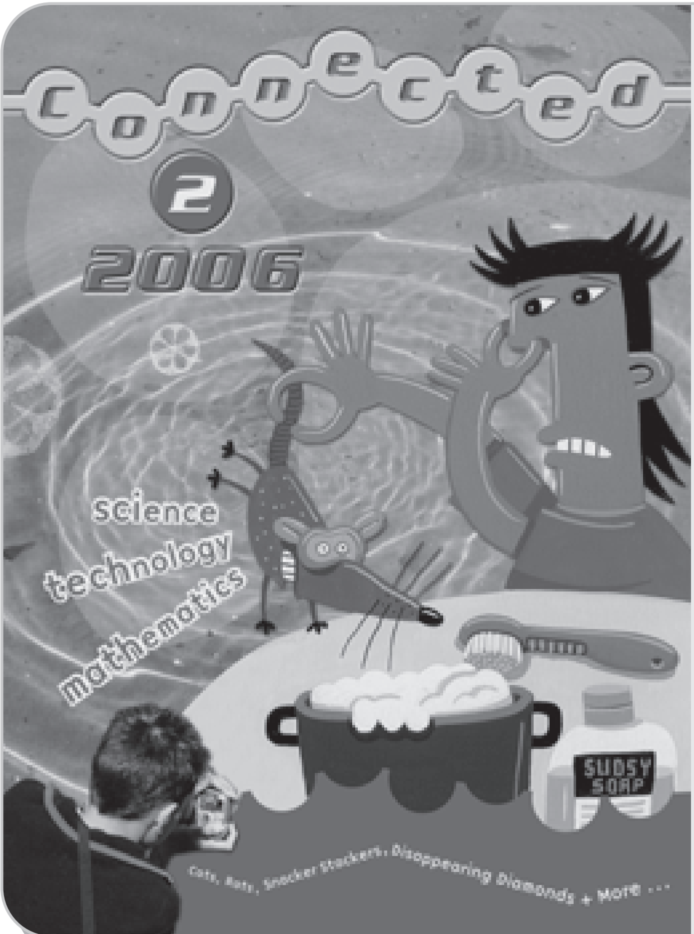
MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga



Notes for Teachers

Connected 2 2006

Contents and Curriculum Links

Introduction

Connected is a series designed to show mathematics, science, and technology in the context of students' everyday lives. The stories and articles are intended to stimulate discussion and to provide starting points for further investigations by individuals, groups, or a whole class. A **shared or guided reading approach** to using these texts will support students in their understanding of the concepts and the technical vocabulary.

Connected 2 is designed to appeal to **year 4–6** students who are working at **levels 1–3**.

General Themes in *Connected 2 2006*

1. Caring for Animals

"I Miss My Pet" is a story about the relative life expectancies of various pet species and ways in which this topic can be explored statistically. The teachers' notes provide data sets that sample the lifespans of city pets compared with rural pets, big dog breeds compared with small dog breeds, and elephants in the wild compared with elephants in captivity. The activities associated with these data sets will help your students to explore and expand on the statistical concepts and methods described in the story.

"Sniff, Swing, Swipe" is an article about keeping life as interesting and as challenging as possible for zoo animals. The article focuses on Sniff, Swing, Swipe 2004, a programme in which student ideas were invited for enriching the lives of kea, spider monkeys, hawksbill turtles, and red pandas in New Zealand zoos. The teachers' notes explore the technological practice of the students in the article and suggest ways in which you could support your own students' technology projects in related contexts.

2. Light

"Patterns of Light" is another article about student projects, this time for science. It's all about Kelson Tu'akoi's award-winning photography project for the 2004 Waikato Science Fair. Kelson was able to capture a variety of intriguing images and then write captions to communicate the science behind these patterns of light. The teachers' notes suggest ways in which your students could investigate the science behind Kelson's images. They could then create a photo-assignment that communicates scientific ideas through visual imagery.

"What Is Light?" continues the Nature of Science and Physical World themes established in "Patterns of Light". This article explores what happens when great minds don't quite think alike. The teachers' notes explore the nature of scientific debate, highlighting case studies in which scientific ideas and evidence have been hotly debated.

3. Competitive Swimming

In "The Big Race", Lola discovers Grandpa's old swimming medal. This cherished prize resulted from hours and hours of training. The discussion and activities suggested in the teachers' notes will help students to explore the maths behind Grandpa's training schedule and the handicapping system devised to keep everyone training hard for the Big Race.

I Miss My Pet

Possible Achievement Objectives

Mathematics

Statistics

- Collect and display category data and whole number data in pictograms, tally charts, and bar charts, as appropriate (Statistical investigations, level 2).
- Talk about the features of their own data displays (Interpreting statistical reports, level 2).
- Make sensible statements about the situation represented by a statistical data display drawn by others (Interpreting statistical reports, level 2).

Developing the Ideas

This scenario introduces students to the idea that statistics can be used to investigate the validity of everyday notions (in this case, about the relative lifespans of different kinds of pets). The question to be investigated could be phrased as *What kind of pet lives longest?* or *How long do different kinds of pet live?*

The students in the story provide a lot of anecdotal data, and once it has been sorted, their challenge is to try and discover the patterns contained within it. By sorting and analysing the data in different ways, the students maximise the useful information that emerges from it.

A key statistical concept raised by the story is that of a *variable* (in this case, "lifespan"). In statistics, a variable is any attribute or characteristic of someone or something that is capable of being counted, measured, or classified in some way. A second key concept is that of *distribution*. A distribution is an arrangement of data in which a particular variable has been isolated for investigation.

A distribution has a *centre* (*central tendency*). The centre is the value around which the data clusters. *Mean*, *median*, and *mode* are measures of central tendency. The mean (average) is found by calculating the sum of all values in the data set and then dividing that total by the number of values. The median is the middle value of a distribution. It is easily found when all the values are arranged from least at one end to greatest at the other. The mode is the "most likely" value, as Mrs Phylum describes it in the story.

A distribution also has *spread*. This is the extent to which the data is clustered around the centre or distributed across a wider range of possible values. One measure of spread is the *range*: the difference between the least and greatest value in the data set.

One further useful statistical concept needs to be mentioned, and that is *outlier*: an extreme value at the lower or upper end of a data set, which may be there as the result of some unusual circumstance.

Of all measures of central tendency, the *mean* is the measure most used in everyday contexts, including news reports. It is a very useful measure, especially where the distribution is a large one. Care does, however, need to be taken when using the mean with a small distribution. The main reason for this is that an outlier can have a big effect on the mean, as can be seen with the goldfish lifespans. Students can easily see what happens to the mean when a single very low or very high value is added to a small data set where all values are centrally clustered. In such situations, the median is likely to be a better measure of central tendency.

The story models a discussion of all the above statistical concepts, their uses, and cautions about their use. All four stages of the statistical enquiry cycle are present:

1. Pose the question.
2. Gather data.
3. Sort and display data.
4. Communicate findings.

The discussion in the story could be the basis of a great deal of group and class discussion. The students could focus initially on identifying, collating, and describing all the statistical terms/concepts that appear. They could then identify the process used in the story, linking the different parts of the narrative to the different stages of the statistical enquiry cycle. They could then critique the process and suggest ways of doing it better.

Note that for reasons of design and economy of space, some of the charts in the book are set out with the categories (animals) on the vertical axis and the measurement (lifespan) on the horizontal axis. If students use a computer spreadsheet and charting program, it is likely that they will have to provide this information the other way around.

