# BIG IDEAS

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| **Diagrams** are fundamental to investigating, communicating, and discovering properties and relations in geometry. | Finding **invariance amidst variation** drives geometric investigation. | Geometry involves creating, testing, and refining **definitions**. | The **proving process** begins with conjecturing, looking for counter-examples, and refining the conjecture, and the process may end with a written proof. | **Geometry** stories and applications vary across cultures and time. |

## Learning Standards

| Curricular Competencies | Content |
|---|---|
| *Students are expected to do the following:*<br>**Reasoning and modelling**<br>• Develop **thinking strategies** to solve puzzles and play games<br>• Engage in **spatial reasoning** in a dynamic environment<br>• Explore, **analyze**, and apply mathematical ideas using **reason**, **technology**, and **other tools**<br>• **Estimate reasonably** and demonstrate **fluent, flexible, and strategic thinking** about number<br>• **Model** with mathematics in **situational contexts**<br>• **Think creatively** and with **curiosity and wonder** when exploring problems<br>**Understanding and solving**<br>• Develop, demonstrate, and apply conceptual understanding of mathematical ideas through play, story, **inquiry**, and problem solving<br>• **Visualize** to explore and illustrate geometric concepts and relationships<br>• Apply **flexible and strategic approaches** to **solve problems**<br>• Solve problems with **persistence and a positive disposition**<br>• Engage in problem-solving experiences **connected** with place, story, cultural practices, and perspectives relevant to local First Peoples communities, the local community, and other cultures | *Students are expected to know the following:*<br>• geometric **constructions**<br>• **parallel and perpendicular** lines:<br>  – **circles as tools** in constructions<br>  – perpendicular bisector<br>• **circle geometry**<br>• **constructing tangents**<br>• transformations of 2D shapes:<br>  – **isometries**<br>  – **non-isometric transformations**<br>• **non-Euclidean geometries** |

  

## Learning Standards (continued)

| Curricular Competencies | Content |
|---|---|
| **Communicating and representing**<br>• **Explain, justify,** and evaluate geometric ideas and **decisions** in **many ways**<br>• **Represent** mathematical ideas in concrete, pictorial, and symbolic forms<br>• Use geometric vocabulary and language to contribute to **discussions** in the classroom<br>• Take risks when offering ideas in classroom **discourse**<br>**Connecting and reflecting**<br>• **Reflect** on geometric thinking<br>• **Connect mathematical concepts** with each other, other areas, and personal interests<br>• Use **mistakes** as **opportunities to advance learning**<br>• **Incorporate** First Peoples worldviews, perspectives, **knowledge**, and **practices** to make connections with mathematical concepts | |

## Big Ideas – Elaborations

MATHEMATICS – Geometry
Grade 12

- **Diagrams:**
  *Sample questions to support inquiry with students:*
  – How would we describe a specific geometric object to someone who cannot see it?
  – What properties can we infer from a diagram?
  – What behaviours can we infer from a dynamic diagram?

## Big Ideas – Elaborations

- **invariance amidst variation:**
  - Invariance amidst variation can be more easily experienced using current technology and dynamic diagrams. For example, the sum of the angles in planar triangles is invariant no matter what forms a triangle takes.

  *Sample questions to support inquiry with students:*
  - How do we construct geometric shapes that maintain properties under variation?
  - What properties change and stay the same when we vary a square, parallelogram, triangle, and so on?
  - How can the Pythagorean theorem be restated in terms of variance and invariance?
- **definitions:**
  - are seldom the starting point in geometry

  *Sample questions to support inquiry with students:*
  - How does variation help to refine our definitions of shapes?
  - How would we define a square (or a circle) in different ways? When would one definition be better to work with than another?
  - How can the definition of a shape be used in constructing the shape?
  - How can we modify a definition of a shape to define a new shape?
- **proving process:**

  *Sample questions to support inquiry with students:*
  - Can we make a conjecture about the diagonals of a polygon? Can we find a counter-example to our conjecture?
  - How can one conjecture about a *specific* shape lead to making another more *general* conjecture about a family of shapes?
  - How can we be sure that a proof is complete?
  - Can we find a counter-example to a conjecture?
  - How can different proofs bring out different understandings of a relationship?
- **Geometry:**
  - Geometry is more than a list of axioms and deductions. Non-Western and modern geometry is concerned with shape and space and is not always axiomatic. It is not always about producing a theorem; rather, it is about modelling mathematical and non-mathematical phenomena using geometric objects and relations. Today geometry is used in a multitude of disciplines, including animation, architecture, biology, carpentry, chemistry, medical imaging, and art.

  *Sample questions to support inquiry with students:*
  - Can we find geometric relationships in local First Peoples art or culture?
  - Can we make geometric connections to story, language, or past experiences?
  - What do we notice about and how would we construct common shapes found in local First Peoples art?
  - How has the notion of “proof” changed over time and in different cultures?
  - How are geometric ideas implemented in modern professions?

