BIG IDEAS

Statistics plays an integral role in research, decision making, and policy in society.	The research question and practical and ethical issues determine whether a **statistical study** should be observational or experimental.	**Statistical analysis** allows us to explore, describe, model, and explain variation.	We can develop **statistical thinking** to help make inferences intuitive.	Statistical findings gain value through **effective communication**.

Learning Standards

Curricular Competencies	Content
Students are expected to do the following: **Reasoning and modelling** • Develop **thinking strategies** to solve puzzles and play games • Explore, **analyze**, and apply statistical ideas using **reason**, **technology**, and **other tools** • **Estimate reasonably** and demonstrate **fluent, flexible, and strategic thinking** about number • **Model** with statistics in **situational contexts** • **Think creatively** and with **curiosity and wonder** when exploring problems **Understanding and solving** • Develop, demonstrate, and apply conceptual understanding of statistical ideas through play, story, **inquiry**, and research • **Visualize** to explore and illustrate variation within and between variables • Apply **flexible and strategic approaches** to explore statistical questions in abstract and situational contexts • Explore research questions with **persistence and a positive disposition** • Engage in **statistical thinking** to answer questions **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:* • **role of statistical thinking** in research and the scientific method • **observational** and **experimental** studies • common **graphical** representations of variation • use of **summary statistics** to describe variation • **association** between two variables • probability **models** for variation • intuition and appreciation of **inferential concepts**, such as confidence intervals and hypothesis tests • use of **software and technology** to enhance statistical ideas • **communication** of statistical findings

Learning Standards (continued)

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

Big Ideas – Elaborations

- **Statistics:**
  Sample questions to support inquiry with students:
  - Why is statistical thinking important in our lives?
  - How do the statistical sciences help us make decisions?
  - What is the role of statistics in the scientific process?
- **statistical study:**
  Sample questions to support inquiry with students:
  - How do studies obtaining data enable us to explore research questions?
  - What features of a study will make it effective, practical, and ethical for exploring a research question?
  - How do we conduct an effective observational study?
  - How do we conduct an effective designed experiment?
- **Statistical analysis:**
  Sample questions to support inquiry with students:
  - Why is it important to explore and understand variation?
  - How can we describe variation graphically?
  - What is the role of probabilistic models for describing variation?
  - Can we describe the sampling variation of a statistic, such as the sample mean?
- **statistical thinking:**
  Sample questions to support inquiry with students:
  - How can we explore the sampling distribution of a statistic?
  - What properties of a sample statistic make it a good estimator of a population parameter?
  - How can technology help us appreciate the properties of a confidence interval?
  - How surprising are the data from a study if the research hypothesis is true?
- **effective communication:**
  Sample questions to support inquiry with students:
  - Why is the communication of statistical findings important?
  - How can we best communicate statistical findings verbally and in writing?
  - What are the roles of context and the target audience in the communication of statistical findings?
  - How can technology assist us in the communication of statistical ideas?

Curricular Competencies – Elaborations

- **thinking strategies:**
  - using reason to determine winning strategies
  - generalizing and extending
- **analyze:**
  - consider a research problem and determine viable investigation approaches
  - critique existing studies, identifying possible flaws and limitations
  - draw viable conclusions from a statistical study
- **reason:**
  - inductive and deductive reasoning
  - predictions, generalizations, conclusions drawn from experiences (e.g., with games and simulations)
- **technology:**
  - software for recording, exploring, and communicating data
  - software tools for illustrating and providing information on probability models
  - web-based visualisation/simulation tools that give intuition to inferential concepts
- **other tools:**
  - manipulatives such as dice, coins, spinners, and other concrete materials
- **Estimate reasonably:**
  - be able to justify the use of an estimate in a statistical context
  - appreciate that statistical estimators exhibit variation across different samples
  - use intuition when sampling distributions via simulations to make inferences
- **fluent, flexible, and strategic thinking:**
  - includes:
    - appreciating the role of variation
    - choosing from different ways to investigate a research question (e.g., Which will be the most appropriate?)
- **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