Further Activities

The table below shows the lifespans of a synthetic but typical population of dogs and cats in a large city and a selected population of dogs and cats living in a rural area. Use this information as the basis for exploring the question *Do dogs and cats live longer in the city or in rural areas?*

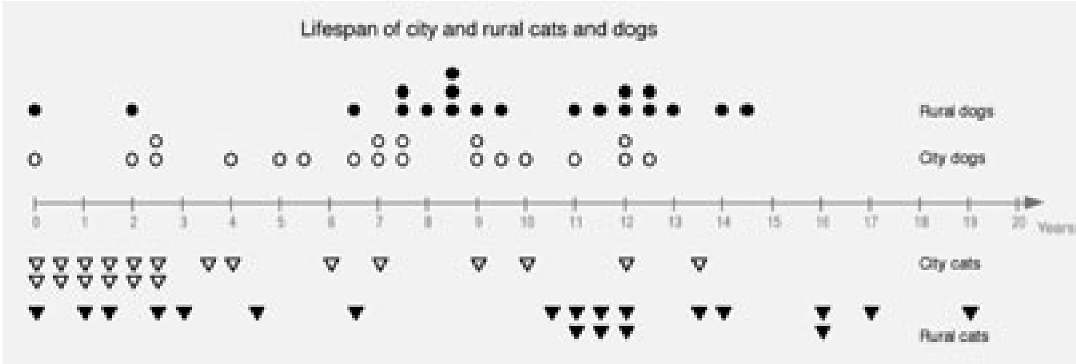
Lifespan (years)			
City pets		Rural pets	
Dogs	Cats	Dogs	Cats
8	4.5	8	16.5
9.5	2.5	10	14.5
3	7.5	8.5	2
0.5	2	8	12.5
7	9.5	9.5	11.5
11.5	0.5	12.5	11
5.5	6.5	9	12.5
3	2.5	14.5	17.5
6	12.5	7	0.5
7.5	4	13	19.5
10.5	14	9	3
12.5	1	2.5	11.5
10	1.5	0.5	3.5
9.5	3	13.5	14
2.5	10.5	12.5	16.5
12.5	0.5	13	12
13	3	15	7
4.5	1	12	12
7.5	2	9.5	1.5
8	1.5	11.5	5

If the data for all four groups is plotted on a single number line, as shown below, we get a better picture of what it "looks like". This kind of graph can be drawn easily on a sheet of paper. It can also be drawn easily using a computer drawing program, making good use of the arrow keys and the copy and paste functions.

Using this graph or a similar one, the students should be able to make a variety of statements that compare the lifespans of city and rural cats and city and rural dogs. They should also be able to make statements that compare the lifespans of dogs with those of cats.

The data for city dogs is very spread out. One dog lived for only 0.5 year. This may be a genuine outlier, but because the data set is evenly spread, the outlier's effect on the mean is minimal. The mean of 7.5 years (this value needs to be calculated) is right in the middle of the data set and is almost the same as the median, 7.75.

The data set for city cats looks quite different. This time, the data is split into two groups. A large group of cats (13) died before the mean age of 4.5 years, while the remaining 7 died somewhere between 6.5 and 14 years. Because a large group died young, those that lived for 9 or more years significantly influence the mean. In this case, the median is a better indicator of average lifespan.



The considerable difference between the cat and the dog data sets could be the subject of an interesting class discussion. One reason for the difference could be the laws that apply to keeping these pets. Dogs have to be locked up in a secure yard, whereas cats are free to roam. Cats, especially young ones, are much more likely to be run over. They may be killed by dogs if they wander into the wrong backyards. Generally, they are exposed to a lot more hazards. It appears from this data, that if a city cat gets through the early years, it has a good chance of living to old age.

If we look at the corresponding rural data, we get a different picture.

It appears from the data that rural dogs live longer than city dogs. There are two notable exceptions to this. Although the exceptions are outliers, they are part of the picture and suggest that if rural dogs can survive the first few years, they have a much better chance of living longer than city dogs. Note that the mean and median are very close together, as in the graph of lifespans of city dogs. (This data relates to rural pet dogs. Working dogs often have a much shorter lifespan, as they are more likely to be euthanised at the end of their useful life.)

The data for rural cats again shows a split into two groups: those that die in their early years and those that live to old age. The mean is well below the median and is not a good measure of the likely lifespan of country cats.

Notice that the range for rural cats and dogs is much bigger than for city animals. This means that cats and dogs in the country that don't fall victim to accidents reach greater ages. A city is a stressful place for animals, with traffic, noise, and frequent exposure to strangers. Stress may make them susceptible to illnesses, and traffic accidents are probably more frequent in cites. These factors may well account for some of the difference in the medians and means for both groups. Make sure that your students go back to the question at the start of this discussion, *Do dogs and cats live longer in the city or in rural areas?* Based on the data in the above tables and graphs, the answer is that rural animals live longer.

A further investigation could be based around the database below. This time, the question could be *Do big dogs live longer than little dogs?* Note that students with big dogs as pets could be distressed by the fact that these breeds have short lifespans. If you decide to work with these data sets, you could list the breeds of all your students' dogs before the lesson and remove any breed that is owned by one of your students.

Lifespan of Dogs (synthetic but typical sample of 20)									
Large dogs (years)					Small dogs (years)				
Bloodhound	English mastiff	Great Dane	Irish wolfhound	Rottweiler	American cocker spaniel	Miniature poodle	Border collie	Jack Russell terrier	Lhasa apso
6	2	8	9	4	13	11	17.5	17	13
7	11	5.5	3	8	9.5	15.5	10	14.5	15
2	7.5	2.5	4.5	3.5	2	7	12.5	13.5	9
9	8.5	6	1	9	11	17	14	16	16
6.5	8	8	8	11	12.5	14.5	3	15.5	14
8	3	10	9.5	10.5	15	10	16.5	1	14.5
8	9	9	3	5.5	8	2	15	15.5	16
1.5	10	5	6	8	2	16.5	13.5	17	13.5
10	11	6.5	1.5	9	13.5	15	16	18.5	1.5
7	6	7	7.5	7.5	12	14	12.5	16	10.5
7.5	7.5	8	6	8	13.5	13.5	0.5	2.5	12.5
8	8	8	7	7	14	15	10.5	11	3
6.5	9.5	8.5	6	9	9	1.5	11	9.5	12.5
10	8.5	4	5.5	7	10	13	10.5	16	14.5
0.5	4	9.5	7	6.5	8.5	16.5	9.5	14.5	17.5
8	8	12	9	7.5	11.5	14.5	15.5	3	13
8.5	9.5	4	5	9	13	9.5	14	13.5	12
7.5	10	10.5	8	8	12.5	10	12	14	16
8	9	11	4.5	3	0.5	11	4	1.5	11

The students should go on to map the data on a number line or number lines (as in the earlier example) and examine the way the data is distributed. Are there significant outliers? Is the bulk of the data grouped closely, or is it evenly spread? Are your students able to pick whether the mean and median will be close together, just by looking at the graphs?

Have your students use calculators to find the mean and the median for each breed. For your reference, they are summarised in this table:

Dog Lifespans (means and medians)										
Breed	Bloodhound	English mastiff	Great Dane	Irish wolfhound	Rottweiler	American cocker spaniel	Miniature poodle	Border collie	Jack Russell terrier	Lhasa apso
Mean lifespan	6.8	7.9	7.5	5.8	7.4	10.1	11.9	11.5	12.1	12.4
Median lifespan	7.5	8.3	8	6	7.8	11.3	13.3	12.3	14.3	13

The above investigation should show that big dogs do not live longer than smaller dogs. In fact, big dogs have much shorter lives – although some large breeds live longer than other large breeds. Genetic differences probably account for the differences in longevity – with the suggestion that many dogs of larger breeds have decreased cellular growth potential. Also, some large breeds are especially likely to develop hip or skeletal problems. A local vet may be prepared to come along and discuss the topic with your students.