## Curricular Competencies – Elaborations

- **thinking strategies:**
  - using reason to determine winning strategies
  - generalizing and extending
- **spatial reasoning:**
  - being able to think about shapes (real or imagined) and mentally transform them to notice relationships
- **analyze:**
  - examine the structure of and connections between geometric ideas (e.g., parallel and perpendicular lines, circle geometry, constructing tangents, transformations)
- **reason:**
  - inductive and deductive reasoning
  - predictions, generalizations, conclusions drawn from experiences (e.g., with puzzles, games, and coding)
- **technology:**
  - graphing technology, dynamic geometry, calculators, virtual manipulatives, concept-based apps
  - can be used for a wide variety of purposes, including:
    - exploring and demonstrating geometrical relationships
    - organizing and displaying data
    - generating and testing inductive conjectures
    - mathematical modelling
- **other tools:**
  - paper and scissors, straightedge and compass, ruler, and other concrete materials
- **Estimate reasonably:**
  - be able to defend the reasonableness of an estimated value or a solution to a problem or equation (e.g., congruencies, angles, lengths)
- **fluent, flexible, and strategic thinking:**
  - being able to generate a family of shapes and apply characteristics across the family
- **Model:**
  - use mathematical concepts and tools to solve problems and make decisions (e.g., in real-life and/or abstract scenarios)
  - take a complex, essentially non-mathematical scenario and figure out what mathematical concepts and tools are needed to make sense of it
- **situational contexts:**
  - including real-life scenarios and open-ended challenges that connect mathematics with everyday life
- **Think creatively:**
  - by being open to trying different strategies
  - refers to creative and innovative mathematical thinking rather than to representing math in a creative way, such as through art or music

## Curricular Competencies – Elaborations

- **curiosity and wonder:**
  - asking questions to further understanding or to open other avenues of investigation
- **inquiry:**
  - includes structured, guided, and open inquiry
  - noticing and wondering
  - determining what is needed to make sense of and solve problems
- **Visualize:**
  - create and use mental images to support understanding
  - Visualization can be supported using dynamic materials (e.g., graphical relationships and simulations), concrete materials, drawings, and diagrams.
- **flexible and strategic approaches:**
  - deciding which mathematical tools to use to solve a problem
  - choosing an effective strategy to solve a problem (e.g., guess and check, model, solve a simpler problem, use a chart, use diagrams, role-play)
- **solve problems:**
  - interpret a situation to identify a problem
  - apply mathematics to solve the problem
  - analyze and evaluate the solution in terms of the initial context
  - repeat this cycle until a solution makes sense
- **persistence and a positive disposition:**
  - not giving up when facing a challenge
  - problem solving with vigour and determination
- **connected:**
  - through daily activities, local and traditional practices, popular media and news events, cross-curricular integration
  - by posing and solving problems or asking questions about place, stories, and cultural practices
- **Explain and justify:**
  - use geometrical arguments to convince
  - includes anticipating consequences
- **decisions:**
  - Have students explore which of two scenarios they would choose and then defend their choice.
- **many ways:**
  - including oral, written, visual, gestures use of technology
  - communicating effectively according to what is being communicated and to whom

## Curricular Competencies – Elaborations

- **Represent:**
  - concretely, diagrammatically, symbolically, including using models, tables, graphs, words, numbers, symbols
- **discussions:**
  - partner talks, small-group discussions, teacher-student conferences
- **discourse:**
  - is valuable for deepening understanding of concepts
  - can help clarify students' thinking, even if they are not sure about an idea or have misconceptions
- **Reflect**
  - share the geometric thinking of self and others, including evaluating strategies and solutions, finding counter-examples, extending, posing new problems and questions, proving results
- **Connect mathematical concepts:**
  - to develop a sense of how mathematics helps us understand ourselves and the world around us (e.g., daily activities, local and traditional practices, popular media and news events, social justice, cross-curricular integration)
- **mistakes:**
  - range from calculation errors to misconceptions
- **opportunities to advance learning:**
  - by:
    - analyzing errors to discover misunderstandings
    - making adjustments in further attempts
    - identifying not only mistakes but also parts of a solution that are correct
- **Incorporate:**
  - by:
    - collaborating with Elders and knowledge keepers among local First Peoples
    - exploring the First Peoples Principles of Learning (e.g., Learning is holistic, reflexive, reflective, experiential, and relational [focused on connectedness, on reciprocal relationships, and a sense of place]; Learning involves patience and time)
    - making explicit connections with learning mathematics
    - exploring cultural practices and knowledge of local First Peoples and identifying mathematical connections
- **knowledge:**
  - local knowledge and cultural practices that are appropriate to share and that are non-appropriated
- **practices:**
  - Bishop's cultural practices: counting, measuring, locating, designing, playing, explaining
  - Aboriginal Education Resources
  - *Teaching Mathematics in a First Nations Context*, FNESC

  

## Content – Elaborations

- **constructions:**
  - angles, triangles, triangle centres, quadrilaterals
- **parallel and perpendicular:**
  - angle bisector
- **circles as tools:**
  - constructing equal segments, midpoints
- **circle geometry:**
  - properties of chords, angles, and tangents to mobilize the proving process
- **constructing tangents:**
  - lines tangent to circles, circles tangent to circles, circles tangent to three objects (e.g., points [PPP], three lines [LLL])
- **isometries:**
  - transformations that maintain congruence (translations, rotations, reflections)
  - composition of isometries
  - tessellations
- **non-isometric transformations:**
  - dilations and shear
  - topology
- **non-Euclidean geometries:**
  - perspective, spherical, Taxicab, hyperbolic
  - tessellations

  