G1

MATHEMATICS SYLLABUS

Secondary One to Four

Implementation starting with
2020 Secondary One Cohort

Ministry of Education
SINGAPORE

Content

SECTION 1: INTRODUCTION

Importance of Learning Mathematics
Secondary Mathematics Curriculum
Key Emphases

1. INTRODUCTION

Importance of Learning Mathematics

Mathematics contributes to the developments and understanding in many disciplines and provides the foundation for many of today's innovations and tomorrow's solutions. It is used extensively to model and understand real-world phenomena (e.g. consumer preferences, population growth, and disease outbreak), create lifestyle and engineering products (e.g. animated films, mobile games, and autonomous vehicles), improve productivity, decision-making and security (e.g. business analytics, academic research and market survey, encryption, and recognition technologies).

In Singapore, mathematics education plays an important role in equipping every citizen with the necessary knowledge and skills and the capacities to think logically, critically and analytically to participate and strive in the future economy and society. In particular, for future engineers and scientists who are pushing the frontier of technologies, a strong foundation in mathematics is necessary as many of the Smart Nation initiatives that will impact the quality of lives in the future will depend heavily on computational power and mathematical insights.

Secondary Mathematics Curriculum

Secondary education is a stage where students discover their strengths and interests. It is also the final stage of compulsory mathematics education. Students have different needs for and inclinations towards mathematics. For some students, mathematics is just a tool to be used to meet the needs of everyday life. For these students, formal mathematics education may end at the secondary levels. For others, they will continue to learn and need mathematics to support their future learning. For those who aspire to pursue STEM education and career, learning more advanced mathematics early will give them a head start.

For these reasons, the goals of the secondary mathematics education are:

- to ensure that all students will achieve a level of mastery of mathematics that will enable them to function effectively in everyday life; and
- for those who have the interest and ability, to learn more mathematics so that they can pursue mathematics or mathematics-related courses of study in the next stage of education.

There are 5 syllabuses in the secondary mathematics curriculum, catering to the different needs, interests and abilities of students:

- G3 Mathematics
- G2 Mathematics
- G1 Mathematics
- G3 Additional Mathematics
- G2 Additional Mathematics

The G3, G2 and G1 Mathematics syllabuses provide students with the core mathematics knowledge and skills in the context of a broad-based education. At the upper secondary levels, students who are interested in mathematics may offer Additional Mathematics as an elective. This prepares them better for courses of study that require mathematics.

Key Emphases

The key emphases of the 2020 syllabuses are summarised as follows:

1. Continue to develop in students the critical mathematical processes such as, reasoning, communication and modelling, as they enhance the learning of mathematics and support the development of 21^{st} century competencies;

2. Develop a greater awareness of the nature of mathematics and the big ideas that are central to the discipline and bring coherence and connections between different topics so as to develop in students a deeper and more robust understanding of mathematics and better appreciation of the discipline; and

3. Give attention to developing students' metacognition by promoting self-directed learning and reflection.

SECTION 2:
MATHEMATICS CURRICULUM

Nature of Mathematics
Themes and Big Ideas
Mathematics Curriculum Framework
21st Century Competencies

2. MATHEMATICS CURRICULUM

Nature of Mathematics

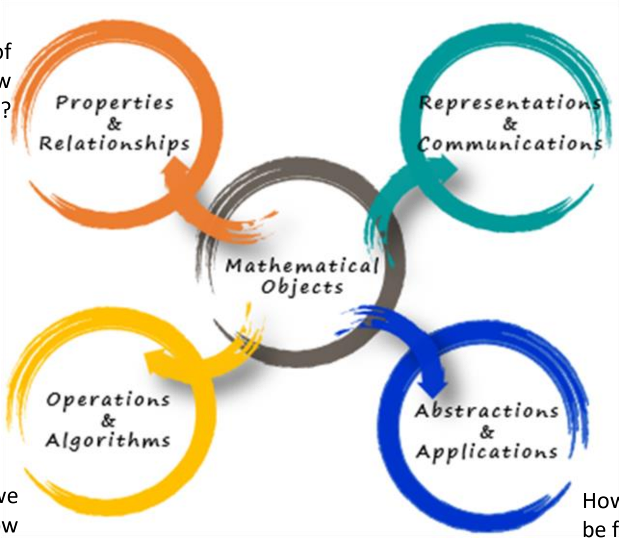
Mathematics can be described as a study of the *properties*, *relationships*, *operations*, *algorithms*, and *applications* of numbers and spaces at the very basic levels, and of abstract objects and concepts at the more advanced levels. Mathematical objects and concepts, and related knowledge and methods, are products of insight, logical reasoning and creative thinking, and are often inspired by problems that seek solutions. *Abstractions* are what make mathematics a powerful tool for solving problems. Mathematics provides within itself a language for *representing* and *communicating* the ideas and results of the discipline.

Themes and Big Ideas

From the above description of the nature of mathematics, four recurring *themes* in the study of mathematics are derived.

What are the properties of mathematical objects and how are they related?

How can the mathematical objects and concepts be represented and communicated?



What meaningful actions can we perform on the objects and how do we carry them out?

How can the mathematical objects be further abstracted and where can they be applied?

1. *Properties and Relationships*: What are the properties of mathematical objects and how are they related?

   Properties of mathematical objects (e.g. numbers, lines, function, etc.) are either inherent in their definitions or derived through logical argument and rigorous proof. *Relationships* exist between mathematical objects. They include the proportional relationship between two quantities, the equivalence of two expressions or statements, the similarity between two figures and the connections between two functions. Understanding *properties and relationships* enable us to gain deeper insights into the mathematical objects and use them to model and solve real-world problems.

2. *Operations and Algorithms*: What meaningful actions can we perform on the mathematical objects and how do we carry them out?

   Operations are meaningful actions performed on mathematical objects. They include arithmetic operations, algebraic manipulations, geometric transformations, operations on functions, and many more. *Algorithms* are generalised sequences of well-defined smaller steps to perform a mathematical operation or to solve a problem. Some examples are adding or multiplying two numbers and finding factors and prime numbers. Understanding the meaning of these *operations and algorithms* and how to carry them out enable us to solve problems mathematically.

3. *Representations and Communications*: How can the mathematical objects and concepts be represented and communicated within and beyond the discipline?