The data below gives the age at death for elephants from two monitored groups: a herd in the wild and a number of animals kept in captivity.

Lifespan of Elephants	
Age (years) at time of death	
Wild	Captivity
56	23
68	12
34	26
71	35
2	31
46	29
58	3
34	14
66	37
69	41
51	18
47	52
3	17
48	23
53	26
68	36
71	46
42	8
51	51
9	18

Lifespan of Elephants										
Captivity					Stem	Wild				
			8	3	0	2	3	9		
8	8	7	4	2	1					
9	6	6	3	3	2					
	7	6	5	1	3	4	4			
			6	1	4	2	6	7	8	
			2	1	5	1	1	3	6	8
					6	6	8	8	9	
					7	1	1			
					8					

The data covers at least seven decades, so a back-to-back stem-and-leaf graph is a good way to put it in order.

There are three outliers in the wild herd (2, 3, and 9, which are lightly shaded); the rest of the data is quite closely grouped. Poachers, predators, and illness are possible explanations for the outliers. The mean lifespan of the wild elephants is 47. But more than half exceeded this age, so the median (51, the two instances of which are darkly shaded) would be a better measure of central tendency.

The elephants in captivity have a mean lifespan of 27 years, which is right in the middle of the data set. The median (the two instances of which are darkly shaded) is 26 years. Notice that there are no outliers in this data.

Students should observe that there is a very great difference between the typical lifespan of an elephant in the wild and that of an elephant kept in captivity. They should be able to voice some possible reasons for this.

- Elephants are one of the most socially advanced animals. They have high-level cognitive skills, and their family groups exhibit complex interactions. Because family life is critical to elephants' social well-being, they may suffer mentally if held alone in isolation. This can affect their health.
- Like humans, they need exercise if they are to maintain good health. (An elephant in the wild will walk approximately 40 kilometres every day. When confined to a small concrete slab, their health deteriorates, and they die young.)

Links to the Number Framework

Many of the tasks suggested in these activities, including ordering the members of a data set, representing them on a number line or stem-and-leaf graph, identifying the median, and working out the range, can be achieved by Stage Five (Early Additive Part–Whole) students. Students can be shown how to calculate the mean using a calculator, but they will need to be at Stage Six (Advanced Additive Part–Whole) to make sense of the concept, which involves proportional thinking.

Sniff, Swing, Swipe

Possible Curriculum Links

Technological Areas

Materials Technology

Structures and Mechanisms

(See the Specific Learning Intentions for links to relevant Achievement Objectives and Components of Technological Practice: Brief Development [BD], Planning for Practice [PfP], and Outcome Development and Evaluation [ODE].)

Achievement Objectives for Science

The Nature of Science and Its Relationship to Technology

- 2.2: Investigate and describe how simple items of technology work.
- 2.3: Investigate the way common items of technology have developed.

Living World

- 2.2: Investigate and understand the general functions of the main parts of animals and plants.
- 2.4: Investigate the responses of plants or animals, including people, to environmental changes in their habitats.
- 3.2: Investigate special features of common animals and plants and describe how these help them to stay alive.

Material World

- 2.2: Investigate and communicate differences in the properties of similar types of materials.
- 3.2: Investigate and describe how the physical properties of materials are related to their use.

The Specific Learning Intentions

The students will be able to:

- develop an understanding of the main stakeholders' needs in the Sniff, Swing, Swipe project (**AO 3, 5, 7–8/BD**);
- investigate the relationship between animal behaviour in the wild and in captivity in order to develop enrichment ideas that will stimulate animals by mimicking the physical and mental challenges they would have faced in the wild (**AO 2, 4–6, 8/BD** and **ODE**);
- plan their project at the outset – and adjust those plans as the project progresses – taking account of all the processes, time, and resources, both material and human, that will be required (**AO 1–3, 5, 7–8/BD** and **PfP**);
- trial and select appropriate materials for behavioural enrichment equipment on the basis of the materials' physical properties, with the fitness for purpose appraisal emphasising safety and durability (**AO 1–2, 4–8/PfP**);
- design and test structural features for behavioural enrichment, with the fitness for purpose appraisal emphasising animal ergonomics (**AO 1–2, 4–8/PfP** and **ODE**);
- undertake outcome development through ongoing evaluation, working closely with animal experts and other stakeholders, especially during concept development and later trials in order to meet the requirements of their brief (**AO 1–8/ODE**).

The Key Ideas

The following aspects of technological practice are exemplified in "Sniff, Swing, Swipe". (Your students could use this case study to inform their practice in a wide range of situations. The suggestions here involve them developing behavioural enrichment equipment for pets or farm animals, but the ideas could be adapted to suit a wider variety of projects in which students develop customised outcomes for specific animal species, groups of people, or individuals.)

- Developing successful behavioural enrichment requires knowledge of the subject animal's life history, anatomy, dexterity, locomotion, natural habitat, behaviours, preferred foods, and so on.
- When developing behavioural enrichment, as well as considering the biology of the animal concerned, you need to take account of the environment in which the enrichment equipment will be located and the amount of human involvement that will be necessary for its operation.
- It's important to consider the suitability of all materials used in terms of safety, durability, and aesthetics – first by thinking carefully about appropriate properties and later through practical trials. (Note that health and safety issues should be discussed and that draft guidelines should be established before any trialling with the animals.)
- The structures and mechanisms in the equipment can be tested in a two-part process, first by developing conceptual designs and then by trialling mock-ups of certain aspects of the design and/or prototypes of the overall outcome.
- Gaining feedback from experts such as zookeepers, vets, animal breeders, and pet shop owners will increase the likelihood of success.

Developing the Ideas

In order to focus your students' minds on the important aspects of technological practice exemplified in "Sniff, Swing, Swipe", you could discuss the following key ideas after the first reading.

Integrating Knowledge from Other Domains

In the "Sniff, Swing, Swipe" case study, biological knowledge was critical to the success of the outcomes. Note that the research and development took place within a structured programme. Point out to your students that, because the flow of ideas was moderated and channelled by criteria specific to the chosen animal's biology, the brief and therefore the outcomes that emerged from it were not too left field or unrealistic. The outcomes were, however, very creative. Point out that "Sniff, Swing, Swipe" demonstrates the way in which well-developed specifications provide essential guidance without stifling innovation.

Although most of the motivation in the examples came from the feeding drive, one or two did not. For example, some of the kea solutions relied as much on the birds' general curiosity and playfulness as on their feeding drive. The mechanical eagle for the meerkat enclosure was based on predator avoidance instincts rather than a feeding drive. This opens up an interesting discussion point about ethics and the balancing of priorities. The students wished to excite the meerkats without stressing them. These discussion points should edge the students towards considering other motivators than just the feeding instinct when they develop their own ideas for behavioural enrichment activities.

Considering the Overall Environment

Another major consideration was the need to accommodate the proposed outcomes within an animal's enclosure. This aspect wasn't highlighted in the article, so it would be a worthwhile discussion point. Zoo enclosures are carefully designed artificial environments, and the enrichment ideas were evaluated on their practicality within these settings. Zoos have a strong function of public entertainment. Behavioural enrichment proposals were stronger candidates if they created an interesting spectacle for the public. Enrichments for public display had to look naturalistic. This wasn't an issue if they were to be used in off-display areas, such as night enclosures. They also had to function with minimal keeper involvement. Occupational Safety and Health regulations governing the weights keepers could lift limited the size and weight of designs.

Considering Potential Materials in the Conceptual Design Phase

In most cases, at the first feedback stage the zookeepers evaluated conceptual designs rather than actual mock-ups or prototypes. Their feedback provided impetus for the students to refine their ideas before progressing to make prototypes. Because prototyping is very resource intensive, it was sensible to progress with only the stronger concepts.

