MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

Notes for Teachers

CONNECTED 2 2004

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 provide starting points for further investigations by individuals, groups, or a whole class. The activities in Connected 2 make science, mathematics, and technology fun for students working at levels 1 to 3 of the New Zealand Curriculum.

General Themes in *Connected 2 2004*

1. *Electronic and Non-electronic Databases*

"A Cinter Netta Search" is a modern version of Cinderella, in which the prince's technical adviser helps him to explore electronic and non-electronic sources of personal information when searching for a mysterious, glass-slippered stranger. The suggested follow-up activities include the students developing their own print, electronic, or audio-visual version of the tale, in which the reader or viewer can choose among options for aspects such as the genre, illustration style, time period, or characters' personalities. In other follow-up activities, the students could carry out their own "missing person" searches by accessing various electronic and non-electronic databases. Part of this activity includes researching the types of personal information that organisations hold about members of the public and the privacy legislation that restricts access to such information.

2. *Electricity Generated by Living Things*

"Of Elbows and Eels" describes how most animals sense and respond to their surrounding world by way of electrical nerve networks. The article also describes how certain fish sense the electrical nerve impulses generated by their prey. Electric eels, a well-known example of such fish, can produce sudden pulses of electricity that are powerful enough to stun prey or potential predators. The teachers' notes focus on nerves, exploring aspects of human sensory perception and responses.

3. *Electricity and Weather*

"Thunder and Lightning" describes the build-up of static charges within storm clouds and the eventual discharge of this electricity as lightning. In the suggested follow-up activities, the students use friction to charge various materials with static electricity. They also explore moving and static electrical charges by carrying out practical activities with battery-powered circuits and linking the associated ideas to the phenomenon of lightning.

4. *Different Types of Ice: Hail and Snow*

"Hard Ice, Soft Ice" expands on the topic of clouds. The article describes how different types of ice result from different freezing processes within clouds. In the suggested follow-up activities, the students perform a teacher-led role play that reflects the behaviour of water molecules when liquid water freezes. This models key features of hail formation. The students then adapt this role play to model the formation of snow, which differs from the formation of hail because snow forms from freezing water vapour (a gas) rather than from liquid droplets.

5. *Date and Time Conversions*

"Time Zones" is designed to help students to understand how and why clock times vary in different parts of the world at any given moment. The story centres on a New Zealand family working out the best time to phone Mum, who is holidaying in Italy. The story provides an opportunity to link mathematical concepts (Number and Measurement) with science concepts (Planet Earth and Beyond) within a single, authentic context.

6. Geometrical Transformations: Rotating 3-dimensional Objects

"Oops!" is a comical story in which an airline pilot flips and turns her plane in order to give passengers a good view of the Southern Alps. In the follow-up activities, the students explore the associated transformations by working out where passengers in various seats will end up after each flip or turn. The activities involve analysing the co-ordinates of the seat-numbering system and representing the transformations both in diagram form and as drawings of the aircraft on isometric dot paper.

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A Cinter Netta Search

Possible Achievement Objectives

Technological Areas

Electronics and Control Technology

Information and Communication Technology

Developing the Ideas

"A Cinter Netta Search" could be used in a unit in which information and communication technology supports learning outcomes for English (especially in the Visual Language strand), as in the first suggested activity, An Interactive Fairy Story. In the second suggested activity, Searching for Old Friends, an initial exploration of written language, as described in the following section, supports learning outcomes for technology education.

Exploring the Text

The outline of this story will be familiar to most students because there are many versions of "Cinderella", including the Grimm brothers' original and Disney's well-known film adaptation. Some students may feel loyal to the "true" story and reluctant to accept the Cinter Netta story until their version is acknowledged as the original. So, after the first reading, you could ask the students whether they can identify the well-known fairy tale that the Cinter Netta story is based on.

Information and communication technology (ICT) terms arise throughout the text. You could begin with a shared reading and note key terms on the whiteboard as they occur, for example, email, Internet, website, flatbed scanner, hits per week, bookmarking favourites, text messaging, newsletter mail-out, quick-dial key, microfilm, computer database, and electronic game console. After the reading, you could remind the class of a key comment by the Prince – that Techno did not know the answers to all his questions, but she did know how to find them. Bearing this statement in mind, the class could briefly discuss the meaning of each whiteboard term in relation to sources of information and ways of accessing them.

