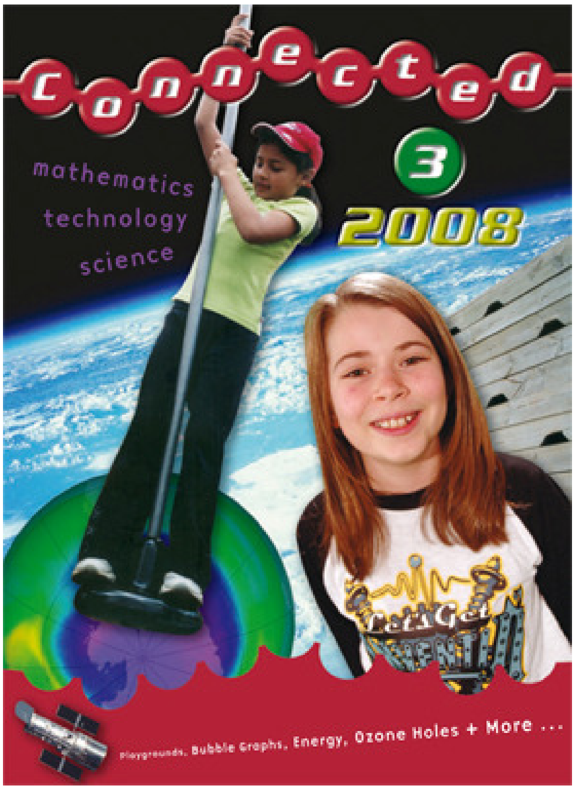
Notes for Teachers



Connected 3 2008

Contents and curriculum links

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Teachers’ notes online format

The 2008 *Connected* teachers’ notes are available in an online format only (HTML and RTF files). You can download and print out copies of these notes from this website.

PDF files of teachers’ notes for issues of *Connected* published prior to 2008 are also being provided on this website.

Availability of the students’ book

Further copies of *Connected* 3 2008 may be ordered from Ministry of Education Customer Services, freephone 0800 660 662, freefax 0800 660 663, email orders@thechair.minedu.govt.nz or online at www.thechair.minedu.govt.nz

Please quote item number 33242.

Introduction

Connected is a series designed to show mathematics, science, and technology in the context of students’ everyday lives. The articles are intended to stimulate discussion and to provide starting points for further investigations by individuals, groups, or a whole class.

- *Connected* 3 is designed to appeal to year **5–8 students** who are working at **levels 2–4**.

For notes on the **key competencies** in relation to *Connected*, see the main *Connected* introduction page.

A **shared or guided reading approach** to using *Connected* texts will support students in their understanding of the concepts and the technical vocabulary. For suggestions on approaches to reading, see the introduction to the *School Journal* teachers’ notes at

http://www.tki.org.nz/r/literacy_numeracy/professional/teachers_notes/school_journal/notes/introduction_e.php

General themes in Connected *3 2008*

1. Creating school environments; planning a playground
2. Using bubble graphs to plot and compare data
3. A fun challenge to experiment with sustainable resources and energy
4. The Ozone hole and climate change

Planning a Playground

Possible achievement objectives

NB: All AOs are quoted from *The New Zealand Curriculum* (2007).

Technology

Students will:

Technological Practice

Brief development (BD)

- L2: Explain the outcome they are developing and describe the attributes it should have, taking account of the need or opportunity and the resources available.
- L3: Describe the nature of an intended outcome, explaining how it addresses the need or opportunity. Describe the key attributes that enable development and evaluation of an outcome.

Nature of Technology

Characteristics of technological outcomes (CoTO)

- L2: Understand that technological outcomes are developed through technological practice and have related physical and functional natures.
- L3: Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures.

Technological Knowledge

Technological modelling (TM)

- L2: Understand that functional models are used to explore, test, and evaluate design concepts for potential outcomes and that prototyping is used to test a technological outcome for fitness of purpose.
- L3: Understand that different forms of functional modelling are used to inform decision making in the development of technological possibilities and that prototypes can be used to evaluate the fitness of technological outcomes for further development.

Specific learning intentions

Students will be able to:

- describe the attributes the playground should have in order to meet identified functional requirements (BD, L2);

- based on their developing understandings of needs, design components, and possible materials, refine both their conceptual statement and the key attributes for the playground (BD, L3);
- describe, and understand the relationship between, the physical and functional attributes of the different items of playground equipment (CoTO, L2);
- explain that the fitness for purpose of the playground equipment is dependent on the success of the relationship between the physical nature and functional requirements of the equipment (CoTO, L3);
- construct functional models in order to explore their design ideas and record and evaluate the evidence gathered from these models (TM, L2);
- explain how the different types of models they use (sketching, 3D-modelling, classifying different types of playground equipment, taking photographs, making computer plans) yield different types of evidence (TM, L3).

Key ideas

Technological Practice

In the context of designing a new school playground, it was important for the Matauri Bay students to explore many ideas to help them develop a brief that would be fit for the school's needs. Their brief needed to take into account the physical and social environment in which the playground would be located.

Designing the brief was a dynamic process. The students continuously modified their initial ideas as they discussed possibilities and needs, researched different ideas, made observations of existing playgrounds, and sought advice from experts.

Nature of Technology

The students quickly appreciated and understood that items of play equipment have a physical and functional nature. They also understood that the physical attributes of a piece of equipment could have more than one function, for example, a log swing bridge could help users improve their balance as well as providing a connection to the next piece of equipment. They also understood that different items of equipment with different physical attributes could have the same function.

Technological Knowledge

Many types of functional models can be used to test design ideas. Different types of functional models provide different evidence.

Developing the ideas

Linking the strands

"Planning a Playground" offers opportunities for in-depth learning experiences focused on one component from each strand. The big ideas involved can be linked as suggested in the diagram below. (It is important to remember that teachers are not expected to incorporate all three strands and every component in each technology unit they teach. Students will, however, need to experience learning opportunities in each strand and component across the whole school technology programme.)