In the conceptual design phase, potential materials were carefully considered. Safety was critically important. The materials couldn't splinter or leave sharp edges if they broke. Also, non-toxic materials were sought, including non-tantalised woods and food-grade paints. Strength and durability were also important properties.

Close Expert Consultation

In the Sniff, Swing, Swipe programme, the consultants were also the initiators and sponsors of the project. They worked almost as colleagues with the students. This is similar to many professional situations in which technologists' peers and managers are consultants and reviewers as well. (This situation was different from many student projects in which expert consultants are identified by the students and engaged as outside contributors.) Even at great distances, the working relationship between the keepers and students was close. The website and email contact were important communication tools. This case study shows that effective communication and close working relationships can be achieved in different ways.

Useful Websites

Auckland Zoo's site has links to all three Sniff, Swing, Swipe projects via their education pages. See **www.aucklandzoo.co.nz/index.php**

- Sniff, Swing, Swipe 1: **www.aucklandzoo.co.nz/sss/sss_001/home.html**
- Sniff, Swing, Swipe 2: **www.aucklandzoo.co.nz/sss/sss_002/home.html**
- Sniff, Swing, Swipe 3: **www.aucklandzoo.co.nz/sss/sss_003/SSS3.homepage.htm**

The other three zoos were:

- Hamilton Zoo **www.hamiltonzoo.co.nz**
- Wellington Zoo **www.wellingtonzoo.com**
- National Aquarium **www.nationalaquarium.co.nz**

International websites include:

- Enrichment Online, a great site that allows you to search for a huge number of enrichments by animal. See **www.enrichmentonline.org/browse/index.asp**
- Honolulu Zoo, which provides stories and some great pictures about enrichment programmes. See **www.honoluluzoo.org/enrichment_activities.htm#links**
- Aussiedog at **www.aussiedog.com.au**, which lists a range of enrichment and training products for dogs and horses as well zoo animals.

Further Activities

After your students have read "Sniff, Swing, Swipe" and discussed how they might have added to or adapted from the enrichments in the article and on the websites, they could carry out a follow-up project, such as:

- developing and trialling behavioural enrichment ideas for their pets or farm animals;
- developing other pet-care equipment;
- developing animal environments, as detailed on page 63 of *Technology in the New Zealand Curriculum* (1995).

The following notes are based on the first of the above suggestions, but they could be adapted to suit the others. To ensure that your students investigate suitable enrichments for particular species, an observational study of animal behaviour is a good start. The following templates will help to structure that process.

Chosen pet or farm animal:	**Observed behaviours**						
	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7

How does your subject animal move? Chosen pet or farm animal:												
Tick as appropriate	Walks	Hops	Jumps	Climbs	Swims	Flies	Swings	Other	Other	Other	Other	Other

How does your subject animal manipulate, break up, and eat its food?				
Chosen pet or farm animal:	Description of feeding behaviour 1	Description of feeding behaviour 2	Description of feeding behaviour 3	Description of feeding behaviour 4

Brief Development

The following brief, based on the Sniff, Swing, Swipe project, is provided here only as an example that your students should modify for their own situation, revisit, and adjust on an ongoing basis as their projects proceed. The focus questions that follow will help them to tailor the brief to their own needs. (You could have the students develop their own brief first, with reference to the focus questions below, and introduce the sample brief afterwards as a follow-up checklist.)

Focus Questions – Brief Development

- Why is behavioural enrichment necessary?
- What is the budget?
- What are the timetable and deadlines for producing a behavioural enrichment item?
- What behavioural enrichments do you know that are available for pets?
    - Are they food-related? If so, how is potential overfeeding taken into account?
    - Do they involve an interesting scent? Do they make noises or movements that interest the animal without frightening it? How else do they attract the animal's interest?
    - If in a display situation such as an aquarium, do they look attractive and naturalistic?
- What do you need to learn about your chosen animal?
- Where can you find appropriate information about the ethical treatment of your chosen animal? How would you know if your chosen animal were stressed?
- What are the essential attributes of a behavioural enrichment item for your particular animal?
- Will there be people available to operate and maintain the enrichment item? How will this affect what's possible?
- How can you ensure that the enrichment item will be safe for both the people and the animal using it?
- Where will the enrichment item be located? How will the location affect its shape, size, look, and functionality?
- What are the basic performance requirements for the necessary materials, including their reliability and durability?
- How can you identify materials and production processes that may be suitable?
- How can you evaluate the effectiveness of your enrichment item? What will be your success criteria?

Sample Brief

Conceptual Statement

Develop a prototype of a behavioural enrichment item suitable for an identified species in a specific New Zealand zoo.

Attributes

The behavioural enrichment must be:

- viable and useful for the zoo;
- designed to encourage natural behaviours;
- non-toxic;
- suited to animal ergonomics;
- robust;
- washable;
- user-friendly for both the animals and the keepers;
- made with non-breakable, smooth-edged materials;
- particularly safe if designed to be destroyed by the animals;
- economical, for example, feasible to produce and made from cheap, readily available, and if possible, recyclable materials;
- in compliance with the zoo's animal ethics policy and with OSH regulations for staff;
- accompanied by supporting documentation that explains its safe and effective use and, if appropriate, how it can be reproduced on an ongoing basis.

Planning for Practice

Careful planning is the key to successful practice, allowing time and other resources to be managed effectively. In particular, the ongoing stakeholder consultation and follow-up development work were effective in the Sniff, Swing, Swipe programme because people and materials were available when they were most needed.

Allow your students time to think about, discuss, and list the main actions the students undertook as part of the Sniff, Swing, Swipe programme. They should then develop a plan of action for their own chosen project, including relevant features from Sniff, Swing, Swipe and adding extra activities according to their particular circumstances. A plan of action for students developing behavioural enrichment ideas for pets might look something like the following. (You could have the students develop their own plan of action first, with reference to the focus questions below, and introduce the sample plan afterwards as a follow-up checklist.)

Focus Questions – Planning for Practice

- How will we define the most useful things we've learnt from our research activities?
- Could our expert consultants help us to decide which biological and environmental factors are more important than others?
- Which parts of the outcome development and evaluation process can we complete independently? Which parts will we need help with?
- Can we develop models to test particular design ideas?
- Which of the experts and other stakeholders will see our models? Will we involve animal owners as well as the experts?
- Will they be involved in helping us to make the models, or will we just ask them to comment on the completed models?

- How will we find out what they think? Can some of the feedback be gained at a distance, or will face-to-face consultation be necessary?
- How can we make sure that the key stakeholders will be available when we need their help?
- What materials will we use for the models? For testing, do we need to use exactly the same materials that we intend to use in the final outcome, or can some models be made with other materials?
- Where will the materials come from?

Sample Plan

- The students identify the animal they wish to design behavioural enrichment for.
- They begin to identify key stakeholders and plan how to make initial contact with them. They consider how much time will be needed for setting up and maintaining relationships. They draft a very provisional timeline around the key times when they will need expert feedback.
- They research the biology of the animal. They produce a list of important biological factors, which inform the development of product attributes for their brief.
- They appraise the animal's domestic environment and compare this with its natural habitat. They consider the constraints and/or opportunities presented by the enclosure or environment.
- They come up with a list of important environmental factors, from which they develop another set of product attributes to complement those that focus on anatomy and behaviour.
- They research existing technology to stimulate their ideas. For example, they might visit or invite guest speakers from farms, catteries and kennels, pet shops, zoos, or veterinary clinics. They might visit websites of pet product manufacturers and of zoos to research enrichment or general care equipment.
- They explore possible materials, developing their understanding of how the physical properties of materials link with their functioning.
- They revisit their brief and refine it in the light of their research.
- They revisit their timeline, scheduling enough time for conceptual design and for the testing and refinement of mock-ups and prototypes.
- They ensure that all the necessary people, equipment, and materials will be available at the right times.