The students may wish to answer the question "Was Cinter worth finding in the first place?" Normally, fairy-tale heroes and heroines have good manners. Ask the students what they think about Cinter's behaviour. Can they suggest why she was not in love with the prince (as would normally be the case in a fairy tale)? This discussion could lead into the Interactive Fairy Story activity below, part of which could focus on computer game addiction.

Further Activities

An Interactive Fairy Story

Do you think you could write a short story about Cinter in which the reader can choose to change certain aspects? For example, the reader might choose a version with a different time period, genre, illustration style, or underlying message. Whatever alternative options the students present to their readers, they should tailor their fairy tale to a specific audience and develop a key message for the story.

The students could produce the pick-a-path story with widely available electronic text, graphics, and presentation software. Alternatively, they could design a booklet with a page index that lists the choices. A comic-book approach may be a helpful limitation to avoid the necessity of typing out a full text. Another option might involve the students developing a television newscast or interview. Storyboarding and graphic design may be part of the development process.

In order to control the scope, the readers' choices could be limited to one of the following:
- the personality of the characters;
- the type of illustrations;
- the time period;
- the genre;
- the underlying message, including the twist at the end, which focuses on addictive behaviour with electronic media.

Illustration

With a focus on illustration, the students could develop their skills in screen printing, costume design, and scanning or digital photography.

The Time Period

If the students opt for a future setting, they could research new products or concepts in the ICT industry. A past setting would involve them comparing current ICT with that of recent or older times. An excellent first point of reference for you or your students would be From Carbons to Computers, a section of the Smithsonian Institution's website. From Carbons to Computers presents a wealth of structured, historical information on the evolution of office culture and technology in the United States. Included on the site are timelines, lesson plans, and online resource lists for further reference.
www.smithsonianeducation.org/educators/lesson_plans/carbons/start.html

The Genre

If the students choose to focus on genre or other aspects of writing, refer to the Fairy Tales unit plan at English Online.
http://english.unitecnology.ac.nz/resources/units/fairytales/home.html

You could discuss the meaning of the term "fable", then read and discuss one or two of Aesop's fables as an illustration of this ancient genre. The animated film *Shrek* is a familiar example of a fairy tale with a message. Like "A Cinter Netta Search", *Shrek* presents an interesting blend of traditional and modern elements, including contemporary humour.

The Underlying Message

The stepmother confided that Cinter had neglected her gardening work and had not left the house for a long time. The Prince and Techno observed that her manners were not good, either. This sort of behaviour is characteristic of electronic game addiction. There is probably local concern about excessive electronic game playing, Internet use, or television viewing. The students could rework the story and shift the focus to this aspect, which is only touched on in the original. An alternative brief might involve the students designing a poster or another display for school or domestic computer rooms to remind users of the need to balance computer activities with other pursuits.

Electronic game addiction could form the basis of a unit. The students could discuss this problem with you, other teachers, and the principal. With official blessing and involvement, they could find out about the scope and effects of the problem, investigate extreme cases, and suggest prevention or mitigation strategies for children (and adults). An excellent overview of the issues is provided by the New Zealand book *Cyberkids* by Brent Waters (Tandem Press, 1995).

As part of this investigation, the students could research the effects of the problem, including the time and money involved and the reduction of physical exercise and face-to-face human contact. You may wish to avoid asking the students to consider the effect of the games' content because this aspect is currently under debate. However, personal safety on the Internet should be highlighted as an important issue. A good source of information on Internet safety is the Ministry of Education-sponsored Netsafe website at **www.netsafe.org.nz**

The students should present their findings formally and perhaps produce a summary for a school newsletter or website.