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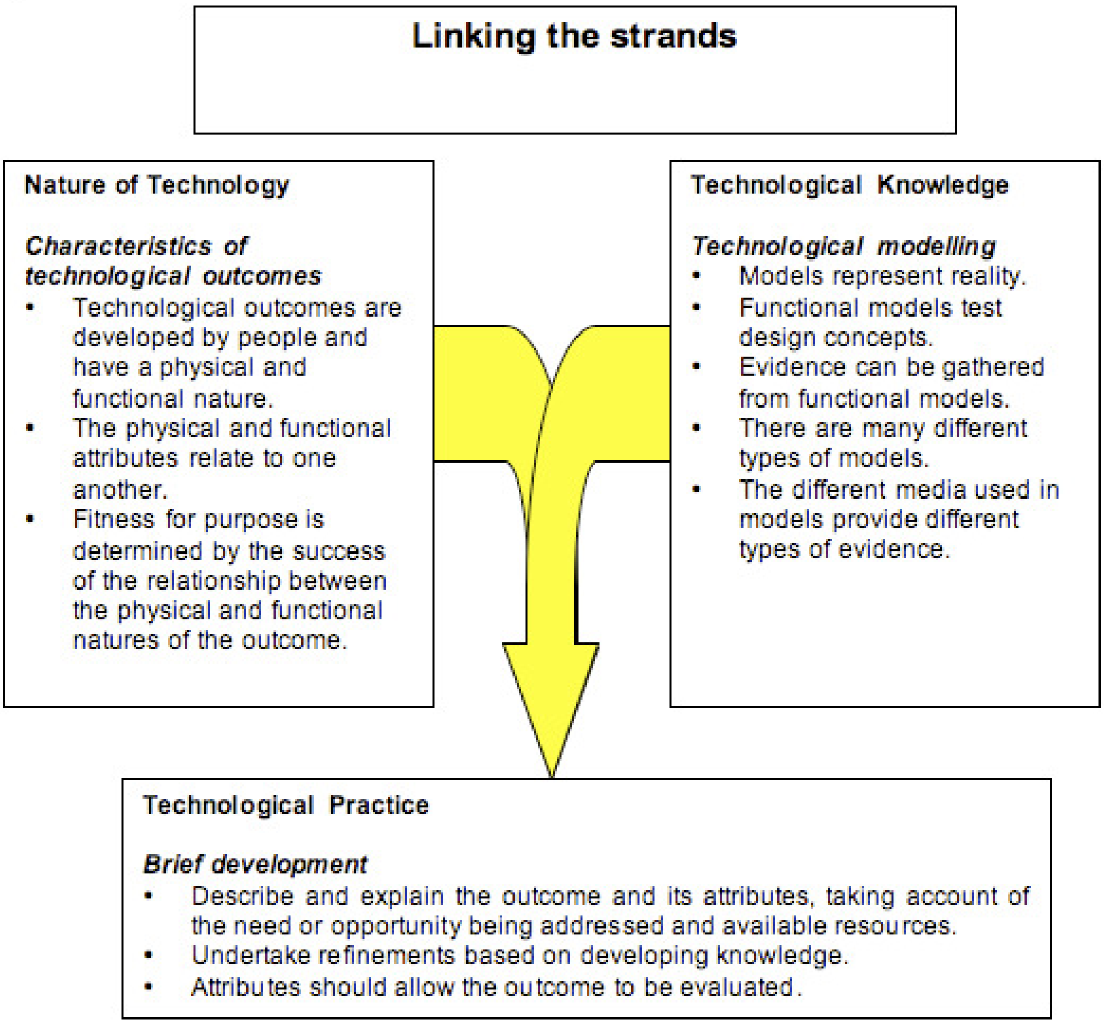

The Matauri Bay students explored and learned about the physical and functional nature of possible items of playground equipment and used functional modelling to evaluate their design ideas. These learning experiences shaped the understandings that guided them in developing their brief.

By focusing on characteristics of technological outcomes (physical and functional attributes, fitness for purpose) and using technological modelling, the students were able to deepen their understanding and increase the level of specification in their brief.

Describing a technological outcome

A technological outcome is a material-based product or system developed through technological practice. An outcome can be "read" or described by referring to both its physical and functional attributes. For example, the physical attributes of an unknown object can give us hints as to what it might have been used for, where it might have been used, and when it might have been made.

To identify the best-suited physical attributes for an outcome, we need to understand the functions required of it and the environment in which it will need to function. Identifying the necessary physical attributes for the outcome guides our selection of materials.

Focus questions

Hand known objects to the students and ask them:

- How can you describe this object?
- Can you divide the descriptors you have used into physical and functional attributes?
- What are the common things that are used to describe different objects in both groups?
- Are there any attributes that could belong in both groups?

Functional modelling

Functional modelling allows for ongoing evaluation of design concepts. Functional models are very important because they allow us to explore ideas, materials, and systems without using expensive materials or completing an outcome only to find that some part of it does not work or is unsuitable in some way. The evidence gathered from models helps us to make decisions, justify those decisions, and reduce risk and wastage of resources.

Focus questions

- Can you give examples of models?
- What sort of models might be used to test our design ideas?
- What information would we find out from each type of model?

- How could you use the evidence gained from different models to justify decision making?

A dynamic process of brief development

As concept designs are tested, knowledge about materials increases, and skill development in working with the relevant materials improves, the brief should continue to develop and become increasingly refined.

The completed brief should fully guide development of the outcome and provide criteria against which the final outcome can be evaluated.

Focus questions

- What is it that you are trying to develop?
- What attributes do you think are key to the successful function of the outcome?
- How will you know if the outcome is successful?

Further activities

While the playground is being installed

The Matauri Bay students could have gone on to do one or more of the related activities suggested below. If your students are able to plan for an actual technological outcome, such as the one outlined in this article, you may wish to consider similar follow-up activities.

