MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA

Supporting NCEA Numeracy in Design and Visual Communication (DVC)

Design and Visual Communication (DVC) provides rich opportunities for ākonga to develop and apply numeracy skills as they conceptualise, develop and communicate design ideas.

Through DVC, ākonga strengthen their understanding of geometry, proportion, scale, ratio and measurement and develop their spatial awareness through experimenting with space, shape, structure and patterns.

In DVC ākonga develop their numeracy skills when they:

» explore and use symmetry, geometric shapes and angles

» use measurement, calculation and estimation in the design process and to create scale models

» visualise and create technical drawings of 2D shapes and 3D models

» use fractions, decimals, percentages, ratios and rates in the design process.

This Numeracy Pedagogy Guide (NPG) takes a selection of mathematical content ideas from Unpacking Numeracy[1] and illustrates small, effective steps that you can trial and weave into your teaching practice.

DVC Numeracy Pedagogy Guide

Operations with numbers	What can this look like in DVC?	What can I do as a kaiako of DVC?
Recognise the (degree of) precision required for the context	Use precise calculations in working drawings. Recognise the degree of precision required for construction details. *Ākonga explore drawings that highlight the need for precision and investigate the results if mistakes are made at the drawing stage.*	Explore examples of malfunctions and failures resulting from lack of precision and accuracy in engineering (e.g., aircraft or automotive products) or architectural contexts. Make connections between the accuracy of design drawings and whether the completed outcome is fit for purpose. Discuss the level of precision required in design working drawings, and potential implications of a lack of precision in a range of DVC contexts. Discuss how scale can impact accuracy. Model how to round numbers and discuss when and how this is applicable in DVC contexts. This NZMaths resource may be useful.
Work with whole numbers up to billions, fractions, decimals to 3 places, percentages and integers	Use decimals when making measurements and carrying out calculations. Use decimals when working with proportions and ratios. *Ākonga use scale in accurate technical architectural drawings, plans and models.* *Ākonga analyse the use of the Golden Ratio1 in product design and apply this ratio in their own design process as they integrate aesthetics and function.* Use fractions and percentages during the design process *Ākonga apply the design principle of the 'rule of thirds' when presenting their designs to an audience.* *When using a laser printer, ākonga use the percentage count of how much material has been cut to estimate how long it will take to complete the laser cutting.*	When working with measurements involving decimals, support ākonga to understand the place value of decimals and the role zero plays as a placeholder. Remind ākonga of the convention of writing a zero in front of a decimal point if the number is less than 1. When working with dimensions of shapes, explain that a ratio is a relationship between two numbers of the same kind, for example, the ratio between length and width of an object. If a ratio is locked, then the result of dividing the length by the width of an object remains the same, regardless of scale. Explain that scale diagrams enable real life dimensions to be calculated from drawings. Explain that some ratios show that the drawing is smaller than real life (e.g. 1:10) while others show that it is an enlargement (e.g., 5:1).
Calculate averages (including the mean)	Use averages when gathering data related to a need or opportunity. *Ākonga calculate average sitting knee heights of students in their class and discuss which averages are most useful for their design process.*	Discuss the application of averages to ergonomics, for example, what do we mean when we say 'average height' or 'average hand size'? Acknowledge that the term average often refers to the mean; however, average is defined as the mean, median and mode. Encourage ākonga to calculate all three averages and select the average they think is most appropriate to their situation. Ask them to justify their thinking.