   Representations are integral to the language of mathematics. They include symbols, notations, and diagrams such as tables, graphs, charts and geometrical figures that are used to express mathematical concepts, properties and operations in a way that is precise and universally understood. *Communication* of mathematics is necessary for the understanding and dissemination of knowledge within the community of practitioners as well as general public. It includes clear presentation of proof in a technical writing as well as choosing appropriate representations (e.g. list, chart, drawing) to communicate mathematical ideas that can be understood by the masses.

4. *Abstractions and Applications*: How can the mathematical objects be further abstracted and where can they be applied?

   Abstraction is at the core of mathematical thinking. It involves the process of generalisation, extension and synthesis. Through algebra, we generalise arithmetic. Through complex numbers, we extend the number system. Through coordinate geometry, we synthesise the concepts across the algebra and geometry strands. The processes of abstraction make visible the structure and rich connections within mathematics and makes mathematics a powerful tool. *Application* of mathematics is made possible by abstractions. From simple counting to complex modelling, the abstract mathematical objects, properties, operations, relationships and representations can be used to model and study real-world phenomena.

Big ideas express ideas that are central to mathematics. They appear in different topics and strands. There is a continuation of the ideas across levels. They bring coherence and show connections across different topics, strands and levels. The big ideas in mathematics could be about one or more themes, that is, it could be about *properties and relationships* of mathematical objects and concepts and the *operations and algorithms* involving these objects and concepts, or it could be about *abstraction and applications* alone. Understanding the big ideas brings one closer to appreciating the nature of mathematics.

Eight clusters of big ideas are listed in this syllabus. These are not meant to be authoritative or comprehensive. They relate to the four themes that cut across and connect concepts from the different content strands, and some big ideas extend across and connect more concepts than others. Each cluster of big ideas is represented by a label e.g. big ideas about Equivalence, big ideas about Proportionality, etc.

Big Ideas about Diagrams

Main Themes: Representations and Communications

Diagrams are succinct, visual representations of real-world or mathematical objects that serve to communicate properties of the objects and facilitate problem solving. For example, graphs in coordinate geometry are used to represent the relationships between two sets of values, geometrical diagrams are used to represent physical objects, and statistical diagrams are used to summarise and highlight important characteristics of a set of data. Understanding what different diagrams represent, their features and conventions, and how they are constructed helps to facilitate the study and communication of important mathematical results.

Big Ideas about Equivalence

Main Themes: Properties and Relationships, Operations and Algorithms

Equivalence is a relationship that expresses the 'equality' of two mathematical objects that may be represented in two different forms. A number, algebraic expression or equation can be written in different but equivalent forms, and transformation or conversion from one form to another equivalent form is the basis of many manipulations for analysing and comparing them and algorithms for finding solutions.

Big Ideas about Functions

Main Themes: Properties and Relationships, Abstractions and Applications

A function is a relationship between two sets of objects that expresses how each element from the first set (input) uniquely determines (relates to) an element from the second set (output) according to a rule or operation. It can be represented in multiple ways, e.g. as a table, algebraically, or graphically. Functional relationships undergird many of the applications of mathematics and are used for modelling real-world phenomena. Functions are pervasive in mathematics and undergird many of the applications of mathematics and modelling of real-world phenomena.

Big Ideas about Invariance

Main Theme: Properties and Relationships, Operations and Algorithms

Invariance is a property of a mathematical object which remains unchanged when the object undergoes some form of transformation. In summing up or multiplying numbers, the sum or product is an invariant property that is not affected by the rearrangement of the numbers. In geometry, the area of a figure, the angles within it, and the ratio of the sides remain unchanged when the figure is translated, reflected or rotated. In statistics, the standard deviation remains unchanged when a constant is added to all the data points.

Many mathematical results express invariance, e.g. a property of a class of mathematical objects.

Big Ideas about Measures

Main Theme: Abstractions and Applications

Numbers are used as measures to quantify a property of various real-world or mathematical objects, so that they can be analysed, compared, and ordered. There are many examples of measures such as length, area, volume, money, mass, time, temperature, speed, angles, probability, mean and standard deviation. Many measures have units, some measures have a finite range and special values which serve as useful references. In most cases, zero means the absence of the property while a negative measures the opposite property.

Big Ideas about Models

Main Themes: Abstractions and Applications, Representations and Communications

Models are abstractions of real-world situations or phenomena using mathematical objects and representations. For example, a real-world phenomenon may be modelled by a function, a real-world object may be modelled by a geometrical object, and a random phenomenon may be modelled by the probability distribution for different outcomes. As approximations, simplifications or idealisations of real-world problems, models come with assumptions, have limitations, and the mathematical solutions derived from these models need to be verified.

Big Ideas about Notations

Main Themes: Representations and Communications

Notations are symbols and conventions of writing used to represent mathematical objects, and their operations and relationships in a concise and precise manner. Examples include notations for mathematical constants like π and e, scientific notation to represent very big or very small numbers, set notations, etc. Understanding the meaning of mathematical notations and how they are used, including the rules and conventions, helps to facilitate the study and communication of important mathematical results, properties and relationships, reasoning and problem solving.

Big Ideas about Proportionality

Main Theme: Properties and Relationships

Proportionality is a relationship between two quantities that allows one quantity to be computed from the other based on multiplicative reasoning. Fraction, ratio, rate and percentage are different but related mathematical concepts for describing the proportional relationships between two quantities that allow one quantity to be computed from the other related quantity. In geometry, proportional relationships undergird important concepts such as similarity and scales. In statistics, proportional relationships are the basis for constructing and interpreting many statistical diagrams such as pie charts and histograms. Underlying the concept of proportionality are two quantities that vary in such a way that the ratio between them remains a constant.

