of solvent

(k) investigate how rate of dissolving of substances depends on:
   (i) stirring
   (ii) surface area of solute
   (iii) temperature

(l) distinguish between solutions and suspensions using simple laboratory tests (e.g. passing a beam of light, filtering using filter paper)

(m) investigate how evaporation to dryness, filtration and magnetic separation can be used to obtain each substance in a mixture

7. WATER POLLUTION

Topic Description

Water is an important matter in our environment. Human activities change the quality of water, affecting aquatic plants, animals and our health.

Given that Singapore has limited water resources and is surrounded by water bodies, we should appreciate that every action we take will have an impact on the quality of water. Pollution of inland water bodies such as the reservoirs will have impact on our drinking water, while pollution of coastal water bodies will have impact on our recreational water activities.

Understanding interactions between our environment and us allows us to appreciate how changes in our actions can affect the quality of water. To ensure our survival, it is important for our environment to be in a state of balance.

Key Inquiry Question

- What impact do our activities have on water quality?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) appreciate the importance of clean water for humans and for the environment (b) recognise that water is an important matter that can be polluted by human activities (c) describe some human activities that cause water pollution (e.g. discharging untreated industrial waste and sewage, disposing litter, oil spill, runoff containing fertiliser/pesticide) (d) describe how water pollution affects living things (e) show care and concern for the environment by reducing water pollution in daily life (f) appreciate science for its usefulness in improving quality of life: knowledge of science (e.g. separation techniques) has helped Singapore to build a sustainable water supply and to produce water safe to drink (e.g. recycling used water)

8. AIR POLLUTION

Topic Description

Air is an important matter in our environment. Natural and human activities change the amount of pollutants in air, affecting our health and our environment. It is hence important to know about the common air pollutants and their sources.

Rapid industrialisation in Singapore and our modern lifestyle have created a high demand for energy. The burning of fossil fuels for electricity generation and use have led to greater emission of air pollutants. Besides these, smoke haze from forest fires in the region also affects our air quality intermittently.

Understanding interactions between our environment and us allows us to appreciate how changes in our actions can affect the quality of air. To ensure our survival, it is important for our environment to be in a state of balance.

Key Inquiry Question

- What impact do our activities have on air quality?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) appreciate the importance of clean air for humans and for the environment (b) recognise that air is an important matter that can be polluted by human activities and natural phenomena (c) name some common air pollutants (e.g. carbon monoxide, nitrogen oxides, particulate matter, sulfur dioxide) (d) state the sources of these air pollutants: (i) carbon monoxide from incomplete burning of fossil fuels (ii) nitrogen oxides from lightning activity and burning of nitrogen in hot engine (iii) particulate matter from forest fire and burning of fossil fuels (iv) sulfur dioxide from volcano and burning of fossil fuels (e) state the following effects of air pollutants on health and on the environment: (i) formation of acid rain due to nitrogen oxides and sulfur dioxide (ii) poisonous nature of carbon monoxide (iii) respiratory problems due to breathing in of carbon monoxide, nitrogen oxides, particulate matter and sulfur dioxide (f) state the effects of acid rain on buildings and living things (g) state that Pollutant Standards Index (PSI) measures the air quality

(h) state the effects of haze on our daily lives (i) show care and concern for the environment by reducing air pollution in daily life

Module 3
OUR BODY AND HEALTH (I)

Overview

Our body is made up of different systems that work together to keep us alive. For example, our digestive, respiratory and circulatory systems work together to release energy from the food we eat. Our bloodstream carries digested food substances and oxygen taken in by our respiratory system to all parts of our body, where respiration takes place. The energy released allows our cells, which are the basic building blocks of our body, to function healthily. Our reproductive system, which matures during puberty, ensures the continuity of humans. However, our health and the continuity of humans are affected by our choices and actions. Engaging in pre-marital/casual sex may cause us to contract sexually transmitted infections, which might then affect our ability to reproduce. Engaging in drug abuse, alcohol abuse or smoking can affect the nervous system and other systems in our body too.

Key Inquiry Questions

- What are the basic building blocks of living things?
- How do we get the energy from food to live, work and play?
- How do we reproduce?
- How can we take good care of our body?

9. CELLS

Topic Description

Cells are the basic building blocks of our bodies. We need a light microscope to observe them and their structures as they are too small to be seen with our naked eyes.

Our bodies function efficiently because there are different types of cells in our bodies performing specific functions. Groups of cells, which is a collection of tissues, form an organ and a group of organs form a system. Different systems in our bodies work together to keep us alive.

