

# Introduction

## Background

The mathematics curriculum for Atlantic Canada has been written in an effort to align the outcomes for student learning in mathematics with the recommendations of *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989). This document identifies the primary goal for all students as the attainment of mathematical power—the ability to make mathematical connections, to reason logically, to communicate and apply mathematics effectively in problem situations. Since the late 1980s, several influential publications have affirmed this goal. In addition to *Curriculum and Evaluation Standards for School Mathematics*, these include two publications from the Mathematical Sciences Education Board—*Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (1989) and *Reshaping School Mathematics* (1990). In addition to these publications, the National Council of Teachers of Mathematics (NCTM) published the companion standards documents *Professional Standards for Teaching Mathematics* (1991) and *Assessment Standards for School Mathematics* (1995). In April 2000, the NCTM published its newest document, *Principles and Standards for School Mathematics*, a revision, rewriting, and restatement of the 1989 *Curriculum and Evaluation Standards for School Mathematics*.

*Foundation for the Atlantic Canada Mathematics Curriculum* (1996) firmly establishes *Curriculum and Evaluation Standards for School Mathematics* (NCTM 1989) as a guiding beacon for pursuing this vision, a vision that fosters the development of mathematically literate students. Curriculum design has been motivated by a desire to ensure that students benefit from world-class curriculum and instruction in mathematics as a significant part of their school learning experience. Today, students are increasingly being challenged to become problem solvers, to understand mathematical concepts by becoming active learners in highly interactive learning experiences. Computers and calculators are becoming common classroom tools, and innovations in assessment of student learning (which include portfolios and open-ended questions) are being used in classrooms.

Mathematics curriculum development in this region has taken place under the auspices of the Atlantic Provinces Education Foundation (APEF), an organization sponsored and managed by the governments of the four Atlantic provinces. The development process has brought together teachers and Department of Education officials to co-operatively plan and execute the development of curricula in mathematics, science, language arts, and some other subject areas.

Each of these curriculum efforts has been aimed at producing a program that would ultimately support the essential graduation learnings (EGLs), also developed regionally. The essential graduation learnings, and the contribution of the mathematics curriculum to their achievement, are presented in the Outcomes section of *Foundation for the Atlantic Canada Mathematics Curriculum*.

The mathematics foundation document provides an overview of the philosophy and goals of the mathematics curriculum, presenting broad curriculum outcomes and addressing a variety of issues with respect to the learning and teaching of mathematics. It describes the mathematics curriculum in terms of a framework of outcomes—general curriculum outcomes (GCOs), which relate to subject strands, and key-stage curriculum outcomes (KSCOs), which identify what students are expected to know and be able to do by the end of grades 3, 6, 9, and 12.

Each course guide builds on the structure introduced in the foundation document by relating specific curriculum outcomes (SCOs) to each KSCO and providing suggestions for learning experiences, instruction, assessment, and resources.

## Rationale

The purposes of high school mathematics are embedded in a context that is broad and consistent with accelerating changes in today's society—a society that is increasingly dominated by technology and quantitative methods. Predictions are that high school graduates in the future will change careers at least four or five times. If we are to develop curriculum for students who need to be flexible with respect to the workplace and capable of lifelong learning, high school mathematics must emphasize a dynamic form of literacy, and high school mathematics instruction must maximize the opportunity for students to achieve outcomes dealing with a broad range of topics. Experiences must be provided that encourage and enable students to gain confidence in their mathematical ability, solve mathematical problems, reason and communicate mathematically, and understand the value of mathematics.

Expectations of employers and post-secondary institutions reflect the need for all students to understand the complexities and technologies of communication, to ask questions, to assimilate unfamiliar information, and to work co-operatively. These needs are best addressed by developing a curriculum that reflects the following beliefs:

- ***Knowing mathematics is “doing mathematics.”***

Mathematics is more than just a collection of concepts and skills to be mastered; it includes methods of investigating and reasoning, means of communication, and notions of context.

Instructional settings and student activities should be developed and grow out of problem situations. This view of learning is summarized in *Everybody Counts* (Mathematical Sciences Education Board, 1989.) “In reality, no one can teach mathematics. Effective teachers are those who can stimulate students to learn mathematics. Educational research offers compelling evidence that students learn mathematics when they construct their own mathematical understanding. To understand what they learn, they must enact for themselves verbs that permeate the mathematics curriculum: ‘examine, represent, transform, solve, apply, prove, communicate’. This happens most readily when they are in groups, engage in discussion, make presentations, and in other ways take charge of their own learning.”

- ***Mathematics has broad content encompassing many fields***

Some aspects of doing mathematics have changed in the last decade. For example, quantitative techniques have permeated almost all intellectual disciplines, and this phenomenon has changed the fundamental mathematical ideas needed. Although traditional topics remain very important components of the curriculum, there is a shift in emphasis from a curriculum dominated by memorization of isolated facts and procedures and by proficiency with paper-and-pencil skills to one that emphasizes conceptual understanding, multiple representations and connections, mathematical modeling, and problem solving.

The integration of ideas from algebra and geometry is particularly strong, with graphical representation playing an important connecting role. Frequent references to graphing utilities indicate the value of computers with appropriate graphing software and/or a graphing calculator availability for students. Topics from statistics, probability, and discrete mathematics are now elevated to a more central position for all students.

Arithmetic computation is not a direct object of study in the high school mathematics curriculum; however, conceptual and procedural understandings of number, numeration, and operations and the ability to make estimations and approximations to judge the reasonableness of results are strengthened in the context of applications and problem solving. Emphasis is placed on the role of technology and appropriate concepts and skills related to their use.

- ***Changes in technology and the broadening of the areas in which mathematics is applied have resulted in growth and changes in the discipline of mathematics itself.***

New technology has not only made calculations and graphing easier, it has changed the very nature of the problems important to mathematics and the methods mathematicians use to investigate them. Because technology is changing mathematics and its uses, students should learn to use graphing calculators and computers as

tools for processing information and performing calculations to investigate and solve problems.

The visualization approach offered through the use of graphing utilities such as the graphing calculator affords more students greater access to more mathematics.

With the wide availability of technology comes additional decision making regarding what skills need to be developed mentally. Some aspects of further development in mathematics are facilitated when students reach an automatic response level with respect to certain basic skills.

## Meeting the Needs of All Learners

An important emphasis in this curriculum is the need to deal successfully with a wide variety of equity and diversity issues. Not only must teachers be aware of, and adapt instruction to account for, differences in student readiness as they begin this course and as they progress, but they must also remain aware of the importance of avoiding gender and cultural biases in their teaching. Ideally, every student should find his/her learning opportunities maximized in the mathematics classroom.

The reality of individual student differences must be recognized as teachers make instructional decisions. While *Mathematics 2206* presents specific curriculum outcomes for the course, it must be acknowledged that all students will not progress at the same pace and will not be equally positioned with respect to attaining a given outcome at any given time. The specific curriculum outcomes represent, at best, a reasonable framework for helping students to ultimately achieve the key-stage and general curriculum outcomes.

# Curriculum Outcomes

## Curriculum Outcomes Framework

The mathematics curriculum is based on a framework of outcomes statements articulating what students are expected to know, be able to do, and value as a result of their learning experiences in mathematics. This framework comprises statements of the essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. *Foundation for the Atlantic Canada Mathematics Curriculum* articulates general curriculum outcomes and key-stage curriculum outcomes. Curriculum guides provide specific curriculum outcomes for each course, together with elaborations and suggestions for related instructional and assessment strategies and tasks. Teachers and administrators are expected to refer to the curriculum outcomes framework to design learning environments and experiences that reflect the needs and interests of the students.

## Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Essential graduation learnings are cross-curricular in nature and comprise different areas of learning: **aesthetic expression, citizenship, communication, personal development, problem solving, technological competence and spiritual and moral development.**

## Aesthetic Expression

*Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.*

## Citizenship

*Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.*

## Communication

*Graduates will be able to use the listening, viewing, speaking, reading and writing modes of language(s) and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.*

## Personal Development

*Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.*

## Problem Solving

*Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts.*

## Technological Competence

*Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.*

## Spiritual and Moral Development

*Graduates will demonstrate an understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct.*

See *Foundation for the Atlantic Canada Mathematics Curriculum*, pages 4–6.

## General Curriculum Outcomes

General curriculum outcomes are statements that identify what students are expected to know and be able to do upon completion of study in mathematics. General curriculum outcomes contribute to the attainment of the essential graduation learnings and are connected to key-stage curriculum outcomes. The seven general curriculum outcomes for mathematics are organized in terms of four content strands: number concepts/number and relationship operations; patterns and relations; shape and space; and data management and probability.

### **Number Concepts/Number and Relationship Operations**

- Students will demonstrate number sense and apply number theory concepts.
- Students will demonstrate operation sense and apply operation principles and procedures in both numeric and algebraic situations.

### **Patterns and Relations**

- Students will explore, recognize, represent and apply patterns and relationships, both informally and formally.

### **Shape and Space**

- Students will demonstrate an understanding of and apply concepts and skills associated with measurement.
- Students will demonstrate spatial sense and apply geometric concepts, properties and relationships.

### **Data Management and Probability**

- Students will solve problems involving the collection, display and analysis of data.
- Students will represent and solve problems involving uncertainty.

## **Key-Stage Curriculum Outcomes**

Key-stage curriculum outcomes (KSCOs) are statements that identify what students are expected to know and be able to do by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in mathematics. This curriculum guide lists key-stage curriculum outcomes for the end of grade 12 (see p. 17). Specific curriculum outcomes are referenced to key-stage curriculum outcomes on these same pages.

## **Specific Curriculum Outcomes**

Specific curriculum outcomes are statements identifying what students are expected to know and be able to do at a particular grade level, which contribute to the achievement of the key-stage curriculum outcomes.

In the table that follows, the grade 9 and Mathematics 1206 Specific Curriculum Outcomes are listed.

## SCO's for Grade 9 and Mathematics 1206

### GCO A: Students will demonstrate number sense and apply number theory concepts.

**Elaboration:** Number sense includes understanding number meanings, developing multiple relationships among numbers, recognizing the relative magnitudes of numbers, knowing the relative effect of operations on numbers and developing referents for measurement. Number theory concepts include such number principles as laws (e.g., commutative and distributive), factors and primes, and number system characteristics (e.g., density).

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**A1** solve problems involving square root and principal square root

**A2** graph and write in symbols and in words the solution set for equations and inequalities involving integers and other real numbers

**A3** demonstrate an understanding of the meaning and uses of irrational numbers

**A4** demonstrate an understanding of the inter-relationships of subsets of real numbers

**A5** compare and order real numbers

**A6** represent problem situations using matrices

*By the end of Mathematics 1206, students will be expected to*

**A2** analyse graphs or charts of situations to identify specific information

**A3** demonstrate an understanding of the role of irrational numbers in applications

**A4** approximate square roots

**A6** apply properties of numbers when operating upon expressions and equations

**A7** demonstrate and apply an understanding of discrete and continuous number systems

**A9** explore properties of square roots in applications

## **GCO B: Students will demonstrate operation sense and apply operation principles and procedures in both numeric and algebraic situations.**

**Elaboration:** Operation sense consists of recognizing situations in which a given operation would be useful, building awareness of models and the properties of an operation, seeing relationships among operations and acquiring insights into the effects of an operation on a pair of numbers. Operation principles and procedures would include such items as the effect of identity elements, computational strategies and mental mathematics.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**B1** model, solve, and create problems involving real numbers

**B2** add, subtract, multiply, and divide rational numbers in fractional and decimal forms, using the most appropriate methods

**B3** apply the order of operations in rational number computations

**B4** demonstrate an understanding of, and apply the exponent laws for integral exponents

**B5** model, solve, and create problems involving numbers expressed in scientific notation

**B6** judge the reasonableness of results in problem situations involving square roots, rational numbers, and numbers written in scientific notation

**B7** model, solve, and create problems involving the matrix operations of addition, subtraction, and scalar multiplication

**B8** add and subtract polynomial expressions symbolically to solve problems

*By the end of Mathematics 1206, students will be expected to*

**B1** model (with concrete materials and pictorial representations) and express the relationships between arithmetic operations and operations on algebraic expressions and equations

**B3** use concrete materials, pictorial representations, and symbolism to perform operations on polynomials

**B5** develop, analyse and apply procedures for matrix multiplication

**B6** solve network problems using matrices

**GCO B: Students will demonstrate operation sense and apply operation principles and procedures in both numeric and algebraic situations. (continued)**

**Elaboration:** Operation sense consists of recognizing situations in which a given operation would be useful, building awareness of models and the properties of an operation, seeing relationships among operations and acquiring insights into the effects of an operation on a pair of numbers. Operation principles and procedures would include such items as the effect of identity elements, computational strategies and mental mathematics.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**B9** factor algebraic expressions with common monomial factors, concretely, pictorially, and symbolically

**B10** recognize that the dimensions of a rectangular model of a polynomial are its factors

**B11** find products of two monomials, a monomial and a polynomial, and two binomials concretely, pictorially, and symbolically

**B12** find quotients of polynomials with monomial divisors

**B13** evaluate polynomial expressions

**B14** demonstrate an understanding of the applicability of commutative, associative, distributive, identity, and inverse properties to operations involving algebraic expressions

**B15** select and use appropriate strategies in problem situations

*By the end of Mathematics 1206, students will be expected to*

## GCO C: Students will explore, recognize, represent and apply patterns and relationships, both informally and formally.

**Elaboration:** Patterns and relationships run the gamut from number patterns and those made from concrete materials to polynomial and exponential functions. The representation of patterns and relationships will take on multiple forms, including sequences, tables, graphs, and equations, and these representations will be applied as appropriate in a wide variety of relevant situations.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

- C1** represent patterns and relationships in a variety of formats and use these representations to predict and justify unknown values
- C2** interpret graphs that represent linear and non-linear data
- C3** construct and analyse tables and graphs to describe how changes in one quantity affect a related quantity
- C4** determine the equations of lines by obtaining their slopes and y-intercepts from graphs and sketch graphs of equations using y-intercepts and slopes
- C5** explain the connections among different representations of patterns and relationships
- C6** solve single-variable equations algebraically and verify the solutions
- C7** solve first-degree single-variable inequalities algebraically, verify the solutions, and display them on number lines
- C8** solve and create problems involving linear equations and inequalities