- Liaise with the people who construct the playground, looking for possible learning experiences based on exploring how a construction project is managed (Planning for Practice).
- Regularly review progress on building the playground to identify key stages and monitor if and why changes happen in the design or choice of materials (Planning for Practice).
- Evaluate the playground against the final brief (Outcome development and evaluation).
- Trial and monitor the use of the playground, noting any unexpected benefits from or problems with the design (Outcome development and evaluation). Evidence from this trialing or (prototype testing) could provide additional understaning:
    - in terms of how the physical attributes of the materials used relate to the function of the play equipment (Characteristics of technological outcomes)
    - in terms of the success and limitation of the models used during its development (Technological modelling).

- Write a report to the board of trustees using information gained from the above activities to confirm the fitness for purpose of the playground and/or suggest modifications/improvements that would further enhance the playground.

Technological modelling

Check out the learning experiences in the explanatory paper on Technological Modelling in the curriculum support package on Techlink at

http://www.techlink.org.nz/curriculum-support/papers/knowledge/tech-model/index.htm

Discuss the types of models used, the information gathered, and the decisions made by the envirogroup in "Room 5's Amazing Meeting Seating" (*Connected* 2 2005).

Characteristis of technological outcomes

Check out the learning experiences in the explanatory paper on Characteristics of Technological Outcomes on the curriculum support package of Techlink at

http://www.techlink.org.nz/curriculum-support/papers/nature/char-tech-out/

Ask your students to bring a mystery technological outcome from home concealed in a container. Ask the students to work in pairs. Before the pairs begin, discuss with the class and list generic physical attributes, such as:

- what materials the item is made of;
- its size, weight, shape, and colour;
- whether the item is uncoated or surfaced with some kind of finish;
- whether the item is in one piece or more than one piece and, if so, how the components are interconnected.

One student then describes their hidden object to the other solely in terms of its physical attributes. The second student tries to work out how the object might function. After seeing what the object actually is, the second student then explains to the first which of the physical attributes helped them to work out how the object might function.

As well as keeping an eye on whether the objects brought from home do represent a technological outcome, observe whether the students understand:

- the difference between physical and functional attributes;
- the relationship between physical attributes and functional attributes;

- the often complex relationship between physical attributes and functional attributes, which is rarely 1 to 1.

List the physical and functional attributes of the technological outcome developed by the writing group at George Street Normal School in "The Adventures of Gary the Worm" (*Connected* 3 2006).

Brief development

Check out the learning experiences in the explanatory paper on Brief Development in the curriculum support package on Techlink at

http://www.techlink.org.nz/curriculum-support/papers/practice/brief-dev/index.htm

Read "Rice, Rice, Rice" and "Room 8's Rice Craze" (*Connected* 2 2007). Get students to discuss how the students in Room 8 gathered information and developed their knowledge and skills to identify what they might make. What were the key attributes of the items they made? What decisions were important as the students developed their outcomes?

Use the case study Nicer Loos on Techlink at

http://www.techlink.org.nz/Case-studies/Classroom-practice/archive-2006/nicer-loos/index.htm

and ask your students to:

- explain what the case-study students decided to develop and why;
- sequence the things they did to develop their brief;
- identify what key attributes were required for their loos.
- evaluate the case-study students' final outcome against the key attributes.

Making Decisions with Bubble Graphs

Possible achievement objectives

Mathematics

Students will:

Statistics

Statistical investigation (SI)

- L3: Conduct investigations using the statistical enquiry cycle:
  - gathering, sorting, and displaying multivariate category and whole-number data and simple time-series data to answer questions;
  - identifying patterns and trends in context, within and between data sets;
  - communicating findings, using data displays.

Statistical literacy (SL)

- L3: Evaluate the effectiveness of different displays in representing the findings of a statistical investigation or probability activity undertaken by others.

Number and Algebra

Number strategies (NS)

- L3: Use a range of additive and simple multiplicative strategies with whole numbers, fractions, decimals, and percentages.

Links with the Number Framework

You could use the problems in this article as an opportunity for students who are advanced additive thinkers (stage 6) to practise adding whole numbers using mental advanced additive strategies.

Specific learning intentions

Students will:

- evaluate the effectiveness of bubble graphs in representing findings. (SL)
- solve whole-number problems involving estimation by using a range of additive and simple multiplicative strategies. (NS)

The key ideas

Background information on bubble graphs

This article introduces students to a type of data display called bubble graphs. Bubble graphs represent data through both the location and size of the data markers (the bubbles).

Bubble graphs are not a distinct category of graph; rather they are a sub-group of scatter plots. Scatter plots allow you to compare two sets of numerical values. Each dot on a scatter plot represents an item for which two pieces of data have been gathered and then plotted on x and y axes. Bubble graphs allow you to compare a third set of values as well: the size of the dot or bubble is determined by the value of the third variable.

The graph below compares money earned from a job with hours worked and job satisfaction ratings. Each bubble represents one person; its position represents how much they earn and how many hours they work; and the size of the bubble relates to how much they enjoy their jobs.

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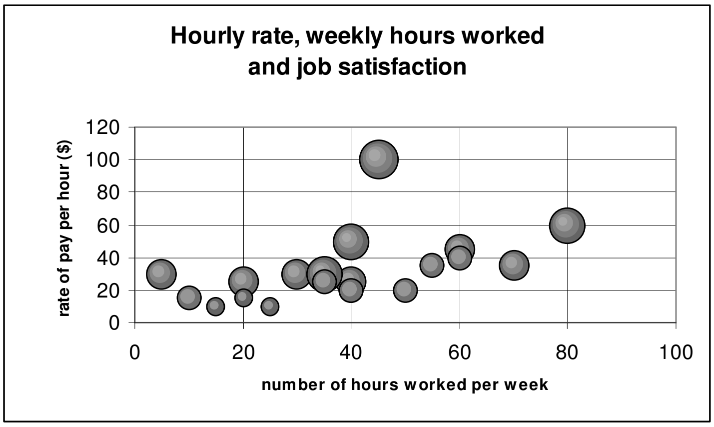

Bubble graphs are effective for investigating possible trends between three groups of data and how they relate to each other. A bubble graph, like a scatter plot, can be used to highlight similarities between large sets of data by looking for:

- where the bubbles cluster on the graph
- what shapes they make as a collection (for example, an ascending line)
- whether the large and small bubbles lie in similar areas.