Outcome Development and Evaluation

Developing enrichment ideas for their own pets or farm animals is a rich and authentic technology activity for students. Working with real animals, however, increases the need for carefully planned trials, combined with expert input, to ensure that the outcomes employ materials and structures that are safe as well as effective.

The Sniff, Swing, Swipe Outcome Development and Evaluation

- The students generated a range of design ideas.
- They consulted among their peers and with outside experts to gain initial feedback on the design concepts.
- They adjusted their design concepts according to the feedback. Some mocked up particular parts of the outcome to test specific functions and/or to appraise the look of the design in tangible form.
- They sought feedback, refined their ideas, and adjusted their brief and plan of action accordingly.

- They then developed detailed plans and built a prototype. Some made further mock-ups to test aspects of the prototype's functionality.
- They evaluated their prototype against the brief. If they were confident that the prototype included all the key attributes, especially those relating to health and safety, they user-tested it with animal subjects.
    - Safeguards were established to ensure that effective intervention could take place if unforeseen safety issues arose. For example, the keepers monitored stress responses.
- The students evaluated stakeholder feedback from the live trials, reviewed the brief, and either retested an adjusted prototype or else produced the final outcome.

Follow-up Questions – Outcome Development and Evaluation

- Have you explored and evaluated different ideas to see whether they meet the requirements of the brief?
- Have you fully considered the stakeholder feedback? Can you show evidence of ongoing stakeholder consultation and your response to it?
- Have you developed a technological outcome that meets your brief?
    - Does your outcome meet the key specifications? In other words, does it display all the features that must be in place?
    - Does it exceed the requirements of the brief?

"Patterns of Light" and "What Is Light?"

Possible Achievement Objectives

Science

Physical World

- 2.1/2: Investigate and describe their ideas about some everyday examples of physical phenomena.
- 3.1/2: Investigate and describe their ideas about some commonly experienced physical phenomena to develop their understanding of those phenomena.

Developing Investigative Skills and Attitudes

- 3/4: Use their science ideas and personal observations, and those of others, to make testable predictions or to identify possible solutions for trialling (Focusing and Planning).
- 3/4: Use organised data and scientific ideas to suggest an answer to their selected questions and problems, and make an evaluation of their investigation (Processing and Interpreting).
- 3/4: Present what they did and what they found out in their investigations in ways and forms appropriate to their peer group (Reporting).

Nature of Science

- 2.1: Use a variety of methods to investigate different ideas about the same object or event.

The Specific Learning Intentions

The students will be able to:

- use their own ideas to first predict and then investigate the interaction between light and a variety of materials;
- suggest explanations using their observations as supporting evidence;
- explore how scientific evidence can be gathered, analysed, and communicated in a variety of ways.

The Key Ideas

- Surfaces and materials transmit, reflect, and/or absorb light.
- Scientists use what they already know to make predictions about what they're not sure of.
- Science ideas must withstand peer review before they are accepted by the science community.
- There are many ways of communicating science ideas. Visual images can be an especially powerful means of getting your message across.

"Patterns of Light"

Developing the Ideas

Two Nature of Science themes link "Patterns of Light" with "What Is Light?". Before the first reading, you could introduce the following Nature of Science themes in child-friendly language. In this way, you will focus the students' minds on the way scientists work as well as on the Physical World ideas about light that they're about to explore. (The twelve themes are presented on the Ministry of Education's Science IS website. See **www.tki.org.nz/r/science/science_is/nos/index_e.php#propList**)

Scientific explanations may involve creative insights.

> Scientific explanations do not simply emerge from observations made during an investigation. A scientific explanation proposes that there is a pattern to what is observed. The pattern that one scientist "sees" may not be apparent to another.

All science knowledge is, in principle, subject to change.

> Science knowledge relies on experimental and observational confirmation. Where data has been incomplete, new or improved data may well lead to the revision of accepted science explanations.
>
> In situations where observations are fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be the greatest.

After reading "Patterns of Light", the class could discuss other ways in which light forms patterns. Examples might include:

- reflections on a plane of glass;
- reflections on shaped glass, such as crystals or curved mirrors;
- sunsets and sunrises;
- rainbows;
- rainbow effects on the surface of oil-and-water mixtures;
- rainbow effects on the surface of bubbles.

These phenomena all result from either the reflection or the refraction of light. These terms will be new for many students, so take a little time to discuss them with the class. Patterns form when light **reflects** – in other words, when it bounces off a surface (as in the first two examples above). Patterns also result when light **refracts** – in other words, when it changes direction slightly as it passes from one substance into another, for example, when it passes from air into water or from air into glass and vice versa. In the last three examples above, white light refracts and splits into its component colours. Sunsets also result from refraction. They occur when blue light is scattered/refracted by atmospheric particles to a greater degree than red and yellow light.

You could select activities from the following suggestions to help your students to understand reflection and refraction. These phenomena caused all the visual effects that Kelson explored in his photo-assignment. By carrying out hands-on investigations, your students will gain a general understanding of how light behaves. They can then move on to read "What Is Light?" and explore both the behaviour of light and the development of knowledge from a Nature of Science perspective.

Further Activities

Activities from Other Ministry of Education Publications

- *Making Better Sense of the Physical World* (Learning Media, 1999) includes Science Focus: Light and Colour on pages 35–54. This chapter presents background information for teachers and a range of student activities that focus on the behaviour of light. The activities and background information are divided into the following topics: mirrors; shadows; magnifiers; and bubbles, rainbows, and colour spinners.
- Suggestions for exploring light and colour at levels 1 and 2 are outlined in *Light and Colour*, book 10 in the Building Science Concepts series, and at levels 3 and 4 in *Seeing Colours*, book 11 in the Building Science Concepts series (Learning Media, 2001).
- The students could carry out the activity outlined in "Make Your Own Sunset" (*Connected 3 1999*). The sunset effect occurs because much of the OHP light in the blue spectrum is scattered by the tiny milk particles in the water – whereas most of the red, orange, and yellow light passes straight through, tinting the screen behind with sunset/sunrise colours.
    - o This phenomenon is called Rayleigh scattering. The scattering is most pronounced when the wavelength of the light is much smaller than the size of the particles. Blue light has a smaller wavelength than yellow, orange, and red light, so more of it is scattered.
    - o In the atmosphere, a significant proportion of blue light is scattered by particles such as dust, whereas much of the orange and red light passes through, tinting clouds with sunset/sunrise colours. (The effect is usually visible only at dawn and dusk because at that time, sunlight enters the atmosphere at a low angle, passing through a longer distance of gas and dust. Rayleigh scattering also increases when the atmospheric particle load is high. For example, when there are bush fires in Australia, intense sunsets are seen in New Zealand.)

Activity: Bright Spots

This activity is adapted from Activity 7: Making Things Bigger and Smaller on page 45 of *Making Better Sense of the Physical World*. The activity is pertinent because students use a lens to concentrate a beam of light on a flat surface. This models the "diamond" effect on the bottom of the pond that Kelson observed. Because of the fire risk, you may wish to limit the students to using an overhead projector. If relying on the Sun as a source of light, make sure that you closely supervise the students or else demonstrate the activity yourself.