*By the end of Mathematics 1206, students will be expected to*

- C1** express problems in terms of equations and vice versa
- C2** model real-world phenomena with linear and quadratic equations
- C3** gather data, plot the data using appropriate scales and demonstrate an understanding of independent and dependent variables, and domain and range
- C4** create and analyse scatter plots using appropriate technology
- C5** sketch graphs from words, tables, and collected data
- C7** model real-world situations with networks
- C8** identify, generalize, and apply patterns
- C9** construct and analyse graphs and tables relating two variables
- C10** describe real-world relationships depicted by graphs, tables of values, and written descriptions
- C13** determine and interpret the slope and y-intercept of a line from a table of values or a graph
- C14** determine the equation of a line using the slope and y-intercept
- C15** develop and apply strategies for solving problems
- C16** interpret solutions to equations based on context
- C17** solve problems using graphing technology

## **GCO C: Students will explore, recognize, represent and apply patterns and relationships, both informally and formally. (continued)**

**Elaboration:** Patterns and relationships run the gamut from number patterns and those made from concrete materials to polynomial and exponential functions. The representation of patterns and relationships will take on multiple forms, including sequences, tables, graphs, and equations, and these representations will be applied as appropriate in a wide variety of relevant situations.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

*By the end of Mathematics 1206, students will be expected to*

**C18** investigate and find the solution to a problem by graphing two linear equations with and without technology

**C21** explore and apply functional relationships informally

**C25** solve equations using graphs

**C26** solve quadratic equations by factoring

**C28** explore and describe the dynamics of change depicted in tables and graphs

**C29** investigate and make and test conjectures concerning the steepness and direction of a line

**C31** graph equations and analyse graphs both with and without graphing technology

**C32** plot points, given a situation or a table of values, to help determine if a graph is linear

**C33** graph by constructing a table of values, by using graphing technology, and when appropriate by the slope y-intercept method

**C35** expand and factor polynomial expressions using perimeter and area models

**C36** explore, determine, and apply relationships between perimeter and area, surface area and volume

**C37** represent network problems using matrices and vice versa

**C38** transform linear equations into slope y-intercept form

**C39** make and test conjectures about how linear and quadratic graphs change as particular values in the equations change

**C40** solve linear equations algebraically

## **GCO D: Students will demonstrate an understanding of and apply concepts and skills associated with measurement.**

**Elaboration:** Concepts and skills associated with measurement include making direct measurements, using appropriate measurement units and using formulas (e.g., surface area, Pythagorean Theorem) and/or procedures (e.g., proportions) to determine measurements indirectly.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**D1** solve indirect measurement problems by connecting rates and slopes

**D2** solve measurement problems involving conversion among SI units

**D3** relate the volumes of pyramids and cones to the volumes of corresponding prisms and cylinders

**D4** estimate, measure, and calculate dimensions, volumes, and surface areas of pyramids, cones and spheres, in problem situations

**D5** demonstrate an understanding of and apply ratios within similar triangles

*By the end of Mathematics 1206, students will be expected to*

**D1** determine and apply formulas for perimeter, area, surface area, and volume

**D3** relate the trigonometric functions to the ratios in similar right triangles

**D4** use calculators to find trigonometric values of angles and angles when trigonometric values are known

**D6** solve problems involving measurement using bearings and vectors

**D7** determine the accuracy and precision of a measurement

**D8** solve problems involving similar triangles and right triangles

**D10** determine and apply relationships between the perimeters and areas of similar figures, and between the surface areas and volumes of similar solids

**D11** explore, discover, and apply properties of maximum area and volume

**D12** solve problems using the trigonometric ratios

**D13** demonstrate an understanding of the concepts of surface area and volume

**D14** apply the Pythagorean Theorem

## **GCO E: Students will demonstrate spatial sense and apply geometric concepts, properties, and relationships.**

**Elaboration:** Spatial sense is an intuitive feel for one's surroundings and the objects in them and is characterized by such geometric relationships as (i) the direction, orientation and perspectives of objects in space, (ii) the relative shapes and sizes of figures and objects, and (iii) how a change in shape relates to a change in size. Geometric concepts, properties, and relationships are illustrated by such examples as the concept of area, the property that a square maximizes area for rectangles of a given perimeter, and the relationships among angles formed by a transversal intersecting parallel lines.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**E1** investigate and demonstrate an understanding of the minimum sufficient conditions to produce unique triangles

**E2** investigate and demonstrate an understanding of the properties of and the minimum sufficient conditions to guarantee congruent triangles

**E3** make informal deductions using congruent triangle and angle properties

**E4** demonstrate an understanding of and apply the properties of similar triangles

**E5** relate congruence and similarity of triangles

**E6** use mapping notation to represent translations, transformations of geometric figures and interpret such notations

**E7** analyse and represent combinations of transformations using mapping notation

**E8** investigate, determine, and apply the effects of transformations of geometric figures on congruence, similarity, and orientation

*By the end of Mathematics 1206, students will be expected to*

**E1** explore properties of, and make and test conjectures about 2- and 3-dimensional figures

**E2** solve problems involving polygons and polyhedra

**E6** represent network problems as digraphs

**E7** demonstrate an understanding of a proof for the Pythagorean Theorem

**E8** use inductive reasoning when observing patterns, developing properties, and making conjectures

**E10** investigate line and rotational symmetry

**E11** draw nets of various polyhedra

## GCO F: Students will solve problems involving the collection, display and analysis of data.

**Elaboration:** The collection, display and analysis of data involves (i) attention to sampling procedures and issues, (ii) recording and organizing collected data, (iii) choosing and creating appropriate data displays, (iv) analysing data displays in terms of broad principles (e.g., display bias) and via statistical measures (e.g., mean) and (v) formulating and evaluating statistical arguments.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

- F1** determine characteristics of possible relationships shown in scatter plots
- F2** sketch lines of best fit and determine their equations
- F3** sketch curves of best fit for relationships that appear to be non-linear
- F4** select, defend, and use the most appropriate methods for displaying data
- F5** draw inferences and make predictions based on data analysis and data displays
- F6** demonstrate an understanding of the role of data management in society
- F7** evaluate arguments and interpretations that are based on data analysis

*By the end of Mathematics 1206, students will be expected to*

- F1** design and conduct experiments using statistical methods and scientific inquiry
- F2** demonstrate an understanding of concerns and issues that pertain to the collection of data
- F3** construct various displays of data
- F4** calculate various statistics using appropriate technology, analyse and interpret displays, and describe the relationships
- F5** analyse statistical summaries, draw conclusions, and communicate results about distributions of data
- F6** solve problems by modeling real-world phenomena
- F7** explore non-linear data using power and exponential regression to find a curve of best fit
- F8** determine and apply a line of best fit using linear regression with technology
- F9** demonstrate an intuitive understanding of correlation
- F10** use interpolation, extrapolation and equations to predict and solve problems
- F15** approximate a line of best fit from a scatter plot

## **GCO G: Students will represent and solve problems involving uncertainty.**

**Elaboration:** Representing and solving problems involving uncertainty entails (i) determining probabilities by conducting experiments and/or making theoretical calculations, (ii) designing simulations to determine probabilities in situations which do not lend themselves to direct experiment, and (iii) analysing problem situations to decide how best to determine probabilities.

The following are the Specific Curriculum Outcomes (SCOs) for grade 9 and Mathematics 1206.