Searching for Old Friends

The Prince wanted to meet up with Cinter again. *Have you ever met up with classmates or family in an event called a reunion?* If it is reunion time for your school, the students could be given part of the work of contacting children in old school photographs, following some of the same methods used by Techno and the Prince. (A simpler brief might involve the students bringing in their year 1 class photographs and identifying individuals that they would like to make contact with again.) A useful website that helps old friends to reconnect is **www.oldfriends.co.nz**

Like Techno, you could act as an adviser, checking to see that the students follow good investigative practice. There is an opportunity to bring in community experts in private investigation, local history, and genealogy. A police officer could visit the school, describe what happens in a missing person case, and advise on the types of ICT that are used in such instances. In lieu of a police visit, you could go to **www.police.govt.nz/service/missing**

One of Techno's methods would be problematic in New Zealand – namely, the posting of Cinter's photograph on the palace website. In many circumstances, the publication of a person's photograph or other personal information without their consent contravenes the principles of The New Zealand Privacy Act 2020. In this context, Techno's actions could result in a lawsuit. You could discuss this with the class.
Why do you think Cinter could sue Techno for posting her photo on the palace website?
What sorts of problems could such a loss of privacy cause for Cinter or another person, for example, a child, sports spectator, shopper, celebrity, or medical patient?
In what situations do you think it would be okay to publish someone's photograph without their consent?

The students could consider how much personal information about them is held by various organisations.
What are some of the main organisations that hold information about us?
What rules apply to sharing that information?
Why do organisations have to respect the privacy of people about whom they hold information?
Do we have a say in deciding who can access our information?
Do organisations ever release information about people without their knowledge or permission?
What sort of personal information about you, if any, do you think should be freely available?

For more information about New Zealand's privacy legislation and associated issues, visit the website of the privacy commissioner at **www.knowledge-basket.co.nz/privacy/top.html**

Links to Technology in the New Zealand Curriculum

The first paragraph of the story is essentially a statement of the problem **(AOs 5, 7)**. In the second paragraph, Techno points out that this is not the first time the Prince has lost track of someone, so he ought to develop his ICT skills **(AOs 1, 2, 6)**.

Techno presses the Prince to describe what is known so far – just as a teacher might. Techno is encouraging the Prince to move from an unsophisticated statement of the problem to a more detailed analysis **(AOs 3, 5, 7)**.

Techno and the Prince then identify and use a range of information and communication tools to search for the slipper owner **(AOs 6a, 6b)**. The Prince has an opportunity to learn about scanning and web authoring, and both Techno and the Prince require knowledge of technological systems **(AOs 1, 2)**.

In the final section, after meeting Cinter in her home, the Prince and Techno start to evaluate whether it was worth finding her. However, they did not evaluate the efficacy of their methods – perhaps the students could role-play a reflective conversation between Techno and the Prince **(AOs 6c, 6d, 7)**. Cinter Netta shares her personal views on the ergonomics of the glass slippers

(AOs 1, 4, 7). The stepmother describes how gaming addiction has affected Cinter Netta's life, and they all note the state of the garden **(AO 7)**.

In the first of the Further Activities, the students are invited to produce an interactive story with changes to key elements. In working with time, they will need to compare present ICT with that of the past or likely future; if focusing on electronic game addiction, they will address the personal and social impact of technology **(AOs 7, 8)**. In the course of whatever reworking the students choose, they will need to develop and apply new production skills **(AOs 1–6)**.

The second of the Further Activities involves private investigation by class groups, following the model of Techno and the Prince. However, the students will need to explicitly tailor their approach to personal circumstances **(AOs 4–6)**. They will receive coaching in the use of the technology available to them **(AOs 1, 2, 3)**. There will be an opportunity for them to consider privacy issues that surround the storage of personal information in organisational databases **(AOs 7, 8)**.

Of Elbows and Eels

Possible Achievement Objectives

Science

Living World

- 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.

Developing the Ideas

"Of Elbows and Eels" will help students to develop ideas about the ways in which organisms sense their environment, process sensory data, and respond appropriately. It also presents ideas about electricity in the living world, which will be an unfamiliar perspective for many students. The following notes focus on the ways in which animals sense and respond to their environments rather than on the more dramatic elements of the article, which describe how electric eels zap potential predators or prey. The two topics could be combined, however, as there are many instances in nature where sensory organs fulfil non-sensory roles. For example, the human tongue is not only a sensory organ but also a food manipulating organ and a vocal organ that enables highly sophisticated communication.

If you wish to pursue the "zapping" topic with your students, there are many books that address animals' adaptations for locating and capturing food and/or adaptations for avoiding being eaten. You could begin by referring to the Ministry of Education's *Making Better Sense of the Living World* (Learning Media, 2001). See especially the chapter Science Focus: Structure and Function.