Spatial properties and representations of objects	What can this look like in DVC?	What can I do as a kaiako of DVC?
Recognise symmetry **Transform objects to design for purpose (i.e. enlarge, reflect, rotate, and translate)**	Identify line symmetry and rotational symmetry in designs and constructions to identify repeating units. *Ākonga use the centreline method to draw symmetrical objects.* Investigate the symmetry and transformation of objects within a design. *Ākonga explore and identify the use of transformation in the design features in Ngā Toi o Tūranga Library.* *Ākonga apply design principles of rotation and symmetry to create a sense of harmony in a design.* *Ākonga enlarge (or reduce) a drawing based on a given ratio.*	Show ākonga a range of images and objects and ask them to identify example of line and rotational symmetry[3]. Explore rotational symmetry[4] and transformations and discuss how these can be applied in design. Discuss how rotational symmetry and transformations can be used to emphasise and develop a motif and idea through the use of repetition. Explore the use of symmetry and asymmetry in designs by Māori architects. Discuss the effect of symmetry in terms of creating a sense of visual balance, comparing this with other ways of creating balance, e.g., radial or informal balance.
Make connections between representations of objects in simple 2D and 3D	Explore and use 2D and 3D drawings of design ideas. *Ākonga create 2D and 3D freehand sketches of designs.* Work with 3D geometric forms, including cubes, prisms (square, rectangular, triangular, pentagonal, and hexagonal), pyramids, cylinders, cones, and tetrahedrons. *Ākonga create surface developments (nets) of prisms and other 3D forms.* *Ākonga use 3D-modelling software to extrude 2D geometric shapes to generate 3D forms that can then be manipulated.*	Explore ways to Represent 3D forms in 2D drawings | NZ Maths Provide 3D forms such as cuboidal boxes that ākonga can open and connect with 2D shapes. Provide opportunities for ākonga to use laser cutting and digital 3D printer files to produce 3D outcomes. Encourage ākonga to compare and construct a range of surface developments (nets) for a container. Discuss how some designs minimise material waste better than others in specific contexts. Discuss how the length and width of 2D shapes result in volume in 3D when depth is added. Support ākonga to form, manipulate, develop, and transform 2D shapes into 3D forms to understand their spatial properties, representations, and relationships.

Location and navigation	What can this look like in DVC?	What can I do as a kaiako of DVC?
Describe position and orientation in situations that are flexible in the system being used	Identify ways that position and orientation can be described. *Ākonga use x, y and z axes to position and orientate concepts in 2D and 3D.* When designing a spatial outcome such as a home, bedroom or town, ākonga factor in the changing position of the sun to capitalise on radiant heat benefits that reduce energy costs.	Explore the significance of orientation in designs, for example, the design of Ōtāhuhu station. Provide opportunities for ākonga to use a 3D printer (or an online video of one being used) to support visualisation of positioning and orientation in 2D and 3D and within x, y and z axes.

Measurement	What can this look like in DVC?	What can I do as a kaiako of DVC?
Use and interpret results of measurement (including timetables and time charts)	Select and use appropriate measuring devices when designing and developing concepts. *Ākonga develop a schedule in a planning tool to ensure the completion of an outcome.* Use measurement and ratios to scale up or down a drawing. *Ākonga use scale rulers and processes to ensure accuracy of design drawings and their ability to transfer into true size and form when built.*	Provide ākonga with a variety of measuring tools such as callipers, scale rulers, scales and other measuring devices, to give them experience with reading scales that have different increments. Ask ākonga to identify potential measurement errors, for example, the wrong scale was chosen for a drawing or the scale was miscalculated in the drawing, and the actions they would take to minimise these errors. Provide regular opportunities for ākonga to practise their estimation skills by asking them to estimate the volume of a container or the floor area of a room.
Select appropriate units and convert between metric measures for the same attribute	Use millimetres and centimetres on a scale ruler to understand how larger scale concepts in tens and hundreds of metres can be created in real-life. Convert between cm, mm and m (and vice versa) in authentic contexts.	Discuss with ākonga which units would be appropriate for a particular context. Explain that decisions about units are determined by both practicality and convention. For example, engineers work in millimetres and metres, dressmakers work in centimetres and metres, and a draftsperson works in millimetres. Discuss how to convert between units of length. Use existing scale drawings of familiar buildings to demonstrate how issues of size, construction, and materials are resolved on paper before actual building begins.
Solve measurement problems in practical contexts » **perimeter** » **volume (cuboids only)** » **area (rectangles, parallelograms, triangles)** » **mass** » **temperature**	Use measurement and calculation to determine whether a design is fit for purpose. *Ākonga work out whether a container can hold a required amount of liquid.* *Ākonga use measurement to create scale models of design outcomes.*	Use worked examples to scaffold ākonga when they apply measurement knowledge and skills in a variety of contexts. Verbalise thinking processes using think-alouds when unpacking the numeracy in DVC problems.