*By the end of grade 9, students will be expected to*

**G1** make predictions of, and conduct experiments and simulations to determine probabilities involving dependent and independent variables

**G2** determine theoretical probabilities of compound events

**G3** compare experimental and theoretical probabilities

**G4** recognize and explain why decisions based on probabilities may be combinations of theoretical calculations, experimental results, and subjective judgements

*By the end of Mathematics 1206, students will be expected to*

## Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes (KSCOs) are statements that identify what students are expected to know and be able to do by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in mathematics. This curriculum guide lists key-stage curriculum outcomes for the end of grade 12 (see p. 17). Specific curriculum outcomes are referenced to key-stage curriculum outcomes on these same pages.

## Specific Curriculum Outcomes

Specific curriculum outcomes are statements identifying what students are expected to know and be able to do at a particular grade level, which contribute to the achievement of the key-stage curriculum outcomes.

In the table that follows (pp. 17–26), the Mathematics 2206 Specific Curriculum Outcomes are listed and aligned to the corresponding KSCO. The numbers that follow each outcomes statement are the page numbers in this document where that outcome is being addressed.

## SCO's KSCO's for Mathematics 2206

### GCO A: Students will demonstrate number sense and apply number theory concepts.

**Elaboration:** Number sense includes understanding of number meanings, developing multiple relationships among numbers, recognizing the relative magnitudes of numbers, knowing the relative effect of operations on numbers and developing referents for measurement. Number theory concepts include such number principles as laws (e.g., commutative and distributive), factors and primes, and number system characteristics (e.g., density).

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> demonstrate an understanding of number meanings with respect to the real numbers</p> <p><b>KSCO ii:</b> order real numbers, represent them in multiple ways (including scientific notation) and apply appropriate representations to solve problems</p> <p><b>KSCO iii:</b> demonstrate an understanding of the real number system and its subsystems by applying a variety of number theory concepts in relevant situations</p> <p><i>Some post-secondary intending students will be expected to:</i></p> <p><b>KSCO iv:</b> explain and apply relationships among real and complex numbers</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>A2</b> relate sets of numbers to solutions of inequalities (44, 50, 52, 54)</p> <p><b>A3</b> demonstrate an understanding of the application of random numbers to statistical sampling (84)</p>

## GCO B: Students will demonstrate operation sense and apply operation principles and procedures in both numeric and algebraic situations.

**Elaboration:** Operation sense consists of recognizing situations in which a given operation would be useful, building awareness of models and the properties of an operation, seeing relationships among operations and acquiring insights into the effects of an operation on a pair of numbers. Operation principles and procedures would include such items as the effect of identity elements, computational strategies and mental mathematics.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> explain how algebraic and arithmetic operations are related, use them in problem-solving situations, and explain and demonstrate the power of mathematical symbolism</p> <p><b>KSCO ii:</b> derive, analyse and apply computational procedures (algorithms) in situations involving all representations of real numbers</p> <p><b>KSCO iii:</b> derive, analyse and apply algebraic procedures (including those involving algebraic expressions and matrices) in problem situations</p> <p><b>KSCO iv:</b> apply estimation techniques to predict, and justify the reasonableness of, results in relevant problem situations involving real numbers</p> <p><i>Some post-secondary intending students will be expected to:</i></p> <p><b>KSCO v:</b> apply operations on complex numbers to solve problems</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>B3</b> demonstrate an understanding of the relationship between arithmetic operations and operations on equations and inequalities (46, 54, 104, 108)</p> <p><b>B4</b> use the calculator correctly and efficiently (46, 54, 70, 68, 72, 74, 104, 106, 108, 110, 112)</p> <p><b>B7</b> estimate and calculate income and deductions (68, 70, 72)</p> <p><b>B8</b> solve problems involving budgets (72)</p> <p><b>B9</b> analyse situations and make decisions involving the financing of purchases (74, 78)</p> <p><b>B10</b> analyse situations and make decisions involving the cost of transportation (76)</p>

## GCO C: Students will explore, recognize, represent and apply patterns and relationships, both informally and formally.

**Elaboration:** Patterns and relationships run the gamut from number patterns and those made from concrete materials to polynomial and exponential functions. The representation of patterns and relationships will take on multiple forms, including sequences, tables, graphs, and equations, and these representations will be applied as appropriate in a wide variety of relevant situations.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> model real-world problems using functions, equations, inequalities and discrete structures</p> <p><b>KSCO ii:</b> represent functional relationships in multiple ways (e.g., written descriptions, tables, equations and graphs) and describe connections among these representations</p> <p><b>KSCO iii:</b> interpret algebraic equations and inequalities geometrically and geometric relationships algebraically</p> <p><b>KSCO iv:</b> solve problems involving relationships, using graphing technology as well as paper-and-pencil techniques</p> <p><b>KSCO v:</b> analyse and explain the behaviours, transformations and general properties of types of equations and relations</p> <p><b>KSCO vi:</b> perform operations on and between functions</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>C6</b> apply the linear programming process to find optimal solutions (48, 52)</p> <p><b>C8</b> demonstrate an understanding of real-world relationships by translating between graphs, tables, and written descriptions (42, 44, 70)</p> <p><b>C11</b> express and interpret constraints (48, 50, 68)</p> <p><b>C18</b> interpolate and extrapolate to solve problems (44, 70, 68)</p> <p><b>C20</b> solve systems of equations and inequalities both with and without technology (54)</p> <p><b>C26</b> demonstrate an understanding of the difference between simple and compound interest (74)</p> <p><b>C28</b> solve simple trigonometric equations (104, 108)</p>

## GCO D: Students will demonstrate an understanding of and apply concepts and skills associated with measurement.

**Elaboration:** Concepts and skills associated with measurement include making direct measurements, using appropriate units and using formulas (e.g., surface area, Pythagorean Theorem) and/or procedures (e.g., proportions) to determine measurements indirectly.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> measure quantities indirectly, using techniques of algebra, geometry and trigonometry</p> <p><b>KSCO ii:</b> determine measurements in a wide variety of problem situations and determine specified degrees of precision, accuracy, and error of measurements</p> <p><b>KSCO iii:</b> apply measurement formulas and procedures in a wide variety of contexts</p> <p><b>KSCO iv:</b> demonstrate an understanding of the meaning of area under a curve</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>D4</b> solve problems using the sine, cosine, and tangent ratios (104)</p> <p><b>D5</b> apply the Law of Sines, the Law of Cosines, and the formula “area of a triangle <math>ABC = \frac{1}{2} bc \sin A</math>” to solve problems (106, 108, 110, 112)</p>

## GCO E: Students will demonstrate spatial sense and apply geometric concepts, properties, and relationships.

**Elaboration:** Spatial sense is an intuitive feel for one's surroundings and the objects in them and is characterized by such geometric relationships as (i) the direction, orientation and perspectives of objects in space, (ii) the relative shapes and sizes of figures and objects, and (iii) how a change in shape relates to a change in size. Geometric concepts, properties, and relationships are illustrated by such examples as the concept of area, the property that a square maximizes area for rectangles of a given perimeter, and the relationships among angles formed by transversal intersecting parallel lines.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry-grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> extend spatial sense in a variety of mathematical contexts</p> <p><b>KSCO ii:</b> interpret and classify geometric figures, translate between synthetic (Euclidean) and co-ordinate representations, and apply geometric properties and relationships</p> <p><b>KSCO iii:</b> analyse and apply Euclidean transformations, including representing and applying translations as vectors</p> <p><b>KSCO iv:</b> represent problem situations with geometric models (including the use of trigonometric ratios and co-ordinate geometry) and apply properties of figures</p> <p><b>KSCO v:</b> make and test conjectures about, and deduce properties of and relationships between, 2- and 3-D figures in multiple contexts</p> <p><b>KSCO vi:</b> demonstrate an understanding of the operation of axiomatic systems and the connections among reasoning, justification and proof</p> <p><i><b>KSCO vii:</b> some post-secondary intending students will be expected to represent and apply vectors in three dimensions algebraically and geometrically</i></p> <p><i><b>KSCO viii:</b> some post-secondary intending students will be expected to explore and apply, using multiple representations, circles, ellipses and parabolas and, in 3-D, spheres and ellipsoids</i></p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>E3</b> represent systems of inequalities as feasible regions (52)</p> <p><b>E4</b> represent linear programming problems using the Cartesian coordinate system (52)</p>