What You Need

- A magnifying glass (biconvex lens)
- Access to a sunny, outdoor area
- An overhead projector
- An eye-dropper
- A small glass jar with a tight-fitting lid
- Water

What You Do

- Have the students use a magnifying glass to concentrate a beam of sunlight onto the ground or a wall, moving the lens closer to and further away from the flat surface. (Alternatively, they could use an overhead projector to cast a square of light onto a wall in a darkened room. If they hold a magnifying glass about 5 or 10 centimetres from the illuminated square on the wall, it will concentrate some of the light into a very bright spot.) Pose some focus questions.

  "How does the patch of light on the ground or wall change as you move the lens?" "Why do you think that happens?"

  "What do you think is happening to the light as it passes through the lens?"

  "Can you draw a simple diagram to show that?"

  "Do you agree with Kelson that the bright diamonds that he saw on the bottom of the pond and the patch of light you've created with a lens were caused in a similar way?" "Why? Why not?"

- Liquid lenses work in the same way as glass lenses. Begin by discussing the terms convex (curving outwards) and concave (curving inwards). A biconvex lens, which curves outwards on both surfaces, is easy for students to make:
  - Fill a glass jar right to the top with water.
  - Stand it on a flat surface and use an eye-dropper to add a little more water. If you look closely, you'll see the surface of the water as a slight bulge above the edge of the jar.
  - Leave the jar standing on the flat surface and very carefully put the lid on. Try to avoid trapping an air bubble in the jar, although a small one won't be a problem. Mop up any water that has trickled down the side of the jar as you placed the lid. You can now use your jar as a liquid lens.
  - Use the jar in the same way as the magnifying glass, or else lay it on its side on the flat tray of an overhead projector and see how it concentrates the light that's projected through it.
  - If you have trapped a bubble of air in the jar, it'll affect the light, too.
  - Draw simple diagrams to show both how your liquid lens affects the direction in which light travels and how bubbles on the surface of a pond act in the same way.

Safety Warnings for Students

Never use a lens to concentrate sunlight onto clothing or a person's skin. You could burn their skin or set the cloth on fire. If using paper, don't leave the beam in one place for more than 20 seconds. Always keep a bucket of water with you in case of fire.

What You Look For

- Do the students' diagrams show the lens's biconvexity?
- Do their diagrams in some way show beams of light entering in parallel and converging as they pass through and out from the lens?
- Do the diagrams show a focus point where the beams intercept? (See the diagram on page 46 of *Making Better Sense of the Physical World*.)
- Do they understand that, if a flat surface were positioned at this focus point, a spot of intense light would be seen?
- When they move the lens back and forth, do they relate the growth and shrinkage of the spot of light to the movement of the focus point?
- Do they understand that the bubbles on the surface of the pond in "Patterns of Light" act as biconvex lenses?

Background Information about Refraction for Teachers

Jean Bernard Léon Foucault (1819–1868) tested the speed of light in transparent substances other than air. He found that the speed of light in water or glass was only about 66 percent of its speed in air. He also discovered that the speed of light is related to the substance's "refractive index". The more slowly light travels through a substance, the more it changes direction at the interface of that substance and air.

The refractive index scale sets air at 1. Compared to this baseline, the refractive index of ice is 1.31, fresh water is 1.33, sea water is 1.35, glass is 1.51, crystal glass is 1.69, and diamond is 2.42. (Cut crystal-glass sparkles more than ordinary cut glass because it has a higher refractive index. For the same reason, cut diamonds sparkle more than cut glass.)

Activity: Using Images to Communicate Science Ideas

This activity is a photographic investigation that's similar to Kelson's science fair project. Explain to the students that the idea is for them to work in pairs and explore and present science ideas of their own choosing by gathering, analysing, and communicating visual evidence.

What You Need

- A suitable location, such as:
  - a river, stream, lake, or pond
  - a mountain, gorge, or valley
  - a beach
  - a stand of bush
  - any other area that the students find scientifically interesting
- A digital camera
- Display materials

What You Do

- Give the students time to consider a topic for their project. To focus their thinking, you may wish to suggest topics for them to adopt or adapt. Encourage them to discuss the possibilities with you and among themselves. Examples might include:
  - the changes in a river from its source to the sea – an article called "Testing the North River" in *Connected 2 1998* is useful background material for this topic;
  - the effects of water or wind on a beach – an article called "The Sands of St Clair" in *Connected 1 2006* is useful background material for this topic;

- o where land and water meet: the interface between the shore and the waters of a pond, lake, or harbour – an article called "The Secret Life of Estuaries" in *Connected 3 2006* is useful background material for this topic;
- o an environmental issue, such as erosion or waste disposal;
- o the interaction of water, light, or wind with leaves or with whole plants.

- The students should then take a selection of photographs that communicate science ideas about their chosen topic. (For some topics, they may need to augment their collection of photographs with examples from books or the Internet.)
- Allow time for the students to discuss, both among themselves and with you, their photographs and the scientific messages they carry. At this stage, in response to peers' questions or comments or to address their own need for extra information, they could carry out some book and Internet research.
- They should then mount their images and write short captions to support their presentation. The captions should link the chosen images with specific science ideas.

What You Look For

- Can the students clearly articulate the focus of their photographic essay and the thinking behind their choice of subject?
- Can they justify their selection of photographs in a general sense and also give reasons for including or excluding particular images?
- Does the presentation communicate a clear scientific message about their chosen topic? Do the captions combine with the images to clarify and enhance the messages?

"What Is Light?"

Developing the Ideas

"What Is Light?" traces the development of thinking about the behaviour and nature of light. It summarises the ways in which pre-eminent scientists of the past used evidence about the properties of light to develop theories – theories that conflicted. The scientists on both sides of the debate were attempting to make sense of their observations and develop a theory to explain their ideas. A number of Nature of Science themes emerge from this case study. Before the first reading, you could outline the italicised ideas in child-friendly language. After the reading, you could return to these ideas for discussion and introduce the others.

Make sure that the students understand they're not expected to hold all those ideas in their heads while reading the article! Rather, treat the ideas as introductory and explain that the class will return to them for discussion after the reading. You could write out the italicised ideas on large sheets of paper and pin them to the wall so that the students can refer to them as the reading progresses.

Exploring Science Ideas

- Scientists' observations are influenced by their science ideas. (To illustrate this concept, you could switch around the old "seeing is believing" maxim: "If I hadn't believed it, I wouldn't have seen it." In other words, we often see what we expect to – and miss what we don't.)
- Scientists' investigations are influenced by their communities.
- *Scientists' predictions are based on their existing science knowledge.* "Scientists use what they know to help themselves understand things they're not sure about."
- *Scientists design investigations to test their predictions.* "When scientists think they understand something new, they test out their ideas by carrying out experiments and observations."

Forming Scientific Explanations

- Scientific explanations may involve creative insights.
- *There may be more than one explanation for the results of an investigation.* "There may be many ways of explaining why something happens during an experiment or observation."
- When an explanation correctly predicts an event, confidence in the explanation as science knowledge is increased.

Science Knowledge

- *Scientific explanations must withstand peer review before being accepted as science knowledge.* "When scientists have proven to themselves that something is right by running an investigation, they share the results with other scientists. The other scientists may try the same investigation to see whether they come up with the same results – and the same explanation for those results. Sometimes there are disagreements at this stage."
- New scientific explanations often meet opposition from other individuals and groups.
- *All science knowledge is, in principle, subject to change.* "Scientists are flexible thinkers. If someone comes up with a new idea and is able to prove it, other scientists accept that new idea. Sometimes the new idea replaces an old one."

The *Science Is* website can be accessed at:

www.tki.org.nz/r/science/science_is/nos/index_e.php

After the reading, revisit the key ideas with the class, focusing on the way in which Newton and Hooke constructed conflicting explanations for their scientific observations – and the responses of later scientists who continued the research into and the debate about the nature of light.

Use the following ideas to focus the discussion. Afterwards you could progress to the first of the Further Activities below to explore these NoS ideas in different contexts.

