**Area of Learning: MATHEMATICS — Statistics Grade 12**

**BIG IDEAS**

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| **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**

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| **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
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**Area of Learning: MATHEMATICS — Statistics Grade 12**

**Learning Standards (continued)**

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| **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 riskswhen 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 statistical concepts
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|  **MATHEMATICS – Statistics Big Ideas – Elaborations Grade 12** |
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| * **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?
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|  **MATHEMATICS – Statistics Curricular Competencies – Elaborations Grade 12** |
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| * **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 deductivereasoning
	+ 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
* **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 arguments based on statistical thinking 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 statistical 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](http://www.fnesc.ca/wp/wp-content/uploads/2015/09/PUB-LFP-POSTER-Principles-of-Learning-First-Peoples-poster-11x17.pdf) (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](http://www.csus.edu/indiv/o/oreyd/ACP.htm_files/abishop.htm): counting, measuring, locating, designing, playing, explaining
	+ [Aboriginal Education Resources](http://www.aboriginaleducation.ca/)
	+ [*Teaching Mathematics in a First Nations Context*,](http://www.fnesc.ca/resources/math-first-peoples/) FNESC
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|  **MATHEMATICS – Statistics Content – Elaborations Grade 12** |
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| * **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?
* **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)
* **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
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