## GCO F: Students will solve problems involving the collection, display and analysis of data.

**Elaboration:** The collection, display and analysis of data involves (i) attention to sampling procedures and issues, (ii) recording and organizing collected data, (iii) choosing and creating appropriate data displays, (iv) analysing data displays in terms of broad principles (e.g., display bias) and via statistical measures (e.g., mean) and (v) formulating and evaluating statistical arguments.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> understand sampling issues and their role with respect to statistical claims</p> <p><b>KSCO ii:</b> extend construction (both manually and via appropriate technology) of a wide variety of data displays</p> <p><b>KSCO iii:</b> use curve fitting to determine the relationship between, and make predictions from, sets of data and be aware of bias in the interpretation of results</p> <p><b>KSCO iv:</b> determine, interpret and apply, as appropriate, a wide variety of statistical measures and distributions</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>F1</b> draw inferences about population from a sample (80, 82, 86, 92)</p> <p><b>F2</b> identify bias in data collection, interpretation, and presentation (80, 86, 88)</p> <p><b>F3</b> demonstrate an understanding of what can be inferred about a population by examining sample means and dispersions (90, 92)</p> <p><b>F4</b> demonstrate an understanding of how the size of a sample affects the variation in sample results (82, 84, 92)</p> <p><b>F5</b> organize and display information in various ways with and without technology (42, 48, 88, 90, 94)</p> <p><b>F7</b> draw inferences from graphs, tables, and reports (68, 88, 94)</p> <p><b>F12</b> interpret normal curves and standard deviation to express levels of confidence (98)</p> <p><b>F13</b> calculate, analyse, and interpret various statistics (88, 94)</p>

## GCO F: Students will solve problems involving the collection, display and analysis of data. *(continued)*

**Elaboration:** The collection, display and analysis of data involves (i) attention to sampling procedures and issues, (ii) recording and organizing collected data, (iii) choosing and creating appropriate data displays, (iv) analysing data displays in terms of broad principles (e.g., display bias) and via statistical measures (e.g., mean) and (v) formulating and evaluating statistical arguments.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO v:</b> design and conduct relevant statistical experiments (e.g., projects with respect to current issues, career applications, and/or other disciplines) and analyse and communicate the results using a range of statistical arguments</p> <p><i>Some post-secondary intending students will be expected to</i></p> <p><b>KSCO vi:</b> test hypotheses using appropriate statistics</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>F15</b> design and conduct experiments/surveys to explore sampling variability (82, 90)</p> <p><b>F17</b> design and conduct experiments/surveys and interpret and communicate level confidence (98, 100)</p>

## GCO G: Students will represent and solve problems involving uncertainty

**Elaboration:** Representing and solving problems involving uncertainty entails (i) determining probabilities by conducting experiments and/or making theoretical calculations, (ii) designing simulations to determine probabilities in situations which do not lend themselves to direct experiment, and (iii) analysing problem situations to decide how best to determine probabilities.

Key-Stage Curriculum Outcomes (KSCO)	Mathematics 2206 Specific Curriculum Outcomes (SCO)
<p><i>By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to</i></p> <p><b>KSCO i:</b> design and conduct experiments and/or simulations to model and solve a wide variety of relevant probability problems, and interpret and judge the probabilistic arguments of others</p> <p><b>KSCO ii:</b> build and apply formal concepts and techniques of theoretical probability (including the use of permutations and combinations as counting techniques)</p> <p><b>KSCO iii:</b> understand the differences among, and relative merits of, theoretical, experimental and simulation techniques</p> <p><b>KSCO iv:</b> relate probability and statistical situations</p> <p><i>Some post-secondary intending students will be expected to</i></p> <p><b>KSCO v:</b> create and interpret discrete and continuous probability distributions and apply them in real-world situations</p>	<p><i>By the end of Mathematics 2206, students will be expected to</i></p> <p><b>G3</b> graph sample distributions and interpret them using the language of probability (94, 96)</p>

## Independent Study

Further to the General Curriculum Outcomes, an Independent Study unit has been developed for Mathematics 2206 and Mathematics 2204/2205. The purpose is to help prepare students for independent learning by providing them with an opportunity to research some mathematical topics and present their new mathematical understandings to other students.

After participating in this unit of work, students will be expected to

**I1** demonstrate an understanding of a mathematical topic through independent research (58, 60, 62, 64)

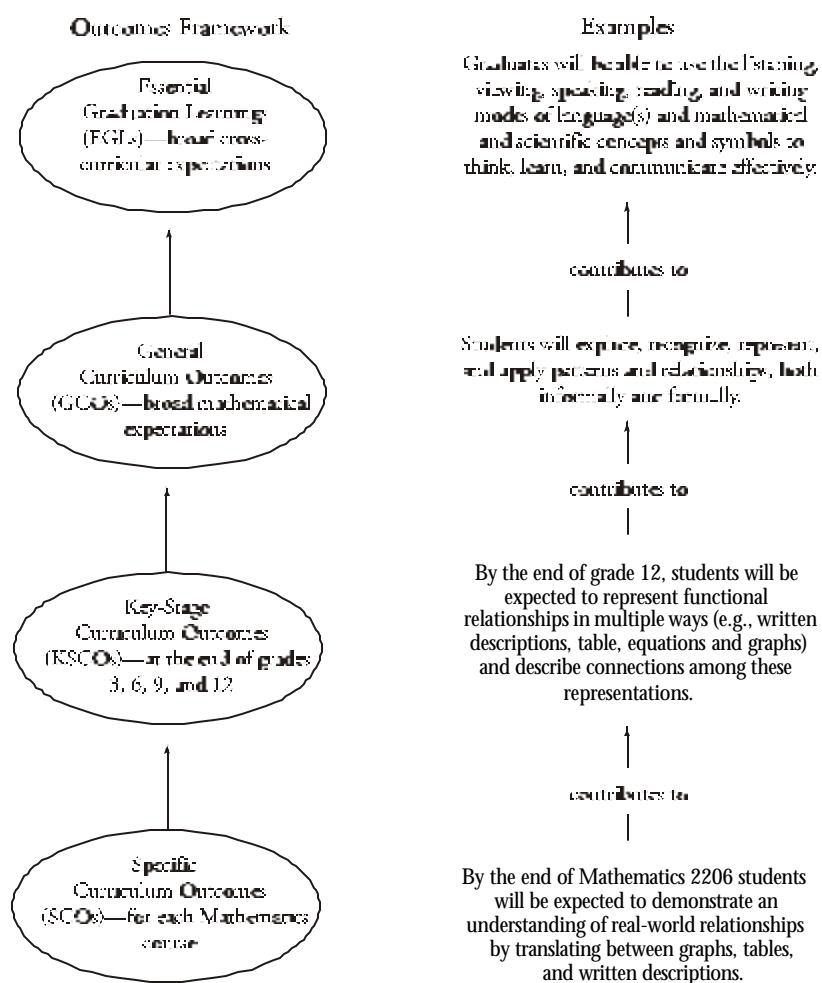
**I2** communicate the results of the independent research (58, 60, 62, 64)

**I3** demonstrate an understanding of the mathematical topics presented by other students (62, 64)

# Program Design and Components

## Program Organization

The mathematics curriculum is designed to make a significant contribution towards students' meeting each of the essential graduation learnings (EGLs), with the communication and problem-solving EGLs relating particularly well to the curriculum's unifying ideas. (See the Outcomes section of *Foundation for the Atlantic Canada Mathematics Curriculum*.) Specific curriculum outcomes represent the means by which students work toward accomplishing the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings.