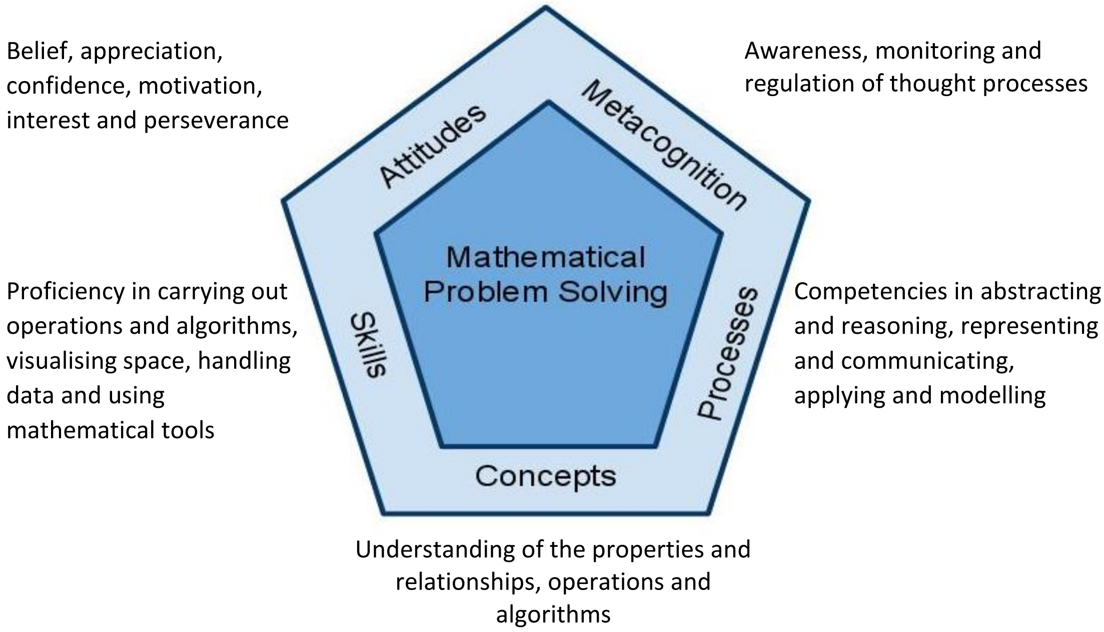
Mathematics Curriculum Framework

The central focus of the mathematics curriculum is the development of mathematical problem solving competency. Supporting this focus are five inter-related components – concepts, skills, processes, metacognition and attitudes.

Mathematical Problem Solving

Problems may come from everyday contexts or future work situations, in other areas of study, or within mathematics itself. They include straightforward and routine tasks that require selection and application of the appropriate concepts and skills, as well as complex and non-routine tasks that requires deeper insights, logical reasoning and creative thinking. General problem solving strategies e.g. Polya's 4 steps to problem solving and the use of heuristics, are important in helping one tackle non-routine tasks systematically and effectively.

Mathematics Curriculum Framework



Concepts

The understanding of mathematical concepts, their properties and relationships and the related operations and algorithms, are essential for solving problems. Concepts are organised by strands, and these concepts are connected and inter-related. In the secondary mathematics curriculum, concepts in numbers, algebra, geometry, probability and statistics and calculus (in Additional Mathematics) are explored.

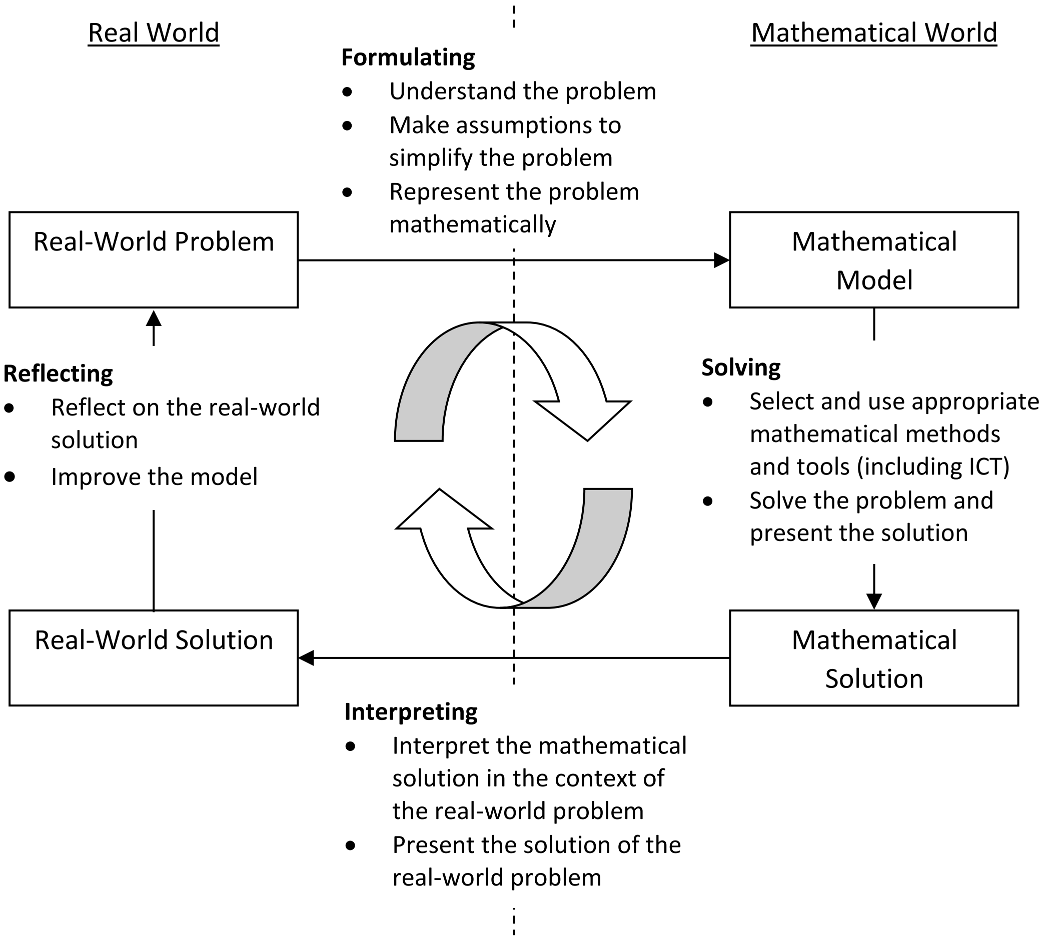
Skills

Being proficient in carrying out the mathematical operations and algorithms and in visualising space, handling data and using mathematical tools are essential for solving problems. In the secondary mathematics curriculum, operations and algorithms such as *calculation, estimation, manipulation*, and *simplification* are required in most problems. ICT tools such as spreadsheets, and dynamic geometry and graph sketching software may be used to support the learning.