The Specific Learning Intentions

The students will be able to:

- explore and describe the links between the five human senses and particular physical stimuli;

- explore and offer simple, scientific explanations for commonly experienced phenomena, such as nerve fatigue.

The Key Ideas

- In order to monitor, survive in, and take advantage of their environment, all organisms sense and respond to the external world.
- Most animals respond to their environment by way of nerve systems.
- Humans have five senses: sight, smell, taste, hearing, and touch.
- Each of the human senses registers a particular physical stimulus or stimuli: sight (light), hearing (sound vibrations), touch (pressure, pain, and temperature), taste (solid or liquid chemicals), smell (airborne chemicals).
- Often, two or more stimuli are sensed simultaneously by the same organ, for example, the human tongue is sensitive to taste, touch, and temperature.
- Often our sensitivity to a sustained stimulus diminishes rapidly, thus allowing the brain to economise on processing insignificant data.
- Our sensitivity to stimuli may vary according to the context of previous environmental conditions – for example, if you jumped into a swimming pool after a cold shower, it would feel warmer than if you jumped in after a hot bath.

The Main Features of the Suggested Learning Sequence

- The students carry out an activity in which they attempt to identify a mug of warm drinking chocolate by using only one of their five senses. This activity introduces the idea that that each of our five senses is tuned to particular stimuli and that we rely on different senses in different situations.
- You read aloud "Of Elbows and Eels" and discuss nerve systems that include a receptor, a sensory neuron, the central nervous system, and a motor neuron.
- The students discuss the particular stimulus or stimuli that each human sense organ is designed to perceive and explore the way in which various senses work together in particular situations.
- They discuss the fact that different animals usually rely more on certain senses than others and explore the dominance of sight in humans.
- Students with a strong interest in the topic carry out extension activities in which they explore other aspects of varying sensitivity, including the parts of human skin that are more sensitive than others and the phenomenon of nerve fatigue.

An Introductory Activity

Activity: Exploring the Students' Ideas about Senses

What You Need

- A mug of warm drinking chocolate or another fragrant food or drink
- Equipment for blocking certain senses, for example, ear plugs, blindfolds, and nose plugs

Safety Warning

Make sure that any "taster" has no known food allergies and that all stages of the activity are closely supervised.

What You Do

- Select two students to test and identify a mug of warm drinking chocolate or another fragrant food or drink that has been prepared in another room. (Alternatives include citrus fruit, herbs, spices, or lukewarm herbal tea.)
- For each tester, block out all but one of the five senses by using such equipment as ear plugs, blindfolds, and nose plugs. For example, you may have one person who can smell and one who can feel or one who can hear and one who can taste. (Ideally, one of the pair should be allocated a sense that is likely to yield a correct response, and the other should be allocated a sense that is unlikely to be helpful.)
- Before the testing begins, ask for a show of hands from the class to see how many think that the sense used by each tester will be useful for identifying the drink.
- If one of the pair is a taster, start with them (for hygiene reasons). Allow each tester to appraise the drinking chocolate.
- Take away the drinking chocolate and ask each tester to write down what they think the mystery item is and why they think that. (Make it clear that you do not necessarily expect each tester to get the correct answer and that "don't know" or "can't tell" are perfectly acceptable responses.)
- Afterwards, share the results and ask each tester to describe what they sensed, if anything, and explain how that sensory information helped them to make their guess (whether it was correct or otherwise).
- Ask the class how they think the sensory information got from the testers' sensory organs to their brain.
- Read "Of Elbows and Eels" to confirm or challenge the students' ideas.

What You Look For

- Do the students' comments reflect the idea that the drinking chocolate is giving off a number of stimuli that are detected by our senses?
- Do the students' comments reflect the idea that different sense organs respond to different stimuli?

Background Information for Teachers: Nerve Circuits and Reflexes

After the reading, take a little time to discuss in simple terms the neural circuitry that allows animals to sense and respond to their environment. **Receptors** are nerve endings (often within sensory organs) that receive stimuli from the outside world. When stimulated, receptors send messages to the central nervous system by way of **sensory neurons**. The **central nervous system** consists of the brain and the spinal cord. In most situations, the brain processes the incoming signals and sends appropriate responses by way of **motor neurons** to specific limbs or organs. In some situations, the brain responds by sending messages to endocrine glands, which secrete hormones to elicit slower and sometimes body-wide responses.