Bubble graphs are most useful with quantitative data, that is, numerical data that gives information about quantities or amounts. So you could use a bubble graph to explore the relationships between shutter delay time, number of megapixels, and the cost of a digital camera because these are all quantitative data.

Bubble graphs are not readily suited to comparing qualitative data, that is, data organised into categories, such as what features a camera has or its brand. You can include some qualitative data by assigning a different colour to each bubble according to its category, as the graphs in the article do by giving each type of playground equipment its own colour. (If you're using a graphing programme, this may have to be done manually by clicking on each bubble after the chart has been made, changing its colour, and then constructing your own key.)

When you're constructing a bubble graph, you need to have three columns of data highlighted in your spreadsheet: the first column or series will be plotted on the x axis, the second series will be on the y axis, and the third series will determine the size of the bubbles.

Developing the ideas

Setting up

Divide your class into thinking groups of three or four students.

Work through the article together. It's best to do the questions as you come to them, rather than reading the whole article first, as the table at the end duplicates some of the information in the graphs in more detail, and the idea is to get the students to learn how to interpret the bubble graphs rather than just depending on the table.

Pose each of the questions in the article in turn, asking the groups to think about and discuss the problem before coming back together as a class to share their ideas.

Question 1

The focus of this question is to help students interpret basic information available in the bubble graph. Possible responses include:

- Spiral slides need 8 square metres of area.
- They cost about $2,500. (It's difficult to give exact amounts using this graph.)
- They are suitable for all six year levels at a primary school.
- They are the third most expensive item after sky surfers and spider gliders.
- They are the item needing the third largest area.
- They are one of only two items that suit all six year levels.

If students are having difficulty interpreting the graph, scaffold their thinking by asking questions such as:

- What do the different colours of the spots on the graph tell you? (Which piece of equipment each bubble represents)
- What do the numbers on the bubbles tell you? (How many square metres of area each piece of equipment needs)
- What is area? (The size of a surface, measured in square units)
- What can you tell just from glancing at the sizes of the bubbles? (Which items of equipment take up the most/least amount of room)
- About how much do you think a sky surfer costs? How do you know? Which part of the bubble do you measure from? (You take a line from the centre of the bubble horizontally along to the y axis, which is the vertical axis with the costs on it. This line would intersect a little bit less than halfway between $3,500 and $4,000, so a reasonable estimate of the cost would be $3,700.)
- The x axis, the horizontal one at the bottom, shows the number of year levels the item is suitable for. The centre of the corkscrew climber is above the 5. What does this mean? (It means that the corkscrew climber is suitable for five different year levels.) Does this graph tell us which year levels the corkscrew climber is suitable for? (No)

Question 2

The focus of this question is to use the information on the graph to justify an opinion. Emphasise that there is no one right answer in questions such as this. In real life, the person who gets their way is often the person who can give the most compelling reasons why their opinion should prevail. Possible responses include:

- No, I don’t agree, because the spider glider is one of the most expensive items and needs the largest area, so it uses up a lot of our budget and space. It’s only suitable for three year levels to use, so it’s not a very fair use of the money if the playground is meant to be for the whole school.
- Yes, I agree, because we need at least one really exciting thing in the playground, and this one isn’t the most expensive item out of the two that sound the most challenging. Three year levels can use it, so that’s half the school. We can have other items in the playground to cater specially for the other levels.

Question 3

This question asks students to interpret information on the graph in order to get a sense of how the bubbles relate to each other in size and position. At this stage, don’t focus on the $10,000 budget but instead give the students an opportunity to get an overview of the available information by asking them to just choose one or two items that match each criterion. Possible responses include:

a) The sky surfer and the spider glider are the two most popular items because they have the largest bubbles.

b) The tumble barrel and the spiral slide are both suitable for all six year levels and are medium-sized bubbles, meaning that they are reasonably popular.

c) None of the cheapest items are really popular, so it involves a judgment call to choose items that are cheap and reasonably popular. The bouncy rocker costs less than $1,000 and isn't the smallest-sized bubble, so it could be a candidate. The tumble barrel is one of the more popular items and is in the middle cost-wise, so it could also be included.

Question 4

Again, this question has no right answer, but students should give information to support their opinions. You may need to begin by teasing out the ideas in the blue speech bubble (page13 of the student book) about linkability (to how many other items) and other offsetting factors (total cost/popularity). Possible responses include:

- Yes, I would include the sky surfer because it's the most popular item, so it's worth spending the extra money on it. I know it's only suitable for two year levels, but it must be something that kids will use a lot or else it wouldn't have shown up as being more popular than things like the corkscrew climber, which five year levels can use. It can also link to three other pieces of equipment, which makes it one of the most versatile items.
- No, I would not include the sky surfer because it would use up over a third of our budget on just one item of equipment, it takes up a lot of room, and it's only suitable for two year levels to use, so most of the school can't use it.

Question 5

This question asks students to consider whether all factors are equal when weighing up options. You may need to define the word "attribute" for them: a characteristic, feature, quality, or property belonging to a person or thing, such as colour, size, cost, shape, and so on. Possible responses include:

a) The graphs give you information for each item about total cost, area needed, popularity, year-level flexibility (number of year levels that can use the item), and linkability (how many other items each item can link to).

b) and c) Answers will vary – it will depend on what the criteria for the playground are. If you need to include as many items as possible for your money, cost will be the most important attribute, and attributes like area needed and linkability will be less important. If you want to create a playground that will cater for the widest range of children, then important attributes to consider would be popularity and year-level flexibility, but area and cost would be less important.