Processes

Mathematical processes refer to the practices of mathematicians and users of mathematics that are important for one to solve problems and build new knowledge. These include abstracting, reasoning, representing and communicating, applying and modelling. Abstraction is what makes mathematics powerful and applicable. Justifying a result, deriving new results and generalising patterns involve reasoning. Expressing one's ideas, solutions and arguments to different audiences involves representing and communicating, and using the notations (symbols and conventions of writing) that are part of the mathematics language. Applying mathematics to real-world problems often involves modelling, where reasonable assumptions and simplifications are made so that problems can be formulated mathematically, and where mathematical solutions are interpreted and evaluated in the context of the real-world problem. The mathematical modelling process is shown in the diagram below.

Mathematical Modelling Process



Metacognition

Metacognition, or thinking about thinking, refers to the awareness of, and the ability to control one's thinking processes, in particular the selection and use of problem-solving strategies. It includes monitoring and regulation of one's own thinking and learning. It also includes the awareness of one's affective responses towards a problem. When one is engaged in solving a non-routine or open-ended problem, metacognition is required.

Attitudes

Having positive attitudes towards mathematics contributes to one's disposition and inclination towards using mathematics to solve problems. Attitudes include one's belief and appreciation of the value of mathematics, one's confidence and motivation in using mathematics, and one's interests and perseverance to solve problems using mathematics.

Mathematics and 21st Century Competencies

The learning of mathematics creates opportunities for students to develop key competencies that are important in the 21st century. When students pose questions, justify claims, write and critique mathematical explanations and arguments, they are engaged in reasoning, critical thinking and communication. When students devise different strategies to solve an open-ended problem or formulate different mathematical models to represent a real-world problem, they are engaged in inventive thinking. When students vary their approaches to solve different but related problems, they are engaged in adaptive thinking.

As an overarching approach, the secondary mathematics curriculum supports the development of 21st century competencies (21CC) in the following ways:

1. The content are relevant to the needs of the 21st century. They provide the foundation for learning many of the advanced applications of mathematics that are relevant to today's world.

2. The pedagogies create opportunities for students to think critically, adaptively and inventively, reason logically and communicate effectively using mathematics, work individually as well as in groups, using ICT tools where appropriate in learning and doing mathematics.

3. The problem contexts raise students' awareness of local and global issues around them. For example, problems set around population, health and sustainability issues can help students understand the challenges faced by Singapore and those around the world.

The learning of mathematics also creates opportunities for students to apply knowledge, skills, and practices across STEM disciplines to solve real-world problems. Students can develop their curiosity, creativity, and agency to make a positive difference to the world. These goals of STEM learning i.e. be curious, be creative and be the change are closely linked to the 21CC.

SECTION 3:
G1 MATHEMATICS SYLLABUS

3. G1 MATHEMATICS SYLLABUS

Aims of Syllabus

The G1 Mathematics syllabus aims to enable students who are bound for post-secondary vocational education to:

- acquire mathematical concepts and skills for real life and to support learning in other subjects;
- develop thinking, reasoning, communication, application and metacognitive skills through a mathematical approach to problem solving;
- connect ideas within mathematics and between mathematics and other subjects through application of mathematics; and
- build confidence in using mathematics and appreciate its value in making informed decisions in real life.

Syllabus Organisation

The concepts and skills covered in the syllabus are organised along 3 content strands. The development of processes, metacognition and attitudes are embedded in the learning experiences that are associated with the content.

Concept and Skills		
Number and Algebra	Geometry and Measurement	Statistics and Probability
Learning Experiences (Processes, Metacognition and Attitudes)		

Problems in Real-World Contexts

Solving problems in real-world contexts should be part of the learning experiences of every student. These experiences give students the opportunities to apply the concepts and skills that they have learnt and to appreciate the value of and develop an interest in mathematics. Problems in real-world contexts should be included in every strand and level, and may require concepts and skills from more than one strand.

Students are expected to be familiar with the following contexts and solve problems based on these contexts over the four years of their secondary education:

- In everyday life, including time schedules (including 24-hour clock) and time zone variation, transport schedules, sports and games, recipes, floor plans, profit and loss (exclude use of the terms 'percentage profit' and 'percentage loss'), etc.
- In personal and household finance, including simple and compound interest[1], taxation, instalments, utilities bills, money exchange, etc.
- In interpreting and analysing data from tables and graphs (exclude distance-time and speed-time graphs)

The list above is by no means exhaustive or exclusive.

Through the process of solving such problems, students will experience all or part of the mathematical modelling process. This includes:

- formulating the problem, including making suitable assumptions and simplifications;
- making sense of and discussing data, including real data presented as graphs and tables;
- selecting and applying the appropriate concepts and skills to solve the problem; and
- interpreting the mathematical solutions in the context of the problem.

[1] For the GCE Exam, the compound interest formula to find the total amount will be provided.

Content by Levels

Secondary One

NUMBER AND ALGEBRA

N1. Numbers and their operations

1.1. negative numbers and primes (exclude prime factorisation)
1.2. integers and their four operations
1.3. four operations on fractions and decimals (including negative fractions and decimals)
1.4. calculations with calculator, including squares, cubes, square roots and cube roots
1.5. representation and ordering of numbers on the number line
1.6. use of $<$, $>$, $\leq$, $\geq$
1.7. approximation and estimation (including rounding off numbers to a required number of decimal places or significant figures and estimating the results of computation)

N2. Ratio and proportion

2.1. comparison between two or more quantities by ratio
2.2. dividing a quantity in a given ratio
2.3. ratios involving fractions and decimals
2.4. equivalent ratios
2.5. writing a ratio in its simplest form

N3. Percentage

3.1. expressing percentage as a fraction or decimal
3.2. finding the whole given a percentage part
3.3. expressing one quantity as a percentage of another
3.4. comparing two quantities by percentage
3.5. percentages greater than 100%
3.6. finding one quantity given the percentage and the other quantity
3.7. increasing/decreasing a quantity by a given percentage
3.8. finding percentage increase/decrease

N5. Algebraic expressions and formulae

5.1. using letters to represent numbers
5.2. interpreting notations:
- ab as $a \times b$
- $\frac{a}{b}$ as $a \div b$ or $a \times \frac{1}{b}$
- a^2 as $a \times a,$ a^3 as $a \times a \times a$, a^2b as $a \times a \times b,$ $\quad ...$
- $3y$ as $y + y + y$ or $3 \times y$
- $3(x + y)$ as $3 \times (x + y)$
- $\frac{3+y}{5}$ as $(3 + y) \div 5$ or $\frac{1}{5} \times (3 + y)$