In certain situations, a brain-moderated response would be too slow, so **reflexes** come into play. Reflexes are automatic, hot-wired responses to particular, extreme stimuli such as sudden injury or an impending collision. In these situations, receptors send messages to the spine rather than the brain. The spine automatically sends a motor nerve response that elicits a reflex action, such as a sudden flinch that diverts and protects the eyes from an impact. Because reflexes are automatically programmed, they do not rely on conscious or unconscious brain activity. However, the brain will respond to the stimulus in its normal way a split second after the reflex. For example, if you touch a very hot surface, you will jerk your hand away automatically, and a second or two later, you will consciously perceive the pain.

The interaction between reflexive and conscious responses can be more complex. For example, if you pick up a very hot plate, you will probably instantly drop it. But if you pick up a hot plate that is valuable, you might reflexively drop it and, a split second later, consciously catch it. The two responses might vie with each other for a second or two as you juggle the plate while searching for a surface to place it on.

Further Activities

Linking the Five Senses with Physical and Chemical Stimuli

After the reading, write the five human senses on the whiteboard and lead the class in a discussion about what stimuli we perceive through each sense. You could record the results of the discussion on a simple chart.

Sense	**Stimulus**
Sight	Light (both brightness and colour)
Hearing	Sound (which is vibration of the air)
Smell	Airborne chemicals and particles
Taste	Solid or liquid chemicals and particles
Touch	Pressure (including the perception of texture) Temperature Pain

Activity: Stimuli and Senses

This activity explores the way in which our reliance on certain senses changes according to circumstance.

What You Need

- A collection of items, such as kitchen utensils, fruit and other foods, soap, and washing powder

What You Do

- Assemble a varied collection of items.
- Ask the students to work in small groups to consider each item and record the senses that they might use if they were asked to identify it.
- In cases where more than one sense could be used, ask the students to rank the senses in order, beginning with the most useful. For example, the ordered list for soap might be sight, smell, then touch.

What You Look For

- Do the students understand that each item is giving off particular sensory stimuli?
- Do they realise that particular organs are sensitive to particular types of stimulus?
- Do they understand that, depending on the circumstances, we rely on some senses more than others and that senses often work together?

You could discuss the fact that humans often rely on sight as their predominant sense – but during a night-time power cut, touch and hearing would come to the fore. Conversely, smell is generally less dominant than our other senses – except in certain situations, for example, in baking, winemaking, and fire emergencies. Also, if a person is born without a certain sense or loses it later in life, their remaining senses will sharpen up to compensate for that loss.

Senses Working Together

Taste and Smell

Mention an item for which two senses would be needed for identification. (For example, unboxed washing powder would probably require smell and sight, smell and touch, or sight and touch for accurate identification.) Some senses almost always work together, for example, smell and taste. Human smell is twenty thousand times more acute than taste, but few of us would realise this unless we had a blocked nose. You can test this out by gently pinching your nostrils closed when you eat. (With a blocked nose, an apple and an onion taste much the same!)

Sight and Taste

Sight and taste also work closely together. When we see a familiar food, we anticipate particular flavours and textures. An interesting activity is to bake a cake with conflicting appearance and taste. For example, you could colour the cake mixture with brown food colouring but flavour it with orange essence and make berry-red icing flavoured with banana essence. (You can make brown food colouring by mixing roughly equal quantities of blue, yellow, and red colourings.) If you are unaware of the trick flavours, your senses become confused when you eat such a cake. Tell the students that you have baked a chocolate-berry cake, invite them each to sample a small piece, and discuss their response to the flavour surprise afterwards. (For detailed information about safe food practices in the classroom, refer to Section 5, Safety and Food Technology, of the Ministry of Education's *Safety in Technology Education: A Guidance Manual for New Zealand Schools* [Learning Media, 1998].)

Activity: Seeing through Touch

Sight is such a dominant sense for humans that if a person is denied visual input and attempts to explore objects with their other senses, the brain takes the data and converts it to a visual mental image. In this process, we draw on previous experiences.