Key Inquiry Question

- What are the basic building blocks of living things?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) state that all living things are made up of cells, which are the basic units of life (b) use light microscope safely and correctly (c) draw and label the main parts of an animal cell (cell membrane, cytoplasm and nucleus) (d) state the functions of the main parts of an animal cell (cell membrane, cytoplasm and nucleus) (e) state that genes determine the traits of humans (f) show an understanding that the traits of humans are passed from parents to children (g) describe the specific functions of bone cells, muscle cells and red blood cells (h) explain how having different types of cells in the body helps the body to function efficiently (i) describe how cells in the body are organised into tissues, organs and systems (j) show an awareness of the ethical and social issues related to the donation/sale of human cells (e.g. egg/sperm), tissues (e.g. blood) and organs (e.g. liver)

10. GETTING ENERGY AND NUTRIENTS FROM FOOD

Topic Description

We need food to survive. Food provides energy required by our bodies, and nutrients to help our bodies to grow and repair ourselves.

Our digestive system breaks down the food we eat into smaller substances with the help of enzymes. Our circulatory system then carries the digested food to other parts of the body, where respiration takes place to release energy from the digested food. Different systems in our bodies work together to release energy and nutrients to allow us to live, work and play.

Key Inquiry Question

- How do we get the energy from food to live, work and play?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) state the importance of digested food as a source of energy and nutrients for building and repairing body tissues
(b) state that food is broken down into smaller substances during digestion
(c) describe how the mouth, stomach and small intestine of the human digestive system help in the digestion of carbohydrates, proteins and fats
(d) investigate the role of enzymes in the digestion of food (names of enzymes are not required)
(e) state that digested food is carried by the blood to the other parts of the human body
(f) state that oxygen is required to release energy from digested food, and carbon dioxide and water are produced, during respiration
(g) describe how the human digestive, respiratory and circulatory systems interact to release energy from food
(h) recognise the health risks of undereating and overeating
(i) appreciate the importance of not wasting food in relation to energy wastage

11. HUMAN REPRODUCTION

Topic Description

Reproduction is an essential life process to ensure the continuity of humans. We become capable of reproduction after changes occur to our body during puberty. For reproduction to be carried out, different reproductive organs must work together as a system. Each of these reproductive organs has its specific functions, and they interact and influence each other. With the advancement in science and technology, we can also try to decrease or increase the chances for pregnancy.

Our health can be affected by infections. These infections can be caused by harmful bacteria or viruses that interact with our body. Sexually transmitted infections (STIs) is one such example. STIs caused by bacteria can be cured by antibiotics but not those caused by viruses. Hence, it is important for us to know how our actions will impact our health.

Key Inquiry Question

- How do we reproduce?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) state the physical changes that occur during puberty
(b) identify the organs in the human male reproductive system (testes, sperm ducts, urethra and penis) and describe their functions
(c) identify the organs in the human female reproductive system (ovaries, fallopian tubes, uterus, cervix and vagina) and describe their functions
(d) describe the menstrual cycle
(e) describe the process of fertilisation in humans
(f) recognise the following forms of facilitated reproduction: artificial insemination and in-vitro fertilisation
(g) state and explain how some temporary methods (e.g. use of condom/diaphragm) and permanent methods of birth control (e.g. vasectomy/ligation) prevent pregnancy
(h) state how sexually transmitted infections can spread
(i) state that sexually transmitted infections can be caused by bacteria or viruses (e.g. gonorrhoea and syphilis by bacteria; AIDS by virus)
(j) state that some sexually transmitted infections caused by bacteria can be cured by antibiotics, but not those caused by viruses
(k) recognise that temporary methods of birth control are not 100% effective in preventing pregnancy and in the spread of sexually transmitted infections
(l) recognise the possible consequences of abortion and pre-marital/casual sex

12. TAKING GOOD CARE OF MY BODY

Topic Description

Our health is affected by our lifestyle choices. Drug abuse, excessive consumption of alcohol and smoking will severely affect the condition of our bodies as drugs, alcohol and tobacco smoke interact with our bodies, causing our circulatory, digestive, nervous and respiratory systems to undergo undesirable changes. Understanding the harmful consequences of such activities can help us make informed decisions in maintaining good health.

Key Inquiry Question

- How can we take good care of our body?