5.3. evaluation of algebraic expressions and formulae
5.4. recognising number sequences (including evaluating simple nth term like $n + 3$ and $2n + 1$)
5.5. translation of simple real-world situations into algebraic expressions

GEOMETRY AND MEASUREMENT

G1. Angles, triangles and quadrilaterals

1.1. right, acute, obtuse and reflex angles
1.2. vertically opposite angles, angles on a straight line and angles at a point
1.3. angles formed by two parallel lines and a transversal: corresponding angles, alternate angles, interior angles

G2. Symmetry

2.1. line and rotational symmetry of plane figures
2.2. lines of symmetry
2.3. order of rotational symmetry

G4. Mensuration

4.1. area of triangle as $\frac{1}{2}$ × base × height
4.2. area and circumference of circle
4.3. area of parallelogram and trapezium
4.4. problems involving perimeter and area of composite plane figures
4.5. volume and surface area of cube and cuboid
4.6. conversion between cm^2 and m^2, and between cm^3 and m^3
4.7. problems involving volume and surface area of composite solids

STATISTICS AND PROBABILITY

S1. Data Handling and Analysis

1.1. simple concepts in collecting, classifying and tabulating data
1.2. analysis and interpretation of:
- tables
- bar graphs
- pictograms
- line graphs
- pie charts

1.3. purposes and uses, advantages and disadvantages of the different forms of statistical representations

Secondary Two

NUMBER AND ALGEBRA

N2. Ratio and proportion

2.6. direct and inverse proportion

N4. Rate and speed

4.1. rates and average rates (including the concepts of speed and average speed)
4.2. conversion of units (e.g. km/h to m/s)

N5. Algebraic expressions and formulae

5.6. addition and subtraction of linear expressions
5.7. simplification of linear expressions, e.g.
- $-2(3x-5)+4x$
- $\frac{2x}{3}-\frac{3(x-5)}{2}$

N6. Functions and graphs

6.1. Cartesian coordinates in two dimensions
6.2. graph of a set of ordered pairs as a representation of a relationship between two variables
6.3. linear functions $(y = ax + b)$
6.4. graphs of linear functions
6.5. the gradient of a linear graph as the ratio of the vertical change to the horizontal change (positive and negative gradients)

N7. Equations

7.1. solving linear equations in one variable
7.2. formulating a linear equation in one variable to solve problems

GEOMETRY AND MEASUREMENT

G1. Angles, triangles and quadrilaterals

1.4. properties of triangles and special quadrilaterals
1.5. properties of perpendicular bisectors of line segments and angle bisectors
1.6. construction of simple geometrical figures from given data (including perpendicular bisectors and angle bisectors) using compasses, ruler, set squares and protractor where appropriate

G2. Congruence and similarity

2.4. congruent and similar figures
2.5. properties of similar triangles and quadrilaterals:
- corresponding angles are equal
- corresponding sides are proportional

G3. Pythagoras' theorem

3.1. use of Pythagoras' theorem
3.2. determining whether a triangle is right-angled given the lengths of three sides

G4. Mensuration

4.8. volume and surface area of prism and cylinder
4.9. conversion between cm^2 and m^2, and between cm^3 and m^3

STATISTICS AND PROBABILITY
S1. Data analysis
1.4. analysis and interpretation of: • dot diagrams • histograms with equal class intervals 1.5. purposes and uses, advantages and disadvantages of the different forms of statistical representations 1.6. purposes and uses of mean, mode and median 1.7. calculation of the mean, mode and median for a set of ungrouped data
S2. Probability
2.1. probability as a measure of chance 2.2. probability of single events (including listing all the possible outcomes in a simple chance situation to calculate the probability)

Secondary Three/Four

NUMBER AND ALGEBRA

N1. Numbers and their four operations

1.8. use of index notation for integer powers
1.9. use of standard form $A \times 10^n$, where *n* is an integer, and $1 \leq A < 10$

N2. Ratio and proportion

2.7. map scales (distance and area)

N5. Algebraic expressions and formulae

5.8. recognising and representing number sequences (include finding an algebraic expression for the *n*th term for simple cases such as $n + 3$ and $2n + 1$)
5.9. expansion of the product of two linear expressions
5.10. multiplication and division of simple algebraic fractions,
e.g. $\left(\frac{3a}{4b^2}\right)\left(\frac{5ab}{3}\right)$; $\frac{3a}{4} \div \frac{9a^2}{10}$
5.11. changing the subject of a simple formula
5.12. finding the value of an unknown quantity in a given formula
5.13. factorisation of linear expressions of the form $ax + kay$
5.14. factorisation of quadratic expressions of the form $x^2 + px + q$

Exclude:

- use of
  - * $(a \pm b)^2 = a^2 \pm 2ab + b^2$
  - * $a^2 - b^2 = (a+b)(a-b)$
- addition and subtraction of algebraic fractions such as $\frac{1}{x} + \frac{1}{x-1}$

N6. Functions and graphs

6.6. quadratic functions ($y = ax^2 + bx + c$) <Sec 4>
6.7. graphs of quadratic functions and their properties <Sec 4>

- positive or negative coefficient of x^2
- maximum and minimum points
- symmetry

N7. Equations

7.3. graphs of linear equations in two variables ($ax + by = c$)
7.4. solving simple fractional equations that can be reduced to linear equations, e.g.

$$\frac{x}{3} + \frac{x-2}{4} = 3$$

$$\frac{3}{x-2} = 6$$

7.5. solving simultaneous linear equations in two variables by
  - * substitution and elimination methods
  - * graphical method

7.6. formulating a pair of linear equations in two variables to solve problems
7.7. solving quadratic equations in one variable by use of

Secondary Three/Four

NUMBER AND ALGEBRA

formula[2]
7.8. formulating a quadratic equation in one variable to solve problems

GEOMETRY AND MEASUREMENT

G3. Trigonometry

3.3. use of trigonometric ratios (sine, cosine and tangent) of acute angles to calculate unknown sides and angles in right-angled triangles (including problems involving angles of elevation and depression)

G4. Mensuration

4.10. volume and surface area of pyramid, cone and sphere[3]
4.11. conversion between cm^2 and m^2, and between cm^3 and m^3
4.12. arc length and sector area as fractions of the circumference and area of a circle

STATISTICS AND PROBABILITY

S1. Data analysis

1.8. percentiles, quartiles, range and interquartile range
1.9. analysis and interpretation of cumulative frequency diagrams

[2] For the GCE Exam, the formula for solving quadratic equations will be provided.
[3] For the GCE Exam, the following formula will be provided: curved surface area of a cone, surface area of a sphere, volume of pyramid, cone and sphere.