It is important to emphasize that the presentation of the specific curriculum outcomes in the guide follows a suggested teaching sequence. Student and teacher resources have been developed to complement the curriculum guide.

It is recognized that students' understandings of concepts will vary in terms of depth and breadth. *Curriculum and Evaluation Standards for School Mathematics* recommends that the study of mathematics for every student revolve "around a core curriculum differentiated by the depth and breadth of the treatment of the topics and by the nature of the applications" (p. 9). While it is expected that all students will work toward achievement of the same outcomes, it is recognized that students will demonstrate different levels of performance.

Program Level	Course 1	Course 2	Course 3	Course 4
Advanced	Mathematics 1204	Mathematics 2205	Mathematics 3205	Mathematics 3207
Academic		Mathematics 2204	Mathematics 3204	Mathematics 3103
Practical	Mathematics 1206	Mathematics 2206	Mathematics 3206	

Students entering level II will select either the Mathematics 2205, Mathematics 2204, or Mathematics 2206 course depending on

- their success in previous mathematics courses
- their interests
- their academic/career goals in and beyond high school

The high school mathematics curriculum has been moulded into four courses (only three courses at the practical-level), each designed for **110 hours** minimum of instruction. All students, at all program levels, will work toward achievement of the **same key-stage outcomes**. While the key-stage curriculum outcomes are intended as targets for all students, they will not be expected to achieve them at a single level of performance. As well, there will be an additional small percentage of students who will see their outcomes significantly altered in individual educational programs.

Many of the specific curriculum outcomes for each grade level are the same, but not all. It is expected that some students can move from one program level to another.

The students in Practical-level courses will be expected to meet the same key-stage curriculum outcomes and many of the same specific (course) outcomes as those in Academic-level. As well, the instructional environment and philosophy should be the same at all levels. The significant difference between Practical- and Academic-level courses will be with respect to the level of performance expected in regard to each outcome and with regard to some topic differences. For example, a consumer unit is included in Mathematics 2206 whereas this unit does not exist in Mathematics 2204.

By and large, the Practical-level course should be characterized by a greater focus on concrete activities, models, and applications, with less emphasis given to formalism, symbolism, computational or symbol-manipulating facility, and mathematical structure. Academic- and Advanced-level courses will involve greater attention to abstraction and more sophisticated generalizations, while the Practical-level course would have less time spent on complex exercises and connections with advanced mathematical ideas.

Typically, students who choose Practical-level courses are those who may have experienced considerable difficulty in mathematics throughout their schooling and may lack confidence in their ability to learn. In addition, their literacy skills may not be on par with students of the same age. They may need more time on (more “passes” at) new concepts in order to understand them and may need connections presented in more explicit ways. They often exhibit lower self-esteem (in relation to mathematics) and require a pace that accommodates the revisiting and reinforcing of concepts, skills, and knowledge. These students need equal and where possible greater access than their peers to technology.

For example, students at all levels in Level III should develop an understanding of exponential relationships, but the methods used to teach these concepts would vary from one course to another. Students taking Practical-level courses have as much need as others to understand the nature of exponential relationships, given the place of these relationships in universal, everyday issues such as provincial and national debt and world population dynamics. The nature of exponential relationships can be developed through concrete, hands-on experiments and data analysis that do not require a lot of formalism or symbol manipulation yet. The more formal and symbolic operations on exponential relationships will be much more prevalent in the Academic- and Advanced-level courses, compare to the practical courses.

## Content Organization

The NCTM *Curriculum and Evaluation Standards for School Mathematics* establish mathematical problem solving, communication, reasoning, and connections as central elements of the mathematics curriculum. *Foundation for the Atlantic Canada Mathematics Curriculum* further emphasizes these unifying ideas and presents them as being integral to all aspects of the curriculum (see pp. 7–11). Indeed, while the general curriculum outcomes are organized around content strands, every opportunity has been taken to infuse the key-stage curriculum outcomes with one or more of the unifying ideas.

These unifying ideas serve to link the content to methodology. They make it clear that mathematics is to be taught in a problem-solving mode, that classroom activities and student assignments must be structured to provide opportunities for students to communicate

mathematically, that teacher encouragement and questioning should enable students to explain and clarify their mathematical reasoning, and that the mathematics with which students are involved on any given day must be connected to other mathematics, other disciplines, and/or the world around them.

## Mathematical Modeling

The mathematical content identified in the strands must not be viewed as independent units of study, but must be organized to develop depth as well as breadth. For this depth to be developed, a number of common connections must be visible to unify the core content. The unifying connections are as follows:

Throughout the strands of mathematics that are being studied, students need to see that mathematics is valuable in making predictions in the real world. Some basic mathematical structures that are used in modeling include graphs, equations, tables, and algorithms. Students need to understand also the limitations of modeling real situations, which are most often very complex. In some situations the modeling appears to be straightforward. Vectors can be used to model the movement of an aeroplane in a wind current; exponential functions can be used to model growth patterns that relate to money and population; quadratics can be used to model trajectory paths. At other times the model may require transformations in the data. Finding lines of best fit will allow us to better understand data from some real situations. Probability simulation may be used to model processes involving gambling, insurance, and genetics.

## Relations and Functions

An emphasis in the high school mathematics program is the study of relationships between two quantities. Across all strands of the mathematics program, students need to see the various ways in which one quantity can vary in relation to another. Students will study relationships, how input and output are related, and how patterns may be described in various ways, such as verbally, graphically, algebraically, and numerically in tables. A formula such as the one for the area of a circle,  $A(r) = \pi r^2$ , does not in itself provide a meaning of the relationship. Students need to see how a change in the radius “r” results in a corresponding change in the area “A(r).” This can be described verbally or graphically.

The type of mathematical reasoning that has students understand that the value of one variable may depend on the value of another, pervades all strands of mathematics. In discrete mathematics the functions are not continuous, but progress in steps; in exponential functions the functions are used to model growth and decay. In geometry, we can examine the relationships that exist between the image and its object for a given transformation, and in probability we may also view the probability of an event as a function of the number of choices available.

## Communicating Mathematics

Communicating in mathematics helps students to develop insight into the nature of mathematics. Much of mathematics involves solving problems where students are required to develop, interpret, and analyse algorithms. When students are given a problem, they should be given opportunities to share the various ways they solved the problem so that they can compare the effectiveness, the efficiency, and the relative appropriateness of the methods used. It is through this type of communication that students deepen their understanding and extend their ability to reason. Technology continues to advance, resulting in a change in the type of problems that we can solve. It is important for students to be able to communicate by using technology to solve problems.