Learning Outcomes that bring about Core Ideas, Practices and Values, Ethics and Attitudes
(a) state the function of the human nervous system and its parts (brain, spinal cord and nerves) (b) describe the harmful effects of drug abuse on the human nervous system, and recognise the consequences of drug abuse on the individuals (e.g. depression), families (e.g. physical abuse) and the society (e.g. crime) (c) describe the harmful effects of alcohol abuse on the human digestive and nervous systems, and recognise the consequences of alcohol abuse on the individuals (e.g. liver damage), families (e.g. physical abuse) and the society (e.g. crime) (d) name some harmful substances in tobacco smoke (e.g. carbon monoxide, nicotine, tar) (e) describe the harmful effects of smoking on the human circulatory, nervous and respiratory systems, and recognise the consequences of smoking on the individuals (e.g. bronchitis), families and the society (e.g. effects of passive smoking) (f) recognise ways to avoid drug abuse, alcohol abuse and smoking (g) show care and concern for personal health by avoiding drug abuse, alcohol abuse and smoking

SECTION 3: PEDAGOGY

Teaching and Learning of Science
Students as Inquirers
Teachers as Facilitators

3. PEDAGOGY

3.1 Teaching and Learning of Science

The starting point for the Science curriculum is that every child wants to and can learn. Hence, as part of our fraternity's education philosophy, we embrace the belief that all children are curious about and want to explore the things around them. The Science curriculum leverages and seeks to fuel this spirit of curiosity. To nurture students as inquirers, teachers are key in facilitating a variety of learning experiences to support students in understanding *Core Ideas*, developing *Practices of Science* and cultivating *Values, Ethics and Attitudes*. These experiences can be situated in authentic contexts in both formal and informal learning platforms. The experiences should inspire students to inquire and innovate. Teachers can better design and enact engaging learning experiences by drawing on the Knowledge Bases (for Subject Matter and Goals, refer to **Sections 1 and 2**) and Pedagogical Practices in the Singapore Teaching Practice (STP). Students should also be provided with opportunities to reflect on their own learning progress and act on feedback provided by teachers as part of assessment for learning (AfL).

3.2 Students as Inquirers

For students to be inquirers, their thinking skills and dispositions should be developed as part of their learning experiences. Students can be provided with learning experiences centred on authentic contexts that allow them to pose questions, be involved in discussions on socio-scientific issues, or be engaged in problem solving. Through these learning experiences, students are encouraged to

- ask questions as they engage with an event, phenomenon, problem or issue. They ask questions which they are interested to find out. The questions can guide the design of investigations, from which they draw valid conclusions.

- gather evidence to respond to their questions. They gather evidence through observations and collect qualitative or quantitative data using simple instruments. After the data collection, they present the evidence in appropriate forms (e.g. tables, charts, graphs) to facilitate the analysis of patterns and relationships. Students can also use the Internet to source for information.

- formulate explanations based on the evidences gathered. They explain using their own ways, based on the evidence gathered (e.g. qualitative descriptions of observations or quantitative data collected over a time interval).

- connect their explanations to various contexts. They explain how the concepts are related or applied in various examples and contexts around them. This helps them to appreciate how Science is relevant in everyday life.

- communicate and justify their explanations. They communicate using various types of representations. For example, they can use texts, drawings, charts, tables, graphs or a combination of representations to support their explanations.

- reflect on their learning and progress. They can reflect on their learning (e.g. what they have learnt, how they would like to improve, what they are curious about) in different ways (e.g. ask questions, write journals). These reflections help them take greater ownership of their own learning and develop deeper conceptual understanding.

Learning takes place individually and collaboratively, as students construct and co-construct meaning from knowledge and experiences. In the learning of Science, students should have opportunities to

- learn with others. In understanding and applying concepts and skills, students can be engaged in pair, group or whole class interactions. For example, they can share with each other what they know about issues (e.g. global warming, air pollution) in pairs, explore the issues using the Internet in groups, and discuss their thoughts in a whole class setting.

- learn using different resources. Students learn through various print resources (e.g. *Science Nuggets* in textbooks, experiments in activity books) and online resources (e.g. lesson packages in the Singapore Student Learning Space (SLS)). They can also tap on everyday materials to test ideas and create products (e.g. making their own toys).

- learn in various environments. Students observe and/ or collect data to understand their environment.

It is important to help students enjoy Science and value the importance of Science in the natural and physical world. To *Inquire*, *Innovate* and be *Inspired* by Science, students would benefit from a range of learning experiences that equip them to learn for life. In planning for such a range of learning experiences, it is important to consider the:

- Learning setting, which shifts between in-school and out-of-school contexts for structured and unstructured learning; and

- Learning focus, which shifts between curriculum-based and interest-driven approaches along the continuum.