Question 6

Students will need to check if they need a climber (which means additional cost) to get up to a piece of equipment. This additional cost can be avoided if one piece links to another piece. For example, if you put a spider glider and a sky surfer in your playground, you could avoid the $410 climber cost of the sky surfer by linking it to the spider glider. You would still need to pay a climber cost for one of the items, otherwise there would be no way of getting up. Cost-conscious students will look for the cheapest climbers and use links to other items of equipment wherever they can. Answers will vary.

Additional information about the playground equipment, which students may work out from the brochures, includes:

a) You can use any combination of the spiral slide, spider glider, corkscrew climber, sky surfer, and tumble barrel that costs less than $10,000. Senior school students are the only ones who can use the spider glider and the sky surfer, so you could use those if you wanted the playground to be challenging. If you did use both of them, that would cost $5,770 (with only one climber for the end, since they link), leaving $4,230 for other items, such as the spiral slide, corkscrew climber or tumble barrel.

b) The only items suitable for all year levels are the spiral slide and the tumble barrel. Both were also reasonably popular, the tumble barrel being slightly more popular. The playground would have to use a combination of these two items in order for all levels to use all of it, perhaps two of each or one spiral slide and three tumble barrels to reflect the greater popularity of the tumble barrel. Whether this would be a very sensible or appealing playground is another question!

c) If you linked one of each of the items that could link together, you could have a corkscrew climber, leading to a sky surfer, leading to a spider glider, finishing with a spiral slide. Unfortunately, this costs slightly over budget, at $10,275, so one cheaper item would need to be substituted for a more expensive one. One combination that would come in under budget is a corkscrew climber, leading to a sky surfer, leading to a spider glider, finishing with a corkscrew climber, costing $9,940.

d) The spider glider and the tumble barrel between them cover the whole range of skills listed. If you used both of them, it would cost $5,770. You could also include the sky surfer because it covers three skills, and use most of your remaining money on a toadstool hopper because it covers two skills. Total cost: $9,680, covering all seven skills, four of them repeated in two items of equipment, and one repeated in three of the items.

e) Students will need to weigh up here whether it's better to have lots of smaller items of equipment or a couple of larger items and whether having a range of equipment is more important than having a greater number of the same thing. One possible 25-square-metre combination that has five different items of equipment is a corkscrew climber connected to a spiral slide, a tumble barrel, a toadstool hopper, and a bouncy rocker. This costs $7,465.

Some things to think about

Students could brainstorm the ideas in the some things to think about questions as a plus-minus-interesting discussion, initially in small groups, and then as a whole class. Look for the students to draw conclusions such as:

- Bubble graphs are useful for comparing three groups of numeric data.
- Having the bubble size determined by things like popularity or area means that you can identify trends and minimum/maximum values at a glance.
- Bubble graphs are not so useful when you're trying to identify things like the exact cost of an item, because it is hard to line up the exact centre of a bubble with the x or y axes.
- Bubble graphs do not give you very useful information about which year levels each item could be used for; instead they tell you how many year levels they can be used for (to turn a qualitative/category value into a quantitative/numerical value).

Further activities

Recognising which graph is the most appropriate to display data is an important skill. Ask the students to define and give examples of when a bubble graph would and would not be appropriate or helpful.

Students could use the statistical enquiry cycle (problem, plan, data, analysis, conclusions) to pose and investigate a question that will generate three groups of numerical data, which can then be displayed and analysed by using bubble graphs and other appropriate data displays.

Possible ideas:

- What’s the ultimate hot chocolate recipe? Variables: teaspoons of chocolate powder; teaspoons of sugar; approval rating from taste-testers on a 1–5 scale.
- Does how fast you can text and how long you play on a game console affect your reaction times? Variables: time taken to text a standardised message; average number of hours on the game console each day; reaction time as measured by catching a dropped vertical ruler on cue and seeing how by how many centimetres it fell through your hand before you caught it.
- Does how tall you are and how fast you can sprint affect how far you can long jump? Variables: sprint speed; height; long-jump distance.
- What’s the optimum amount of water and fertiliser for plant growth? Variables: amount of water given over one week; amount of fertiliser given per week; amount plant grew after x weeks.
- Does distance and frequency affect how much you enjoy walking to school? Variables: distance walked; percentage of days walked last week; rating of enjoyment levels on a scale of 1–5.
- Do fitness and sprint speed help you to score more goals in soccer? Variables: time taken to sprint 100 metres; time taken for heart-rate to recover to resting pulse after a 100-metre sprint; number of goals scored in your last five soccer games.

After the students have displayed their data using bubble graphs, help them to interpret their information by asking questions such as:

- What information does your graph tell you?
- What could you say about the general shape of the whole group of bubbles? Can you use that shape to make predictions or draw conclusions?
- Is there anywhere on your graph where you have clusters of bubbles? What does this tell you?
- Are there places on your graph where all the small bubbles or all the large bubbles are collected? What does this tell you about your data?
- Can you see any trends in your data? You know there’s a trend if you could predict where a new person or item would probably fit on your graph, given that you know one or two of the other variables.
- If you investigated these questions with another class, do you think you would get similar results and trends? Why or why not?
- What might you do differently if you were doing this activity again?

Further references

Ministry of Education resources

Data squares are a useful tool for sorting and categorising multivariate data. The Statistics section of the website New Zealand Maths has a level 3 Data Squares unit that introduces the use of these at

http://www.nzmaths.co.nz/Statistics/Investigations/datasquaresL3.aspx

Scatter plot graphs, of which bubble graphs are a sub-set, are explored in the Statistics section of New Zealand Maths in the level 3 unit Paper Planes at
http://www.nzmaths.co.nz/Measurement/Length/paperplanesl3.aspx

Scatter plot graphs also feature in "Fish Figures" on pages 12–13 of the revised Figure It Out levels 3–4 *Statistics*.