Mathematical arguments help students address questions such as “How do I know if I’m correct?” “Is this always true?” “Is there any solution to satisfy these conditions?” When students are asked to justify a result, they must be able to see how things fit together in a natural way. Mathematical justification communicates a student’s understanding and allows the student to express ideas in many different ways, including discussions of what is and is not accepted. Students may, for example, be asked to clarify when it is appropriate to use the Law of Sines.

Mathematical discourse should be part of every lesson, since it promotes both reasoning and understanding in mathematics.

## Multiple Representations

Real understanding in mathematics is present when students are able to use and choose representations to clarify and communicate. Students who are in control of their learning may choose or find the representation they find most useful. For example, a student who has studied the quadratic function demonstrates mathematical power when he or she is able to move between the graph and the equation to find solutions to the quadratic equation or inequality and understands the implications of these solutions.

An understanding of the multiple ways of representing an idea or solving a problem as well as the recognition of the equivalence of the various representations results in deeper understandings of mathematical structure and process. For example, if students examine the same geometry concepts from an Euclidean, analytic, and transformational approach, they will develop a much stronger intuitive understanding of these concepts.

## Learning and Teaching Mathematics

What students learn is fundamentally connected to how they learn it. The view of learning mathematics as an integrated set of intellectual tools for making sense of mathematical situations has created a need for new forms of classroom organization, communication patterns, and

instructional strategies. The teacher is no longer the sole dispenser of knowledge but is rather a facilitator and educational conductor whose major roles include

- creating a classroom environment to support the teaching and learning of mathematics
- setting goals and selecting or creating mathematical tasks to help the students reach these goals
- stimulating and managing classroom discourse so that the students are clearer about what is being taught
- analysing student learning, the mathematical tasks, and the environment in order to make ongoing instructional decisions

Good mathematics teaching and learning take place in a range of situations. Instructional settings and strategies should create a climate that reflects the constructive, active view of the learning process. This means that learning does not occur by passive absorption and imitation but rather as students actively assimilate new information and construct their own meanings.

Students' opportunities to learn mathematics are a function of the setting and the kinds of tasks and discourse in which they participate. What students learn about particular concepts and procedures and their own mathematical thinking depends upon the ways in which they engage in mathematical activity in their classrooms. Their dispositions toward mathematics are also shaped by such experiences. Consequently, the goal of developing students' mathematical power requires careful attention to pedagogy as well as to the curriculum.

Mathematics instruction should vary and should include opportunities for group and individual assignments, discussion between teacher and students and among students, appropriate project work, practice with mathematical methods, and exposition by the teacher.

Instructional settings should include varied learning environments, which encourage the development of specific co-operative behaviours. Students should be expected to work together to help each other, and at the same time they can be expected to complete individual projects. Students develop strategies and skills in asking questions, listening, showing, explaining, finding out what others think, and determining ways to complete a project.

## **Summary of Changes in Instructional Practices**

Moving away from

- teacher and text as exclusive sources of knowledge
- rote memorization of facts and procedures
- extended periods of individual practising of routine tasks

- instruction based almost completely on teacher exposition
- paper and pencil manipulative skill work
- the relegation of testing to an adjunct role with the sole purpose of assigning grades

toward practices that include

- the active involvement of students in constructing and applying mathematical ideas
- problem solving as a means as well as a goal of instruction
- effective questioning techniques that promote student interaction
- the use of a variety of instructional formats (small groups, explorations, peer instruction, whole class, project work)
- use of computers and calculators as tools for learning and doing mathematics when appropriate
- student communication of mathematical ideas orally and in writing
- the establishment and application of the interrelatedness of mathematical topics
- the systematic maintenance of student learnings and embedding review in the context of new topics and problem situations
- assessment of learning as an integral part of instruction

## Integrating Technology

The integration of computers, graphics calculators, video technology, and other technologies into the mathematics classroom allows students to

- explore individual or groups of related computations or functions quickly or easily
- create and explore numeric and geometric situations for the purpose of developing conjectures
- perform simulations of situations that would otherwise be impossible to examine
- easily link different representations of the same information
- model situations mathematically
- observe the effects of simple changes in parameters or coefficients
- analyse, organize, and display data

All of these situations enhance discovery learning and problem-solving potential. At the same time, teachers have the opportunity to use technology to communicate with fellow mathematics teachers, to share lessons with experts, and to expose their students to information that would otherwise be inaccessible.

Students will need to learn to make judgments as to when the use of technology is appropriate and when it is not. In all situations, it is imperative that technology be used both as a tool to include, rather than exclude, students and as a means of creating new teaching strategies. It also allows students to be exposed to more mathematical concepts.

## Learning Resources

This curriculum guide represents the central resource for the teacher of mathematics with respect to Mathematics 2206 of the high school mathematics program. Other resources are ancillary to it. This guide should serve as the focal point for all daily, unit, and yearly planning, as well as a reference point to determine the extent to which the curriculum outcomes have been met.

Nevertheless, other resources will be significant in the mathematics classroom. Textual and other print resources will be significant to the extent to which they support the curriculum. Schools, school districts, and departments of education should work together in making professional resources available to teachers as they seek to broaden their instructional and mathematical skills. As well, manipulative materials and appropriate access to technological resources need to be at hand.

It is highly recommended that teachers familiarize themselves not only with *Foundation for the Atlantic Canada Mathematics Curriculum*, but also with *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), *Professional Standards for Teaching Mathematics* (NCTM, 1991), *Assessment Standards for School Mathematics* (NCTM, 1995), and *Principles and Standards for School Mathematics* (NCTM, April 2000). Because of the extent of information contained in these documents, teachers are cautioned that assimilation of the ideas contained will require much reflection, discussion, and rereading. All high school mathematics teachers may wish to join the National Council of Teachers of Mathematics (NCTM) for professional growth. Membership can include a subscription to *The Mathematics Teacher*, a journal that contains a wealth of information and practical teaching suggestions. Institutional or individual membership can be obtained by telephoning 1-800-235-7566 (NCTM order office), or by contacting the NCTM representative on your mathematics teacher association's executive.

## Assessing and Evaluating Student Learning

In recent years there have been calls for change in the practices used to assess and evaluate students' progress. Many factors have set the demands for change in motion, including the following:

- *new expectations for mathematics education as outlined in Curriculum and Evaluation Standards for School Mathematics*

The *Curriculum Standards* provide educators with specific information about what students should be able to do in mathematics. These expectations go far beyond learning a list of mathematical facts; instead, they emphasize such competencies as creative and critical thinking, problem solving, working collaboratively, and the ability to manage one's own learning. Students are expected to be able to communicate mathematically, to solve and create problems, to use concepts to solve real-world applications, to integrate mathematics across disciplines, and to

connect strands of mathematics. For the most part, assessments used in the past have not addressed these expectations. New approaches to assessment are needed if we are to address the expectations set out in *Curriculum and Evaluation Standards for School Mathematics*.