3.3 Teachers as Facilitators

In the teaching and learning process, teachers play an important role in stimulating students' curiosity, as well as encouraging students to see the value of Science and its applications in their everyday lives. This can be done through the contextualised learning approach where teachers use the contexts in the modules to facilitate students' understanding and appreciation of the relevance of scientific concepts in their daily lives.

To do these, teachers should ensure that the learning experiences provided for students go beyond learning facts and outcomes of scientific investigations. Teachers should play the role of facilitators to support students as inquirers.

As facilitators, teachers should:

- provide students with opportunities to ask questions about events/ phenomena/ problems/ issues that are related to their daily lives, society and environment;
- support students in gathering and using evidence;
- encourage students to formulate and communicate explanations based on evidence gathered;
- encourage students to apply concepts learnt in understanding daily events/ phenomena, finding solutions to problems/ issues and creating products; and
- check on students' understanding to ascertain if learning has taken place and provide appropriate and meaningful feedback to address students' learning gaps.

The *Pedagogical Practices* in the STP, as shown in **Figure 5**, comprise four core *Teaching Processes* which lie at the heart of good teaching. Teachers can refer to the *Teaching Processes* and relevant *Teaching Areas* under each process to guide them in the design and enactment of students' learning experiences. To design student-centred learning experiences, teachers will need to consider student profiles, readiness and needs as they transit from primary to lower secondary, as well as understand the interest and aspirations of these students as they progress to the next stage of studies and the future workplace.

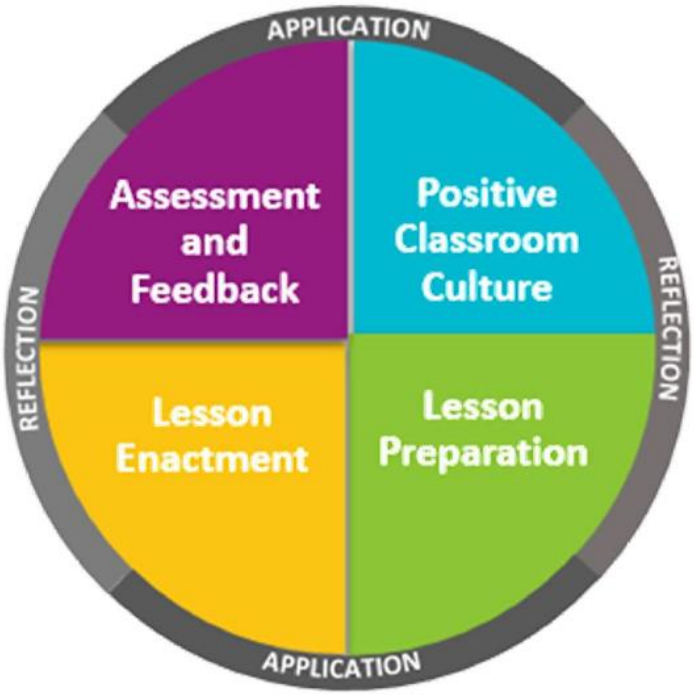


Figure 5: Pedagogical Practices depicted in STP

Use of ICT

Teachers are also encouraged to design active learning with ICT, where appropriate, as ICT is useful for lesson enactment, assessment and feedback. In integrating ICT tools in the Science classroom, teachers should consider the affordances of the ICT tools, the students' needs and readiness in interacting with the tools and the effectiveness of the tools in meeting the specific needs of the students. Teachers should exercise professional judgement in selecting, modifying and adapting the teaching aids and resources, including the integration of ICT, to enhance student learning.

Leveraging the affordance of ICT, the use of digital resources housed on digital platforms such as SLS complements the instructional materials to support teaching and learning. Online collaboration tools can also be used by teachers to facilitate students' participation in discussing the results of experiments or science-related issues. These tools also provide teachers with evidence on students' learning as part of formative assessment. Teachers can also access the SLS to search for relevant learning resources to complement their teaching and learning, assign these resources to students for self-directed learning, or customise the content in the resources to suit their students' learning needs. The SLS provides an opportunity for schools to tap on technology to allow students to learn at their own pace, both in and out of the classroom.

To ensure that the knowledge and skills learnt in school remain relevant in a technologically-driven landscape, students will be acquainted with the use of basic digital instruments (e.g. data loggers) through a variety of learning experiences. When teachers guide students in using digital instruments to collect experimental data, associated competencies such as choosing an appropriate instrument for measurement and analysing data (e.g. graph drawing in print activity book) can be developed.