Other resources

CensusAtSchool (NZ) contains data from voluntary online surveys of year 5–13 students, which can be accessed for use by students. Examples of quantitative data collected here are number of languages spoken, height, foot size, arm span, hair length, reaction time, number of text messages sent and received in a day, monthly amount spent on phone bill, bedtime, and personal ratings of how important various issues such as global warming and having a healthy lifestyle are to them. Students could pose a question that could be investigated with randomly selected data from this site. For example:

- Is reaction time affected by age and/or bedtime?
- Do people who send and receive a lot of texts get less sleep?

Go to http://www.censusatschool.org.nz/

Jumping for Joules

Possible achievement objectives

NB: All AOs are quoted from *The New Zealand Curriculum* (2007).

Technology

Students will:

Nature of Technology

Characteristics of technology (CoT)

- L2: Understand that technology both reflects and changes society and the environment and increases people's capability.
- L3: Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.

Technological Knowledge

Technological systems (TS)

- L1: Understand that technological systems have inputs, controlled transformations, and outputs.
- L2: Understand that there are relationships between the inputs, controlled transformations, and outputs occurring within simple technological systems.

Science

Students will:

Nature of Science

Participating and contributing (P&C)

- L1/2:Explore and act on issues and questions that link their science learning to their daily living.
- L3/4: Use their growing science knowledge when considering issues of concern to them.
- L3/4: Explore various aspects of an issue and make decisions about possible actions.

Investigating in science (IinS)

- L1/2: Extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models.

- L3/4: Build on prior experiences, working together to share and examine their own and others' knowledge.
- L3/4: Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.

Physical World

Physical inquiry and physics concepts (PI&PC)

- L3/4: Explore, describe, and represent patterns and trends for everyday examples of physical phenomena, such as movement, forces, electricity and magnetism, light, sound waves, and heat.

Specific learning objectives

Students will be able to:

- explore and act on issues and questions that link their growing science knowledge to their daily living (P&C; IinS);
- explain technology as a purposeful intervention to design a solution that addresses a need or provides new opportunities to improve life (CoT);
- explain how technology both reflects and changes society and environments by enhancing people's ability to manipulate, store, transport, or control things (CoT);
- identify the inputs, controlled transformations, and outputs of simple technological systems (TS);
- explain the purpose of a technological system in terms of how the inputs and the nature of the transformation process enables the creation of the desired output (TS);
- describe the effect of forces on motion and objects in terms of forms of energy and energy transformation (PI&PC; IinS);
- investigate and describe how energy is transformed and controlled in a technological application (PI&PC; TS; IinS).

The key ideas

Nature of Technology/Nature of Science

Technology is defined as a purposeful intervention in the world to create the made world. Design opportunities are often the result of needing to address issues in order to improve our lives and the environments in which we live. The design solutions presented in "Jumping for Joules" impact on society by enhancing our ability to manipulate and control energy, and increase our understandings of how things could be "done differently" to address energy needs.

Science is defined as the development of explanations about the natural and made worlds. Understanding and applying science ideas in creative ways allows us to explore and act on a range of issues in our daily lives. Technology and science frequently work together for mutual benefit.

Technological Knowledge

In the context of technological knowledge, Melanie needed to devise a technological system. The system she devised involved both mechanical and electrical components and processes:

- inputs (trampoline, pulleys, gears, generator, people providing a source of kinetic energy, bikes, and so on);
- outputs (circular movement of clothesline, electrical energy);
- transformation processes (vertical movement into circular movement, kinetic energy into electrical energy);
- control (mass of jumper, number of pulleys/cyclists, gearing, cadence – the speed of pedal rotation).

Physical World

- Machines can be used to transform energy from one form into another.
- Gears can be used to change the direction or speed of a machine's movement.
- Kinetic energy can be used to do useful work.

Developing the ideas

Characteristics of technology/Understanding about science

The context of "Jumping for Joules" allows aspects of both the Nature of Science (NOS) and the Nature of Technology (NOT) to be explored, while also incorporating investigation into physics concepts.

Science knowledge is generated and validated based on its ability to *explain* the world successfully. Technological knowledge is generated and validated based on its ability to provide for a technological outcome to *function* successfully.

In this context, Melanie is able to explain how the machines operate in terms of her growing science knowledge. She is able to apply this science knowledge to develop a solution to a topical issue.

The technological systems developed draw from her knowledge of science but these understandings are modified to ensure that the solution she develops functions successfully in the different environments. Therefore the issue and opportunities she saw and the technological outcome she developed were dependent on the science understandings, alongside the understanding of the constraints and possibilities of the physical and social environments in which the outcome would ultimately be situated.

Focus questions

- What science ideas did Melanie use to explain how her inventions worked?
- What did she change as she developed her inventions?
- Why did she make these changes?
- What changes were made because of her science knowledge?
- What changes were made because of factors that related to the issue or the opportunity she saw?

Physics – a study of energy

Energy is an important concept in science. Students develop understandings about energy by exploring and applying ideas about different forms of energy (for example: light, sound, heat, electricity, kinetic energy). It's important to learn about energy sources, energy transfer, and transformation within these contexts.

Focus questions

- What forms of energy can you identify in Melanie's trampoline invention?
- What changes occurred?
- What mechanisms caused the changes?
- What forms of energy can you identify in the gyminator?
- What changes occurred?
- What mechanisms caused the changes?

Technological systems

A technological system is different from a non-technological system.

- A non-technological system is often described as step-by-step process or connected set of actions (for example, getting reading for school in the morning, making a batch of biscuits).
- A technological system is one that has been designed to bring specific components together for a particular function. Technological systems have inputs, outputs, and transformation processes. The transformation processes within technological systems do not need *additional* human design input to ensure that they function. Humans

may provide key inputs, however, as in Melanie's technological system for which she and others provide the kinetic energy. (Examples of technological systems include a toaster, a wind-up toy, a compost heap, a computer.)