- Some science knowledge and ideas last only a short time before they have to be adjusted, whereas other ideas remain unchanged for long periods of time.
- Our own values and beliefs about the world influence how we think about science.
- Sometimes we don't agree with other people's ideas.
- We use observations as evidence to support our ideas. For example, we can find out about science and develop new ideas by carrying out investigations.
- We can share our scientific findings and ideas in many ways that involve writing, drawing, and talking.

Further Activities

Different Perspectives – and a Few Feuds – in Science

The students could learn about and discuss other instances in which ideas were researched, debated, refined, and possibly discarded over an extended period of time, for example:

- Pope Urban VIII versus Galileo
  www.tki.org.nz/r/science/science_is/activities/resources/galileo.doc (Note that the NoS activity with which this case study is linked is for level 7 and 8 students. However, you could read the case study aloud to your students with simplifications in the vocabulary.)
- Different stories about the Moon
  "Rona me te Mārama" (play), *School Journal*, Part 2 Number 4, 1993.
  www.tki.org.nz/r/science/science_is/activities/isact_moon_marama_e.php

- How different cultures name constellations
  www.tki.org.nz/r/science/science_is/activities/isact_name_constellations_e.php

- Changing theories about Mars
  www.tki.org.nz/r/science/science_is/activities/isact_theories_mars_e.php (Note that this activity is designed for level 5 and 6 students but could be simplified for your class.)
  www.tki.org.nz/r/science/science_is/activities/resources/mars_story.doc

Useful References

The New Zealand Curriculum Exemplars:

- How Do We See? 1
- How Do We See? 2
- How Do We See? 3
- Signs for a Dark Night
  (See **www.tki.org.nz/r/assessment/exemplars/sci/index_e.php**)
  As well as showing how students develop Physical World understandings about light, the exemplars above focus on:
  - investigating in science;
  - developing and communicating scientific understanding;
  - thinking in scientific ways.

The Big Race

Possible Achievement Objectives

Mathematics

Measurement

- Read and interpret everyday statements involving time (Developing concepts of time, rate, and change, level 3).
- Show analogue time as digital time, and vice versa (Developing concepts of time, rate, and change, level 3).

Number

- Write and solve problems which involve whole numbers and decimals and which require a choice of one or more of the four arithmetic operations (Exploring computation and estimation, level 3).

Mathematical Processes

- Devise and use problem-solving strategies to explore situations mathematically (Problem Solving, all levels).
- Interpret information and results in context (Developing Logic and Reasoning, all levels).

Developing the Ideas

Competitive swimming is about distance, time, and speed. Training develops a swimmer's style and stamina, making it possible to cover more distance in less time. This context is rich in mathematics.

Introductory Activities

Distance Calculations

Using the information in the story, challenge your students to work out what distance Grandpa was covering:

- If he was exercising daily in the week when he was wading to help his injured knee recover.
- Each day and each week when he was training in the college pool ($33\frac{1}{3}$ metres). Assume that he used this schedule each time he trained:

Style	Arms only	Legs only	Freestyle	Sprints	Slow lengths
Lengths	6	6	12	6	12

- Each day and each week when he was training in the town pool (50 metres). Assume that he used this schedule each time he trained:

Style	Arms only	Legs only	Freestyle	Sprints	Slow lengths
Lengths	10	10	10	5	15

- In a year of training in the 50-metre pool. Assume that he used the above schedule each time he trained.

The students should express these distances in metres and then in kilometres (using a decimal point to separate off the remaining fraction of a kilometre). Encourage them to discuss and use a variety of strategies to calculate these distances and to calculate the team performances below.

Comparing Improvements

Use the information from the tables in the story (team trial and race 1 results), together with the tables below (race 2 and race 3 results), as the basis for an investigation into how the different teams improved their performance over the series of races.

For each race:

- Did each team improve its time and, if so, by how much?
- Which team improved the most and by how much?
- Which team improved the least? How much of an improvement was this?

From the team trial to race 3:

- By how much did each team reduce its time?
- Which team reduced its time the most? Which reduced it least?

In race 3:

- In what order would the teams have finished if there had been no handicapping?

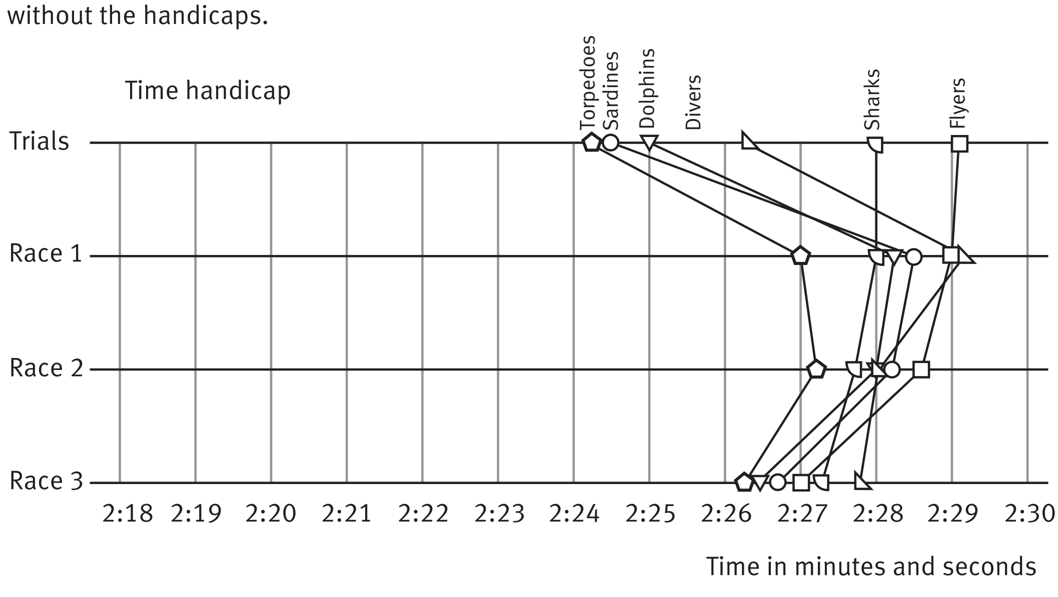
Race 2 Results			
Team	**Time incl. handicap**	**Time excl. handicap**	**Race 3 handicap**
Sharks	2 min 27.7 s 2nd	2 min 25.7 s	Start at 3 s
Divers	2 min 28.1 s 4th	2 min 25.1 s	Start at 3 s
Dolphins	2 min 28.0 s 3rd	2 min 23.0 s	Start at 5 s
Sardines	2 min 28.2 s 5th	2 min 22.5 s	Start at 6 s
Flyers	2 min 28.5 s 6th	2 min 28.5 s	Start at GO
Torpedoes	2 min 27.2 s 1st	2 min 20.2 s	Start at 8 s