SECTION 4: ASSESSMENT

Purposes of Assessment
Assessing Lower Secondary Science Normal (Technical)

4. ASSESSMENT

4.1 Purposes of Assessment

Assessment is the process of gathering and analysing evidence about student learning to make appropriate decisions and enhance learning. Assessment is integral to the teaching and learning process. In designing assessments, we need to have **clarity of purpose**. Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. It should produce both quantitative and qualitative descriptions of a student's progress and development that can be analysed and used to provide feedback for improving future practices.

- Assessment provides feedback to **students**. It 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. The use of feedback in this way helps students work towards mastering their 21CC.

- Assessment provides feedback to **teachers.** It enables them to understand the strengths and weaknesses of their students. It provides information about students' attainment of learning outcomes (which includes 21CC development) as well as the effectiveness of their teaching.

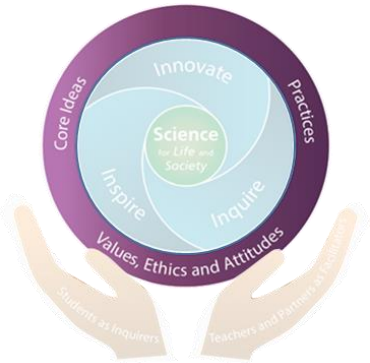
- Assessment provides feedback to **schools**. The information gathered facilitates the placement of students in the appropriate course, and the promotion of students from one level to the next. It can also help to inform the review of instructional programmes in schools.

- Assessment provides feedback to **parents**. It allows them to monitor their child's attainment and progress through the information obtained.

4.2 Assessing Lower Secondary Science Normal (Technical)

What to Assess?

The Lower Secondary Science Normal (Technical) curriculum is designed using the contextualised approach and aims to develop 21CC and scientific literacy in students.



With reference to the *Science Curriculum Framework*, students should be provided with strong grounding in the three fundamentals:

- *Core Ideas* of Science;
- *Practices; and*
- *Values, Ethics and Attitudes* in Science.

It is essential for assessment to be closely aligned to the curricular objectives, content and pedagogy.

How to Assess?

As assessment serves many purposes, it is guided by the specific purpose for which it is intended. Before making an assessment about a certain aspect of students' learning, teachers should ensure that the form of assessment used will generate information that reflect accurately the aspect of learning teachers intend to assess. Assessment should, where possible, include items with real-world contexts and incorporate the affordances of ICT.

Different forms of assessment should be used to assess different aspects of learning. In addition to written assessments, teachers should conduct performance-based assessments, which may include:

- Debates
- Drama/ Show and Tell
- Learning Trails
- Model-making
- Portfolio
- Posters
- Practical work
- Projects
- Reflections/ Journals

Designing Assessment for Learning

AfL is assessment conducted constantly during classroom instruction to support teaching and learning. The critical feature about AfL is that information gathered from the assessment is used to adjust and improve the teacher's teaching practices, as well as surface students' learning progress and difficulties.

Teachers are also encouraged to explore the use of ICT for AfL.

Designing Assessment of Learning

Assessment of Learning (AoL) aims to summarise how much or how well students have achieved at appropriate checkpoints of a course of study. The mid-year and end-of-year examinations are examples of AoL. To ensure content validity, the assessment should be designed to cover a representative sample of the syllabus, allowing students to make connections across what they have learnt in the course of the two-year study. The assessment content should well-represent the syllabus in terms of scope and relevance as well as be pitched at the appropriate difficulty level.

SECTION 5:
GLOSSARY OF TERMS

5. GLOSSARY OF TERMS

S/N	Term	Description
1	appreciate	recognise the value of the topic
2	deduce	draw conclusion(s) based on concepts, facts and given information
3	describe	write in words (using diagrams where appropriate) the main points of the topic or (visual) observations associated with the phenomena
4	distinguish	identify differences
5	draw	make a freehand diagram to show the structure of the object or give an accurate representation of the object according to conventions (e.g. circuit symbols)
6	estimate	give an approximate value of the quantity with reasonable order of magnitude
7	explain	give reasons or make some reference to concepts and facts
8	identify	select and/ or name
9	interpret	convert information from one form to another
10	investigate	find out by conducting experiments
11	measure	obtain a reading from a suitable measuring instrument
12	recognise	identify characteristics, concepts and facts that are critical to the understanding of the topic
13	record	write value of the measured/ estimated quantity with appropriate unit
14	relate	identify and explain the relationships
15	show awareness	have superficial knowledge of the topic
16	state	give concise response (by recall) with little or no supporting argument
17	understand (show an understanding)	recall, interpret, explain and apply information (e.g. concepts, facts)

SECTION 6:
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