- ***understanding the bonds linking teaching, learning, and assessment***

Much of our understanding of learning has been based on a theory that viewed learning as the accumulation of discrete skills. Cognitive views of learning call for an active, constructive approach in which learners gain understanding by building their own knowledge and developing connections between the facts and concepts. Problem solving and reasoning become the emphases rather than the acquisition of isolated facts. For summative purposes, especially for end of term or end of school year assessments, it is necessary to survey a larger representation of the concepts, skills, and procedures developed in a course. In such instances, the use of multiple-choice items for a portion of the test provides an opportunity to survey a larger number of the outcomes. This increases the reliability and validity of the test instrument. Assessments that require students to solve problems, demonstrate skills, create products, and create portfolios of work reveal a different dimension to student's understanding and reasoning of mathematics. If students are expected to develop reasoning and problem-solving competencies, then teaching must reflect such, and in turn, assessment must reflect what is valued in teaching and learning. Feedback from assessment directly affects learning. The development of problem-solving and higher-order thinking skills will become a realization only if assessment practices are in alignment with these goals.

- ***limitations of traditional methods used to determine student achievement***

Do traditional methods of assessment provide the student with information on how to improve performance? We need to develop methods of assessment that provide us with accurate information about students' academic achievement and information to guide teachers in decision making to improve both learning and teaching.

## What Is Assessment?

Assessment is the systematic process of gathering information on student learning. Assessment allows teachers to communicate to students what is really valued—what is worth learning, how it should be learned, what elements of quality are considered most important, and how well students are expected to perform. In order for teachers to assess student learning in a mathematics curriculum that emphasizes applications and problem solving, they need to employ strategies that recognize the reasoning involved in the process as well as in the product. *Assessment Standards for School Mathematics* (NCTM, 1995, p. 3) describes

assessment practices that enable teachers to gather evidence about a student's knowledge of, ability to use, and disposition towards mathematics and how to make inferences from that evidence for a variety of purposes.

Assessment can be informal or formal. Informal assessment occurs while instruction is occurring. It is a mind-set, a daily activity that helps the teacher answer the question, "is what is taught being learned?" Its primary purpose is to collect information about the instructional needs of students so that the teacher can make decisions to improve instructional strategies. For many teachers the strategy of making annotated comments about a student's work is part of informal assessment. Assessment must do more than determine a score for the student. It should do more than portray a level of performance. It should direct teachers' communication and actions. Assessment must anticipate subsequent action.

Formal assessment requires the organization of an assessment event. In the past, mathematics teachers may have restricted these events to quizzes, tests, or exams. As the outcomes for mathematics education broaden, it becomes more obvious that these assessment methods become more limited. Some educators would argue that informal assessment provides better quality information because it is in a context that can be put to immediate use.

## Why Should We Assess Student Learning?

We should assess student learning in order to

- improve instruction by identifying successful instructional strategies
- identify and address specific sources of the students' misunderstandings
- inform the students about their strengths in skills, knowledge, and learning strategies
- inform parents of their child's progress so that they can provide more effective support
- determine the level of achievement for each outcome

As an integral and ongoing part of the learning process, assessment must give each student optimal opportunity to demonstrate what he/she knows and is able to do. It is essential, therefore, that teachers develop a repertoire of assessment strategies.

## Assessment Strategies

*Documenting classroom behaviours*

Some assessment strategies that teachers may employ include the following.

In the past teachers have generally made observations of students' persistence, systematic working, organization, accuracy, conjecturing, modeling, creativity, and ability to communicate ideas, but often failed

to document them. Certainly the ability to manage the documentation played a major part. Recording information signals to the student those behaviours that are truly valued. Teachers should focus on recording only significant events, namely those that represent a typical student's behaviour or a situation where the student demonstrates new understanding or a lack of understanding. Using a class list, teachers can expect to record comments on approximately four students per class. The use of an annotated class list allows the teacher to recognize where students are having difficulties and identify students who may be spectators in the classroom. However, for summative purposes, grades should reflect the degree to which students achieve the curriculum outcomes.

*Using a portfolio or student journal*

Having students assemble, on a regular basis, responses to various types of tasks is part of an effective assessment scheme. Responding to open-ended questions allows students to explore the bounds and the structure of mathematical categories. As an example, students are given a triangle in which they know two sides, or an angle and a side, and they are asked to find out everything they know about the triangle. This is preferable to asking students simply to find a side length because it is less prescriptive and allows students to explore the problem in many different ways and gives them the opportunity to use many different procedures and skills. Students should be monitoring their own learning by being asked to reflect and write about questions such as:

- What is the most interesting thing you learned in mathematics class this week?
- What do you find difficult to understand?
- How could the teacher improve mathematics instruction?
- Can you identify how the mathematics we are now studying is connected to the real world?

In the portfolio or in a journal, teachers can observe the development of the students' understanding and progress as a problem solver. Students should be doing problems that require varying lengths of time and represent both individual and group effort. What is most important is that teachers discuss with their peers what items are to be part of a meaningful portfolio and that students also have some input into the assembling of a portfolio.

*Projects and investigative reports*

Students will have opportunities to do projects at various times throughout the year. For example, they may conduct a survey and do a statistical report, they may do a project by reporting on the contribution of a mathematician, or the project may involve building a three-dimensional shape. Students should also be given investigations in which they learn new mathematical concepts on their

own. Excellent materials can be obtained from the National Council of Teachers of Mathematics including the *Student Math Notes* (These news bulletins can be downloaded from the Internet.)

### *Written tests, quizzes, and exams*

Written tests have been accused of being limited to assessing a student's ability to recall and replicate mathematical facts and procedures. In fact, written tests provide great potential for a valid and reliable method of assessing curriculum.

How might we improve the use of written tests?

- Our challenge is to improve the nature of the questions being asked, so that we are gaining information about the students' understanding and comprehension.
- Tests must be designed so that questions being asked reflect the expectations of the outcomes being addressed.
- Teachers must also begin by reflecting on the quality of the test being given to students. Are they being asked to evaluate, analyse, and synthesize information, or are they simply being asked to recall isolated facts from memory? Teachers should develop a table of specifications when planning their tests.
- In assessing students we have a professional obligation to ensure that the assessment reflects those skills and behaviours that we truly value. The bottom line is that good assessment is equivalent to good instruction and therefore promotes student achievement.

# Course Organization

## Course Design

This section of the guide presents Mathematics 2206 curriculum outcomes that students are expected to achieve during that year. Teachers are encouraged, however, to consider what comes before and what follows to better understand how the students' learnings at a particular course level are part of a bigger picture of concept and skill development.

Mathematics 2206 is organized into five units: Making Choices: Linear Programming; Independent Study; Decision-Making in Consumer Situations; Statistics; and Trigonometry. The presentation of the specific curriculum outcomes in each unit reflects a suggested teaching sequence.

## The Two-Page Spread

The following pages detail curriculum outcomes. Each two-page spread is dedicated to a small number of specific curriculum outcomes. As much as possible, connections are made through references to other pages of related outcomes or topics.

At the top of each page the unit topic is presented, with the appropriate specific curriculum outcome(s) (SCOs) displayed in the left-hand column. The second column presents the elaboration, which includes instructional strategies and suggestions, as well as some examples that might be used to illustrate achievement of outcomes. The third column includes worthwhile tasks for instruction and/or assessment purposes. While the strategies, suggestions, and examples are not intended to be rigidly applied, they will help to further clarify the specific curriculum outcome(s) and to illustrate ways to work toward the outcome(s) while maintaining an emphasis on problem solving, communication, reasoning, and connections.

The final column is entitled Suggested Resources and will, with your additions, over time become a collection of useful references to resources that are particularly valuable with respect to achieving the outcome(s) given. Materials listed in this column range from useful to valuable. They are not essential to the delivery of the curriculum.