Curricular Competencies – Elaborations

- **Think creatively:**
  - by
    - being open to trying different strategies
    - appreciating that in statistical contexts, there is often no single correct answer
    - proposing a viable research question for investigation
    - designing a study to explore a research question
  - refers to creative and innovative mathematical thinking rather than to representing math in a creative way, such as through art or music
- **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 appropriate to explore in a research question
- **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 statistical ideas are useful in addressing a research question or hypothesis
  - choosing an effective strategy to address a research question (e.g., observational or experimental study, choice of variable[s] to measure, display method, inferential approaches)
- **persistence and a positive disposition:**
  - not giving up when facing a challenge
  - engaging in research and exploration with vigour and determination
- **statistical thinking:**
  - gain deeper understanding through data collected to answer questions about local cultures
- **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 mathematical 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, use of technology
  - communicating effectively according to what is being communicated and to whom
- **Represent:**
  - using models, simulations, tables, graphs, words, numbers, symbols
  - connecting meanings among various representations
  - using concrete materials and dynamic statistical software (applets/simulation tools) to explore variation
- **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 mathematical thinking of self and others, including evaluating strategies and solutions, extending, posing new problems and questions
- **Connect statistical 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

Curricular Competencies – Elaborations

- **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

- **role of statistical thinking:**
  - census versus sample
  - identifying research questions and target population
  - historical perspective on the development of statistical research and theories
  - role of data in helping to answer questions (e.g., Lind study on scurvy, 1753); randomization as a fairly recent development
- **observational:**
  - Observational studies involve observation of a sample from the target population, without intervention.
  - Observational studies can include surveys and questionnaires.
  - When are observational studies necessary and appropriate?
  - What are the limitations of observation studies?
  - Lurking variables can impact conclusions.
  - The wording of survey items can incur bias.
  - How should we design an observational study to explore an appropriate research question?
- **experimental:**
  - Experimental studies involve intervention for collection of data.
  - Randomization of treatments to experimental units can eliminate issues with lurking variables and bias.
  - There may be practical and ethical concerns (e.g., long-duration studies on smoking, effectiveness of medications).
  - How should we design an experiment to explore an appropriate research question?

Content – Elaborations

- **graphical:**
  - Graphical methods should always be used to explore data.
  - Graphical approaches can display data distributions.
  - Focus on interpreting data through bar charts, histograms, dot plots, boxplots, scatterplots, tables.
  - Graphical approaches can be used to explore the association between variables (e.g., clustered bar charts, scatterplots).
  - Software should be used (e.g., Minitab).
  - What are the advantages and disadvantages of different representations?
- **summary statistics:**
  - measures of centre, spread (range, variance, standard deviation interquartile range), including five-number summary
  - use of Chebyshev's inequality
  - use of correlation in measuring association between quantitative variables
- **association:**
  - categorical variables: contingency tables — clustered, stacked bar charts
  - quantitative variables: scatterplots
  - correlation and causation
- **models:**
  - binomial distribution:
    - When is it appropriate?
    - What does it model?
    - What assumptions can be made?
    - Shape of distribution affected by n and p.
  - normal (Gaussian) distribution:
    - when it is useful
    - roles of the mean and standard deviation, 68-95-99.7 rule
  - central limit theorem: describing the variation of a sample mean
  - use of simulation software to explore sampling distributions
- **inferential concepts:**
  - making intuitive inferences based on a large number of simulations
  - intuition on interval, estimation of means and proportions via simulation
  - inference for proportion via simulation (randomization/permutation tests)
  - inference for a mean via simulation (randomization/permutation tests)
  - two-sample questions via simulation (randomization/permutation tests)

Content – Elaborations

- **software and technology:**
  - Software can assist us in exploring and summarizing data.
  - Online simulation-based learning tools can help us gain intuition of inferential concepts, such as sampling distribution, interval estimation, and hypothesis tests.
- **communication:**
  - communicating statistical findings in context, appropriate to the target audience
  - writing a report on a research project involving an observational study
  - writing a report on a research project involving a designed experiment
  - presenting to an audience on a research project involving an observational study
  - presenting to an audience on a research project involving a designed experiment