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<tr><th>Statistics and data</th><th>What can this look like in DVC?</th><th>What can I do as a kaiako of DVC?</th></tr>
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Recognise and use appropriate data displays to investigate questions or claims for summary, comparison and simple time series situations

Interpret data displays using features such as clustering, centrality, spread, unusual pieces of data, frequencies and patterns

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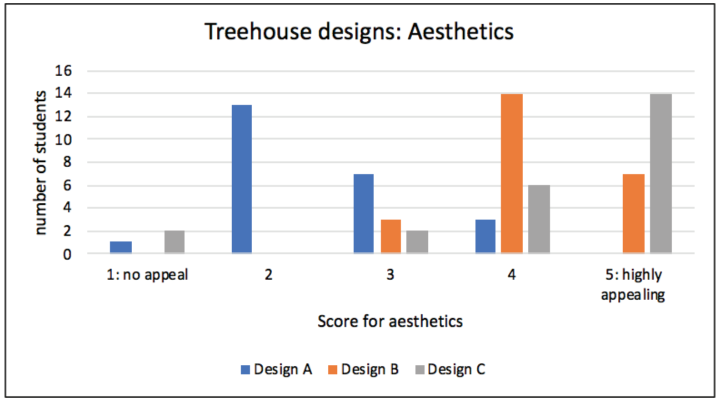
Gather and use qualitative and quantitative data to make decisions.

During the development of a design brief, ākonga design and ask questions to gather meaningful data and consult with stakeholders. They use this data to develop their design as part of an iterative process.

Interpret data displays related to stakeholder feedback.

An ākonga designing a treehouse gathers data feedback on design preferences from 24 classmates.



What I notice: Aesthetically, Design A was the least favourable of the three designs. Design C seems to be the most aesthetically pleasing.

Evidence: 14 students (over half the class) gave Design C a score of 5 for aesthetics. Over half the class gave Design A a score of 2. Design B was also popular, with no low scores, and most of the class (21/24) giving it a score of 4 or higher for aesthetics.

Relate to context: I will go with Design C as it was rated the most favourable because it had the highest number of score 5s. I'd like to gather more feedback from the two students who gave it a ranking of 1 to find out what they didn't like about it.

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As ākonga investigate their brief and begin to develop attributes and design specifications, guide ākonga to pose questions, seek responses and use accurate data from end-user and stakeholder feedback to support refinement of design decisions.

Discuss advantages and limitations of different strategies for gaining stakeholder feedback, including:

- open- and closed-question surveys, via email, phone or hard copy
- face-to-face structured, semi-structured, or unstructured interviews.

Discuss with ākonga the different types of questions they could use in a questionnaire.

Give groups of ākonga statistical questions they can use in pairs or small groups to discuss and interpret data displays of feedback received from stakeholders and/or end-users, for example:

- What do you notice?
- What patterns can you see?
- What does it make you wonder?
- What conclusions can you draw from this data set/display?
- What gaps might there be in the information it provides?

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Footnotes

[1] The Unpacking Numeracy document outlines key content that ākonga will need to understand in order to achieve NCEA Numeracy.

[2] The Golden Ratio is a mathematical ratio that is commonly found in nature and, when used in design, contributes to aesthetically pleasing outcomes. The Golden Ratio occurs when a line is divided into two parts ('a' and 'b'), where the longer part (a) divided by the shorter part (b) is equal to (a + b) divided by a. Mathematically, this relationship is $a/b = (a + b)/a = 1.618$

[3] Line symmetry (also called reflectional symmetry or mirror symmetry) is where one half of an object is the reflection of the other half. Rotational symmetry is the number of times an image can turn onto itself within one full turn (360°). This means that every object has at least one order of rotational symmetry. Total order of symmetry = number of line symmetries + order of rotational symmetry.

[4] The language used in mathematics when describing a transformation is exact. This support guide (PDF) may be useful for ākonga when they communicate how they have developed a motif, and explain how they know the transformation has been applied correctly.