Focus questions

- What were the inputs in the two systems developed by Melanie?
- What were the outputs in the two systems?
- What happened in the transformation process in both systems?
- What mechanisms did Melanie use to control the outputs?

Further activities

Ask your students to:

- reread "Jumping for Joules" and write a brief (containing a conceptual statement and key attributes) for one of Melanie's inventions;
- using pulleys and or gears, design and make a mechanism that changes the direction of an initial movement;
- using the same gears, design and make a mechanism that increases or decreases the force exerted;
- design a simple technological system to do a specific task with certain conditions (designated by you).

Devise your own *Let's Get Inventin'* scenario, for example:

- get students to write down two common objects on separate pieces of paper;
- put all the paper suggestions into a hat;
- get each student to draw out two pieces of paper and see what ideas are sparked by the combination of the objects.

See "Eco-friendly Inventions" (*Connected* 3 2004).

Encourage your students to explore the differences between science and technology by thinking about who are scientists and who are technologists. Suggest that they each draw a picture of a scientist at work and a similar-sized picture of a technologist at work. Analyse the drawings produced by the class.

- Are there similarities between what the scientists are doing?
- Are there similarities between what the technologists are doing?
- What differences are there between what the scientists and what the technologists are doing?

After looking at some of the people and work described on Techhistory and/or Techlink (references below), ask the students to think about the following questions:

- How do the people described compare with the categories of scientist and technologist?
- What do the general public think about scientists and technologists and the work that they do? (Each student could ask some members of their family and family friends.)
- Is the work that scientists do valuable? Explain why or why not. Is the work that technologists do valuable? Explain why or why not. (It may be important to tease out the meanings of "valuable" for these questions.)

Further references

Ministry of Education resources

More about the physical world

Check out *Making better Sense of The Physical World* (1999).

Check out the Building Science Concepts books: *Light and Colour: Our Vision of the World*, Book 10; *Seeing Colours: The Spectrum, the Eye, and the Brain*, Book 11; *Flight: Control in the Air*, Book 17; *Exploring Sound: Using Sound-makers and Musical Instruments*, Book 18; *Properties of Sound: How Sound-makers and Musical Instruments Work*, Book 19; *Solar Energy: Sun Power on Earth*, Book 29; *Floating and Sinking: How Objects Behave in Water*, Book 37; *Understanding Buoyancy: Why Objects Float or Sink,* Book 38; *Heat on the Move: Transferring Heat through Temperature Difference*, Book 36; *Invisible Forces: Magnetism and Static Electricity*, Book 49; *Standing Up: Skeletons and Frameworks*, Book 51; *Windmills and Waterwheels: Harnessing the Energy of Wind and Water*, Book 54; *Bikes: Levers, Friction, and Motion*, Book 59.

The work of scientists and technologists

Read about scientists at:

http://www.roadshow.org/index.php?option=com_content&task=view&id=43&Itemid=73

http://pbskids.org/dragonflytv/scientists/index.html

Read about some technologists on Techhistory (under People) at:

http://www.techhistory.co.nz/

or (for more detailed case studies), visit Techlink at,

http://www.techlink.org.nz/Case-studies/Technological-practice/index.htm

When looking at developing further ideas about technological systems, check out the learning experiences in the explanatory paper on Brief Development in the curriculum support package on Techlink at

http://www.techlink.org.nz/curriculum-support/papers/practice/brief-dev/index.htm

Other resources

Visit the *Let's Get Inventin'* site for further information about the competition and other inventions at

http://tvnz.co.nz/view/page/687734

Visit the Royal Society of New Zealand BP challenge site at http://www.rsnz.org/education/bp_chall/2004.php

The Ozone Hole

Possible achievement objectives

NB: All AOs are quoted from *The New Zealand Curriculum* (2007).

Technology

Students will:

Nature of Technology

Characteristics of technology (CoT)

- L3: Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.

Technological Knowledge

Technological modelling (TM)

- L1: Understand that functional models are used to represent reality and test design concepts and that prototypes are used to test technological outcomes.
- L2: Understand that functional models are used to explore, test, and evaluate design concepts for potential outcomes and that prototyping is used to test a technological outcome for fitness of purpose.
- L3: Understand that different forms of functional modelling are used to inform decision making in the development of technological possibilities and that prototypes can be used to evaluate the fitness of technological outcomes for further development.

Science

Students will:

Nature of Science

Understanding about science (UaS)

- L1/2: Appreciate that scientists ask questions about our world that lead to investigations and that open-mindedness is important because there may be more than one explanation.
- L3/4: Appreciate that science is a way of explaining the world and that science knowledge changes over time.
- L3/4: Identify ways in which scientists work together and provide evidence to support their ideas.

Communicating in science (CiS)

- L1/2: Build their language and develop their understandings of the many ways the natural world can be represented.
- L3/4: Begin to use a range of scientific symbols, conventions, and vocabulary.
- L3/4: Engage with a range of science texts and begin to question the purposes for which these texts are constructed.

Material World

Properties and changes of matter (P&CoM)

- L1/2: Observe, describe, and compare physical and chemical properties of common materials and changes that occur when materials are mixed, heated, or cooled.
- L3/4: Group materials in different ways, based on the observations and measurements of the characteristic chemical and physical properties of a range of different materials.
- L3/4: Compare chemical and physical changes.

The structure of matter (TSoM)

- L4: Begin to develop an understanding of the particle nature of matter and use this to explain observed changes.

Chemistry and society (C&S)

- L1/2: Find out about the uses of common materials and relate these to their observed properties.
- L3/4: Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.