SECTION 4:

TEACHING, LEARNING AND ASSESSING

Teaching Processes
Phases of Learning
Formative Assessment
Use of Technology and e-Pedagogy
Blended Learning
STEM Learning
Developing CT in Mathematics

4. TEACHING, LEARNING AND ASSESSING

Teaching Processes

The Pedagogical Practices of The Singapore Teaching Practice (STP) outlines four Teaching Processes that make explicit what teachers reflect on and put into practice before, during and after their interaction with students in all learning contexts.

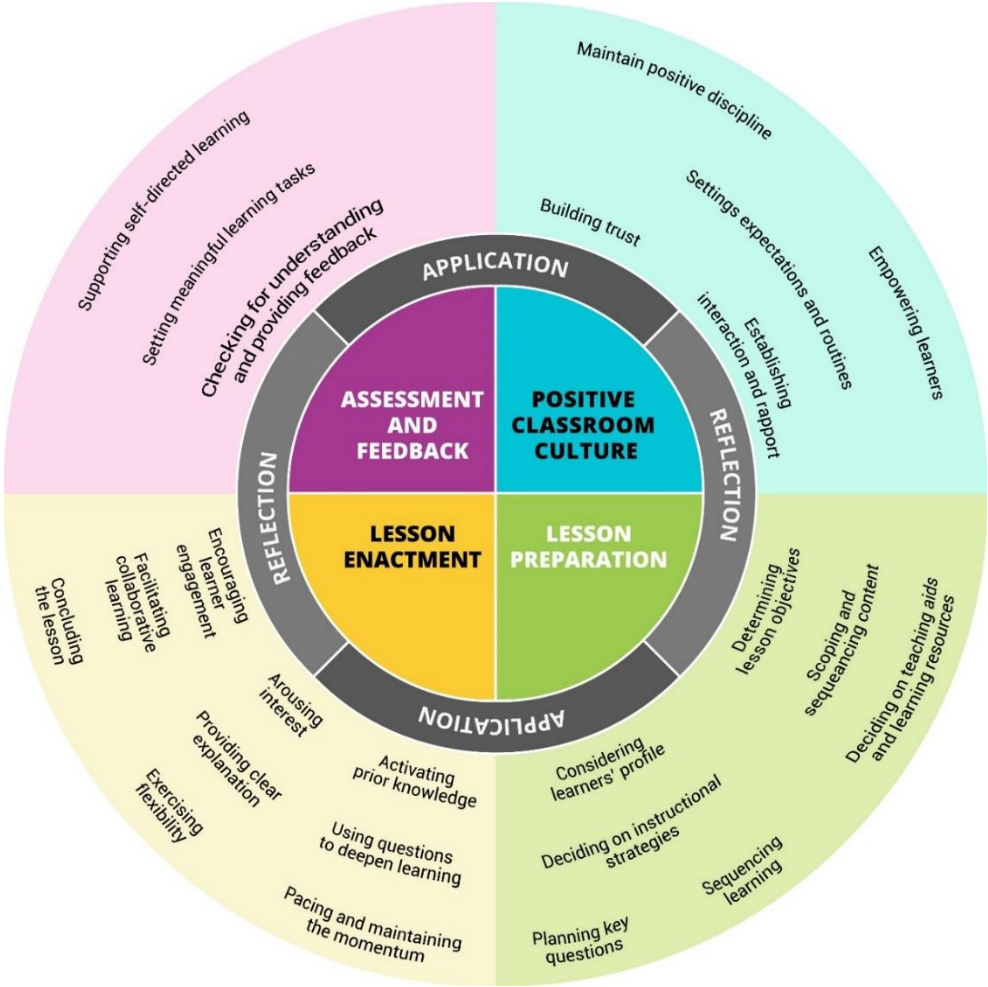
It is important to view the Pedagogical Practices of the STP in the context of the Singapore Curriculum Philosophy (SCP) and Knowledge Bases (KB), and also to understand how all three components work together to support effective teaching and learning.

Taking reference from the SCP, every student is valued as an individual, and they have diverse learning needs and bring with them a wide range of experiences, beliefs, knowledge, and skills. For learning to be effective, there is a need to adapt and match the teaching pace, approaches and assessment practices so that they are developmentally appropriate.

The 4 Teaching Processes are further expanded into Teaching Areas as follows:

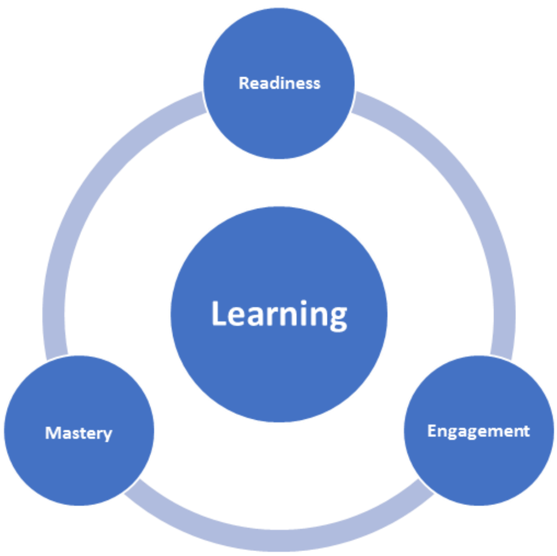
Assessment and Feedback • Checking for Understanding and Providing Feedback • Supporting Self-Directed Learning • Setting Meaningful Assignments	Positive Classroom Culture • Establishing Interaction and Rapport • Maintaining Positive Discipline • Setting Expectations and Routines • Building Trust • Empowering Learners
Lesson Enactment • Activating Prior Knowledge • Arousing Interest • Encouraging Learner Engagement • Exercising Flexibility • Providing Clear Explanation • Pacing and Maintaining Momentum • Facilitating Collaborative Learning • Using Questions to Deepen Learning • Concluding the Lesson	Lesson Preparation • Determining Lesson Objectives • Considering Learners' Profile • Selecting and Sequencing Content • Planning Key Questions • Sequencing Learning • Deciding on Instructional Strategies • Deciding on Teaching Aids and Learning Resources

The Teaching Areas are not necessarily specific to a single Teaching Process. Depending on the context, some of the Teaching Areas could be considered in another Teaching Process. The Teaching Processes are undergirded by a constant cycle of application and reflection.