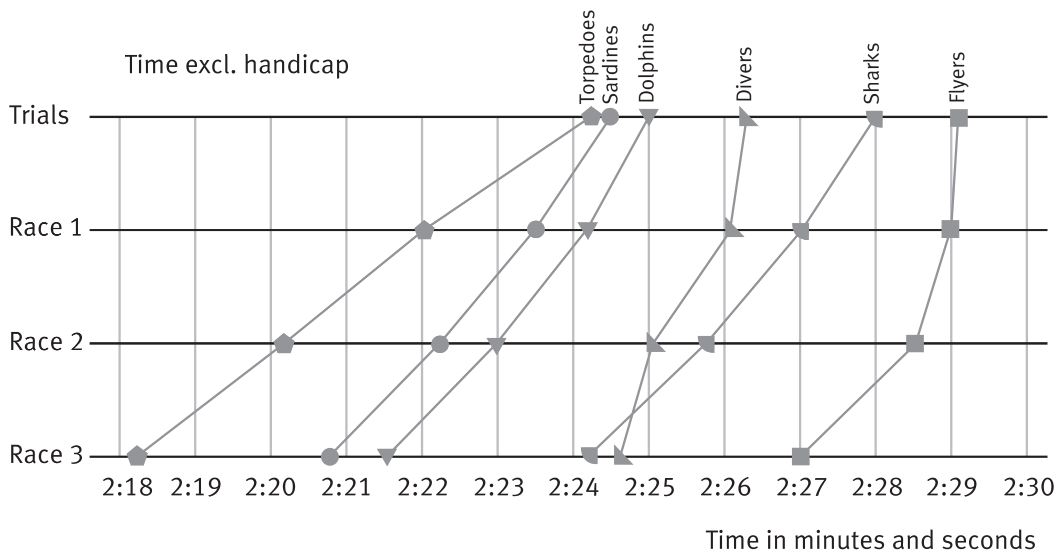
Race 3 Results		
Team	**Time incl. handicap**	**Time excl. handicap**
Sharks	2 min 27.2 s 5th	2 min 24.2 s
Divers	2 min 27.7 s 6th	2 min 24.7 s
Dolphins	2 min 26.5 s 2nd	2 min 21.5 s
Sardines	2 min 26.7 s 3rd	2 min 20.7 s
Flyers	2 min 27.0 s 4th	2 min 27.0 s
Torpedoes	2 min 26.3 s 1st	2 min 18.3 s

Graphing Strategies

This data is known as time–series data, meaning that this data is evidence of change in some variable over time (in this case, change in the length of time taken to swim a race). In order to interpret the data, the students will need to find a way of graphing it. Encourage a "draw and explore" impulse on the part of students when confronted with statistical data.

They could draw four identical number lines, one for the trial and one for each of the races. This kind of graph is easy to lay out on grid paper, but you may need to show the students how to set up and label the axes. If they use a different coloured pencil or pen to connect each team's times, they will be able to follow the progress more easily. After they've graphed times that include the handicaps, they could draw another graph with the same axes to display the times without the handicaps.





Using these graphs, the students should be able to answer the questions above about the relative improvements of the different teams. They can look at each team in turn or compare the performance of any two or more teams. They can see that, if the handicap is ignored (as in the second graph), the teams maintained their relative placing across all four races with the exception of the Divers, who fell behind the Sharks in race 3. How does a comparison of the two graphs show the effect of the handicapping? Which teams benefit from the handicapping, and which teams are penalised by it?

Further Activities

Increasingly Accurate Timepieces

In Grandpa's day, hand-held stopwatches were used to time races and races were timed to a tenth of a second. This kind of timing was the best available, but it depended on the reactions of the timekeepers for accuracy. Today, timing is all electronic, with swimmers touching a touch pad at the ends of the pool as they complete each lap. This system, introduced for the first time at the Munich Olympics in 1972, allows for races to be timed to a hundredth of a second.

Below are the results from the men's freestyle relay at the Manchester 2002 Commonwealth Games. The times are to a hundredth of a second. Have your students investigate the differences between the performances of the teams in the heat and in the final:

- Did each team improve its time and, if so, by how much?
- Which team improved the most? By how much?
- Which team improved the least? How much was this improvement?

Men's 4 x 100 m Freestyle			
Heat 1		**Heat 2**	
England	3:25.05	Australia	3:20.70
Cyprus	3:32.96	South Africa	3:22.35
Bahamas	3:37.66	Canada	3:23.06
Kenya	3:49.59	Barbados	3:36.13
Malawi	4:17.83	Isle of Man	3:45.06

Men's 4 x 100 m Freestyle Final		
Place	**Country**	**Time (min)**
Gold	Australia	3:16.42
Silver	South Africa	3:18.86
Bronze	Canada	3:19.39
4th	England	3:20.72
5th	Cyprus	3:27.82
6th	Barbados	3:33.91
7th	Bahamas	3:34.05
8th	Isle of Man	3:44.62
9th	Kenya	3:49.59
10th	Malawi	4:17.83

Obtain the results of the 2006 Commonwealth Games in Melbourne and challenge your students to compare the times for the men's 4 x 100 relay with the results for the 2002 event.

Analogue and Digital Time

When Grandpa wrote in his swimming journal, he was visualising analogue time, but when Lola was reading the journal, she was visualising digital time. (You may need to explain to the class that it wasn't until the 1970s that digital clocks and watches become widely available.)

An entry in Grandpa's diary reads:

> *Alarm rang at five to six. Twenty-five minutes later, left the house on bike. Arrived at swimming pool early as it only took me seven minutes. We were all changed when coach arrived. He was five minutes late. At six thirty-eight, we did ten minutes of stretching and warm-ups. Into pool at ten to seven.*
>
> *Swam training schedule. Last fifteen minutes spent practising racing starts and finishes for relay race tonight. Out of pool at quarter to eight. Home at eight o'clock.*

Draw analogue clock faces to show how Grandpa saw each of these times and draw digital faces to show how Lola saw them:

- the time the alarm rang;
- the time Grandpa left the house;
- the time he arrived at the pool;
- the time the coach arrived;
- the time Grandpa finished the warm-ups;
- the time he got into the pool;
- the time he started practising for the relay;
- the time he got out of the pool;
- the time he got home.

Fitness Circuits

The class could design a small fitness circuit that can be completed in about a minute and use it to explore timing and time calculations. On day 1, the students:

- practise the circuit;
- complete one circuit and time each other, using both analogue and digital stopwatches;
- discuss the advantages and disadvantages of analogue and digital watches in terms of accuracy, ease of understanding, and visual intuition – for example, on an analogue watch, you can see the time before and after the present moment, but on a digital watch, all you can see is the present moment;
- estimate how long they think it will take to complete four laps of the circuit and then test this out;
- compare the actual results with their estimates, using analogue and digital watches;
- record their best time.

On day 2, the students:

- practise the circuit;
- time each other for one circuit, using both analogue and digital watches;
- time each other for four circuits, using both analogue and digital watches.

Ask the students to record an estimate of the time in which they expect to complete one circuit and four circuits after five days of training. At the beginning, they could graph what they predict to be their likely improvement day by day. Each day, they could have a speed trial (before their training session, when they're fresh), chart their time, and compare this actual result with their prediction/goal.

At the conclusion of this activity, the results from everyone could be collated into a single database, a longitudinal data set. Students could be identified as A, B, C, and so on in order not to single out individuals whose performance is lacking. The gender of each person should be noted. And of course, the timed result for each of the five days will be recorded. This database can then be explored in multiple ways, using (as always) student-created graphs.

Useful References

Numeracy Project Book 9: *Teaching Number through Measurement, Geometry, Algebra and Statistics*, pages 3–5, provides useful background for these activities.

For a detailed description of the conceptual development necessary to understand the mathematics in this context and for associated units of work, refer to **www.nzmaths.co.nz** Click on the "Measurement" jigsaw piece and then on "Time" on the navigation bar at the top of the page.

Links to the Number Framework

Stage 6 (Advanced Additive Part–Whole)

At this stage, students are able to see that 3 lengths of a $33\frac{1}{3}$-metre pool equate to 100 metres. They can calculate the total lengths, using decimals to express the results in kilometres. Using friendly numbers or an alternative strategy, they can work out the difference between two times, expressed in minutes, seconds, and tenths of a second. By comparing the time differences, they can rank the teams in terms of their relative improvements. To be able to graph the race times, students will need to be able to draw a number line segment, mark it with seconds, and interpolate tenths.

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