Specific learning intentions

Students will be able to:

- describe and compare physical and chemical changes (P&CoM1–4);
- begin to develop an understanding of the particle nature of matter (TSoM4);
- link the observed chemical and physical properties of a range of materials to technological uses and natural processes (C&S3/4);
- appreciate that scientists ask questions of our world that lead to investigations and that open-mindedness is important because there may be more that one explanation (UaS1/2);
- appreciate that science is a way of explaining about the world and that science knowledge changes over time (UaS3/4);

- understand the importance of communicating science ideas in order to validate new science ideas (CiS1–4);
- understand how society and environments impact on and are influenced by technology in historical and contemporary contexts (CoT3);
- understand the difference between a functional model and a prototype (TM1–3).

Developing the ideas

The air that we breathe

The chemistry needed to understand this article is quite complex. Students need to build up ideas about matter by exploring groups of substances and their properties. A progression of learning experiences can be planned around the following questions and using the resources listed below.

Focus questions

Begin with some basic questions.

- Can you give examples of solids, liquids, and gases?
- Can you describe how a substance such as water changes its state?
- How can you explain what happens to a substance when it dissolves?

Explore whether your students understand that matter may be made from small particles, before asking them:

- Can you use "particle theory" to explain the different states of matter?
- Can you explain physical change in terms of how the particles are arranged and how they move?

Refer to the BSC title *The Air around Us: Exploring the Substance We Live in*, Book 30 for building ideas about the air we breathe and for associated activities. Explore the ideas that air is a substance consisting of a mixture of gases, which has the properties of fluids (Big idea in the Concept Overview).

You may also wish to check whether your students understand the differences between the physical and chemical properties of substances and the physical and chemical changes that they undergo.

Science ideas change

It is important that students understand that science ideas change over time. Change occurs for many reasons. For example:

- Explanations of the world are based on observations. Our observations become better as we learn more about the world and we get improved instruments that help us "see" better.
- Other scientists with different ideas and viewpoints challenge existing ideas.
- Scientists from different disciplines work together to explain phenomena.
- The environment itself changes, which might mean that scientists have to change their ideas and theories.

Focus questions

- Why has our use of CFCs changed?
- Can you find other examples of chemicals that that are no longer in use because we now know they are dangerous to the environment, plants, and/or animals (including humans)? (It might be interesting to look at the news stories in August–September 2008 about melamine contamination in milk and milk products.)
- Can you find information that suggests some other chemicals that we presently use might be harmful?
- Who is publishing this information?

Believe it or not

Scientists need to communicate their ideas to both their fellow scientists and the public. Other scientists need to be able check new ideas and, if the public are to believe what the scientists are saying, then new ideas need to be explained carefully with demonstrations, diagrams, graphs, and models.

Focus questions

- After reading the article, how many different ways can you identify in which the scientists explain their findings?
- What type of explanations or evidence do you find most convincing?

Minimising risk

Technologists employ many practices and strategies to minimise the risk of new technological outcomes. They do extensive modelling in the design phases to explore possible problems with the structural design and the materials used. Prototypes of the fully developed outcome are used to gather information about how the outcome actually interacts with the people and the environment it must function in and explores the impacts on each, to confirm the fitness for purpose of the outcome or provide evidence for changes and/or modifications to enhance it.

Focus questions

- How did Thomas Midgley use CFCs?
- What test did he do with CFCs?
- How could technologists minimise the risk of using a new material in a technological outcome?
- Could Midgley have known about the risk to the ozone layer in 1930?*
- Can all risks be managed or negated in future developments of technological outcomes?
- Should this stop us designing and making things?

*Note that there are other examples to explore.

- Midgley also pioneered the use of lead in petrol, with the same lack of consideration for wider implications. This was even more shocking because the toxicity of lead was well recognised by Midgley's time. He knew that workers processing petroleum were dying of lead poisoning.
- Midgley reflects a time when pollution wasn't in people's consciousness, and all sorts of so-called breakthroughs escaped close scrutiny. DDT is another example that could be looked at in this context. Rachel Carson's *Silent Spring* (1962) represented a quantum leap in our environmental consciousness that is similar to modern-day changes in our thinking about climate change.
- Extreme irony alert! When Thomas Midgley was 51, he was struck down by polio and lost the use of both his legs. With his typical inventiveness, he devised a system of ropes, pulleys, and hoists so that he could get himself in and out of bed every day. And finally, in what might seem an almost inevitable twist, he got tangled up in the ropes of his own invention and died of strangulation.

Further activities

Read "King of the Hill" (*School Journal*, Part 3 Number 1, 2008). Discuss and analyse the making of the trolleys with the class. Questions could inlude:

- What science knowledge would be helpful when making the trolleys? (See the activities in *Making Better Sense of the Physical World*, pp. 105–119 and the Building Science Concepts titles: *Working with Metals: The Origins and Applications of Common Metals*, Book 33; *Marbles: Exploring Motion and Forces*, Book 42; *Standing Up: Skeletons and Frameworks*, Book 51; and *Bikes: Levers, Friction, and Motion*, Book 59.)
- Explain why this knowledge would be helpful.

- Can you devise a model, diagram, static 3D model, or moving model that helps to explain the useful science ideas?
- What possible risks to the trolley riders, trolleys, and/or environment can you name?
- What modelling (testing, mock–ups, plans, trials, planning) could you do to minimise the risks?

Further references

Ministry of Education resources

Ideas for learning experiences that build understandings about matter can be found in *Making Better Sense of the Material World* (2001) and the Building Science Concepts series titles: *Where's the Water?: Water's Form, and Changes in Form*, Book 15; *Sand, Salt, and Jelly Crystals: Mixing and Melting Materials*, Book 16; *Bread: The Chemistry of Breadmaking*, Book 56; *Eggs: Mixing, Beating, Crushing, and Heating*, Book 57; *Ice: Melting and Freezing*, Book 58; *Candles: Investigating Combustion*, Book 64.

Suggestions for learning experiences exploring ideas about science can be found on Science IS at

http://www.tki.org.nz/r/science/science_is/nos/index_e.php – propList

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