Phases of Learning

The Teaching Areas in STP are evident in the effective planning and delivery of the three phases of learning - *readiness*, *engagement* and *mastery*.



Readiness Phase

Student readiness to learn is vital to learning success. Teachers have to consider the following:

- Learning environment
- Students' profile
- Students' prior and pre-requisite knowledge
- Motivating contexts

Engagement Phase

This is the main phase of learning where students engage with the new materials to be learnt (*Encouraging Learner Engagement*). As students have diverse learning needs and bring with them a wide range of experiences, beliefs, knowledge and skills, it is important to consider the pace of the learning and transitions (*Pacing and Maintaining Momentum*) using a repertoire of pedagogies.

Three pedagogical approaches form the spine that supports most of the mathematics instruction in the classroom. They are not mutually exclusive and could be used in different parts of a lesson or unit. Teachers make deliberate choices on the instructional strategies (Deciding on Instructional Strategies) based on learners' profiles and needs, and the nature of the concepts to be taught. The engagement phase can include one or more of the following:

- Activity-based Learning
- Inquiry-based Learning
- Direct Instruction

Regardless of the approach, it is important for teachers to plan ahead, anticipate students' responses, and adapt the lesson accordingly (Exercising Flexibility).

Mastery Phase

The mastery phase is the final phase of learning where students consolidate and extend their learning. To consolidate, teachers summarise and review key learning points at the end of a lesson and make connections with the subsequent lesson (Concluding the Lesson). The mastery phase can include one or more of the following:

- Motivated Practice
- Reflective Review
- Extended Learning

Formative Assessment

Assessment is an integral part of the teaching and learning. It can be formative or summative or both. Formative assessment or Assessment for Learning (AfL) is carried out during teaching and learning to gather evidence and information about students' learning.

The *purpose* of formative assessment is to help students improve their learning and be self-directed in their learning. In learning of mathematics, just as in other subjects, information about students' understanding of the content must be gathered *before*, *during* and *after* the lesson.

The outcomes of the mathematics curriculum go beyond just the recall of mathematical concepts and skills. Since mathematical problem solving is the focus of the mathematics curriculum, assessment should also focus on students' understanding and ability to apply what they know to solve problems. In addition, there should be emphasis on processes such as reasoning, communicating, and modelling.

The overarching objectives of assessment should focus on students':

- understanding of mathematical concepts (going beyond simple recall of facts);
- ability to reason, communicate, and make meaningful connections and integrate ideas across topics;
- ability to formulate, represent and solve problems within mathematics and to interpret mathematical solutions in the context of the problems; and
- ability to develop strategies to solve non-routine problems.

The process of assessment is embedded in the planning of the lessons. The embedding of assessment process may take the following forms:

- Class Activities
- Classroom Discourse
- Individual or Group Tasks

Assessment provides feedback for both students and teachers.

- Feedback from teachers to students informs students where they are in their learning and what they need to do to improve their learning.
- Feedback from students to teachers comes from their responses to the assessment tasks designed by teachers. They provide information to teachers on what they need to do to address learning gaps, how to modify the learning activities students engage in, and how they should improve their instruction.
- Feedback between students is important as well because peer-assessment is useful in promoting active learning. It provides an opportunity for students to learn from each other and also allows them to develop an understanding of what counts as quality work by critiquing their peers' work in relation to a particular learning outcome.

Use of Technology

Computational tools are essential in many branches of mathematics. They support the discovery of mathematical results and applications of mathematics. Mathematicians use computers to solve computationally challenging problems, explore new ideas, form conjectures and prove theorems. Many of the applications of mathematics rely on the availability of computing power to perform operations at high speed and on a large scale. Therefore, integrating technology into the learning of mathematics gives students a glimpse of the tools and practices of mathematicians.

Computational tools are also essential for the learning of mathematics. In particular, they support the understanding of concepts (e.g. simulation and digital manipulatives), their properties (e.g. geometrical properties) and relationships (e.g. algebraic form versus graphical form). More generally, they can be used to carry out investigation (e.g., graphing tools), communicate ideas (e.g. presentation tools) and collaborate with one another as part of the knowledge building process (e.g. discussion forum). In particular, every student should be familiar with basic spreadsheet skills.

Getting students to design and implement some of the algorithms in mathematics (e.g. finding prime factors, multiplying two matrices, finding the median of a list of data) can potentially help these students develop a clearer understanding of the algorithms and the underlying mathematics concepts as well.

Blended Learning

Blended Learning transforms our students' educational experience by seamlessly blending different modes of learning. The key intents are to nurture: (i) self-directed and independent learners; and (ii) passionate and intrinsically motivated learners.

Blended Learning provides students with a broad range of learning experiences as shown in the diagram below. It includes the integration of *home-based learning (HBL) as a regular feature of the schooling experience*. Regular HBL can equip students with stronger abilities, dispositions and habits for independent and lifelong learning, in line with MOE's Learn for Life movement. Generally, all topics in the Secondary Mathematics syllabuses can be redesigned as a form of Blended Learning.

Examples of Blended Learning Experiences

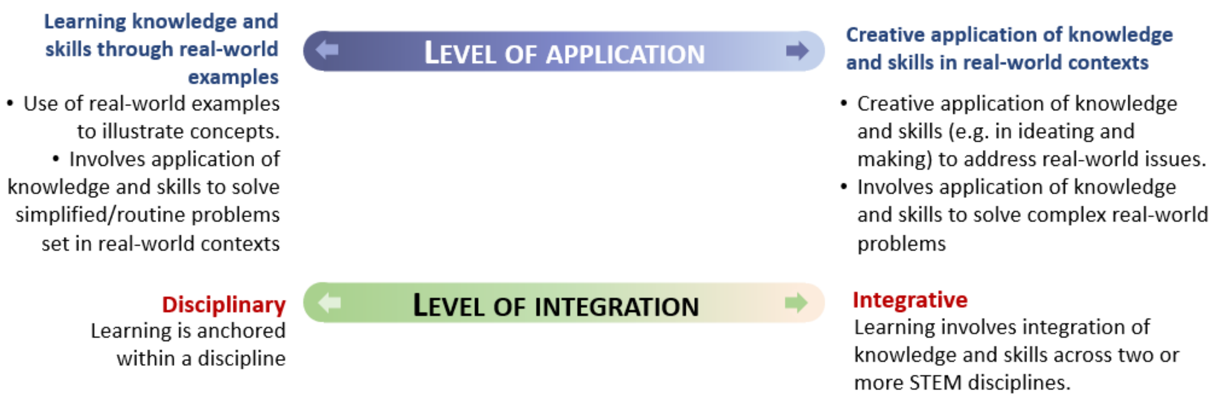
HBL also provides dedicated time and space for students to actively discover their interests and plan how they should go about pursuing them through student-initiated learning (SIL). There are three broad types of SIL activities, namely, school-curated, student-initiated with school facilitation and full student-initiated. These activities should be safe, wholesome and grounded on shared national values, and should engender a spirit of lifelong learning. Examples of SIL for Secondary Mathematics are exploring how Mathematics is used in an area of interest such as game designing and interior designing, and attempting real-world problems outside of the Mathematics curriculum.

For effective Blended Learning experiences, traditional in-class learning should be thoughtfully integrated with other learning approaches such as technology-based approaches. Teachers should be intentional and selective with the aspects of the curriculum to be delivered in school or at home, and leverage technology where it is meaningful and helpful for learning.

STEM Learning

STEM education seeks to strengthen the interest and capabilities of our students in STEM to prepare them for an increasingly complex and uncertain world. We want our students to be curious about the world around them, to think creatively and critically in solving problems, and be concerned citizens who make a difference in society. These are the goals of STEM education.

When designing STEM learning experiences, we can consider two aspects: 1) level of integration and 2) level of application. These two aspects lie on a continuum as illustrated in the figure below.



Design Considerations for STEM Learning

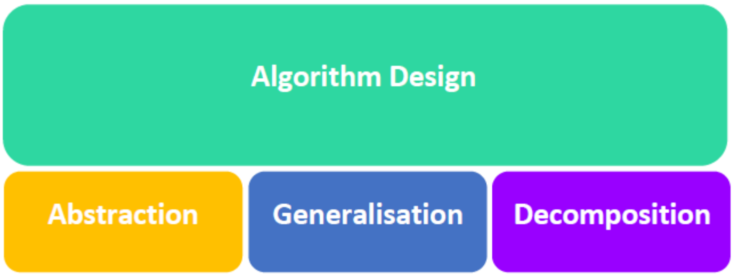
STEM learning experiences can happen at different levels of application,

- <u>within each STEM discipline:</u> Make learning relevant by selecting suitable real-world contexts to illustrate the knowledge, skills and practices in mathematics. Encourage creative application by allowing students to apply their mathematical knowledge, skills, and practices to work collaboratively in solving real-world problems and issues.
- <u>through integrating across STEM disciplines</u>: Enhance students' understanding to provide them with a more coherent and complete understanding of what they are learning in Mathematics by making connections with what is learnt in other STEM disciplines. Equip

students with the ability to manage complexity through learning experiences that require them to apply their knowledge, skills and practices across the STEM disciplines and work collaboratively in solving real-world problems with multiple solutions.

Developing Computational Thinking (CT) in Mathematics

Computational thinking can be described as the thought process involved in formulating problems and developing approaches to solving them in a manner that can be implemented with a computer (Wing, J. M., 2006). In general, computational thinking refers to four thinking skills, namely – abstraction, decomposition, generalisation and algorithm design, all of which are fundamental to problem-solving in mathematics.



Four Skills in Computational Thinking

The mathematics curriculum supports the development of CT by engaging students in tasks that involve algorithm design. Students will learn how to identify the essential information as input for their algorithm (abstraction), think of a general approach to solve the problem (generalisation) and to simplify the design of their algorithm by breaking them down into parts (decomposition) if necessary.

Designing algorithms, be it in words, flowcharts, or pseudo code, help students articulate their problem-solving approaches and make their thinking visible.

SECTION 5:
SUMMATIVE ASSESSMENT

Assessment Objectives
National Examinations

5. SUMMATIVE ASSESSMENT

Assessment Objectives

The purpose of summative assessments, such as tests and examinations, is to measure the extent to which students have achieved the learning objectives of the syllabuses.

The assessment objectives (AOs) reflect the emphasis of the syllabuses and describe what students should know and be able to do with the concepts and skills learned in each syllabus.

The AOs for the G1 Mathematics syllabus are given below.

AOs	G1 Mathematics
AO 1	**Use and apply standard techniques** • recall and use facts, terminology and notation • read and use information directly from tables, graphs, diagrams and texts • carry out routine mathematical procedures
AO 2	**Solve problems in a variety of contexts** • interpret information to identify the relevant mathematics concept, rule or formula to use • translate information from one form to another • make and use connections across topics/subtopics • formulate problems into mathematical terms • analyse and select relevant information and apply appropriate mathematical techniques to solve problems • interpret results in the context of a given problem
AO 3	**Reason and communicate mathematically** • justify mathematical statements • provide mathematical explanation in the context of a given problem

National Examinations

Students will take national examination in their final year. The examination syllabuses can be found in the SEAB website. The following segment shows the national examination code and the scheme of assessment for the G1 Mathematics syllabus.

Scheme of Examination Papers

G1 Mathematics (Code – 4046; First Year of Examination – 2023)

Paper	Duration	Description	Marks	Weighting
1	1 h 30 min	There will be 11 – 13 short-answer questions of 2 – 4 marks each, largely context-free and testing fundamental concepts and skills, followed by 2 longer questions of 6 – 8 marks, developed around a context. Candidates are required to answer **all** questions which will cover topics from the following strands • Number and Algebra • Geometry and Measurement	50	50%
2	1 h 30 min	There will be 11 – 13 short-answer questions of 2 – 4 marks each, largely context-free and testing fundamental concepts and skills, followed by 2 longer questions of 6 – 8 marks, developed around a context. Candidates are required to answer **all** questions which will cover topics from the following strands • Number and Algebra • Statistics and Probability	50	50%