What You Need

- Cardboard
- Scissors
- Glue
- A bag

What You Do

- Cut simple, geometrical shapes out of thick cardboard.
- Place six or seven different "shape cards" in a bag.
- Have a student pull out one shape card at random and attempt to identify it with their eyes shut.
- Discuss the mental processing of the sensory data.
  Did your brain convert the touch messages from your fingers into a visual picture in your "mind's eye"?

What You Look For

- Do the students realise that raw sensory data needs to be processed by our brain if we are to make any sense of it?
- Do they realise that this processing can result in powerful mental images of objects or the environment? (Visual images are often dominant, as in this case, but mental images can also be aural, olfactory, taste, or tactile.)

Extension Activities: Varying Sensitivity

Activity: Paint Brush Touch Test

What You Need

- A small paintbrush for each pair of students

What You Do

- Have the students work in pairs and gently touch each other with a paintbrush on various parts of the body, starting with the lips for hygiene reasons: lips, cheek, palm of hand, back of hand, arm, knee, elbow, top of feet, and soles of feet.
- Ask them to draw up a list that ranks how strongly they felt the paintbrush on the different skin areas.
  Is your ranked list similar to other people's?
- You could also ask them to draw an outline of the human body and shade it to create a "sensitivity map".
  Can you suggest reasons for the different sensitivity of various parts of your skin?

What You Look For

- Can the students offer reasoned explanations for the results of the activity?
- Do their explanations reflect the idea that our tactile sensitivity is concentrated in areas of skin that are specialised to receive important sensory data?

Background Information for Teachers: Varying Skin Sensitivity

The Paint Brush Touch Test activity explores the fact that various areas of our skin are more sensitive to tactile stimuli than others. For example, our fingers are very sensitive because they are a crucial tool for exploring objects and substances. Our lips and facial skin are very sensitive because, with the face's concentration of hearing, smell, taste, tactile, and sight organs, it is a type of "sensory HQ"; we use our lips for eating, which is a crucial activity; and our lips and face are used for giving and receiving affection, which in many animals is an important aspect of social and pair bonding.

Activity: Hot Water, Cold Water

What You Need

- Two glass or plastic bowls
- Cold and warm tap water

What You Do

- Half-fill one bowl with cold tap water.
- Half-fill the other bowl with warm tap water.
- Have the students place one hand in each bowl and let them rest there for two minutes.
- At the end of the two minutes, ask them whether they are more aware of the cold or the hot water. Can they explain any difference in their perception of the temperature?
- Pour the water from one bowl into the other and have the students place both hands in the mixed water.
- Ask them whether the water feels different on each hand. What causes the different temperature perception?

What You Look For

- Can the students offer reasoned explanations for the results of the activity?
- Do they mention nerve fatigue (or a term that conveys the concept) in their explanation for what happens in the first part of the activity?

- Do they suggest that the warm water is closer to our body temperature than the cold water when explaining why nerve fatigue is slightly more pronounced with the warm water?
- Do they mention that their hands have come from different prior conditions when explaining why the mixed water feels warm to the cold hand but neutral to the warm hand?

Background Information for Teachers: Nerve Fatigue

The Hot Water, Cold Water activity explores the fact that our sensitivity to a sustained stimulus often decreases over time. For example, we quickly become used to a smell even though it has not actually diminished. Pool water feels cold when we first jump in, but it soon feels warmer even though its temperature has not in fact changed. This phenomenon is caused by nerve fatigue. Put simply, once the brain has processed a stimulus and decided that it requires no action, it often frees itself up for other duties by blocking further messages of a similar type. This blocking occurs in the base of the brain.

Because of this sensory blocking, we do not feel most parts of our bodies unless we think about them. For example, we might feel our hands for a minute or so after linking our fingers but this awareness quickly disappears unless we call it to mind. Similarly, we may gradually lose awareness of mild pain until we think about it again.

Other Animals' Senses

The students could research other animals' unusual senses, for example, echolocation in bats and marine mammals; heat sensitivity in mosquitoes and snakes with warm-blooded prey; migrating animals' sensitivity to the Earth's magnetic field; bees' ability to sense ultraviolet light; and electromagnetic sensitivity in sharks and other fish (including electric eels) that inhabit murky water or prey on buried organisms.

Thunder and Lightning

Possible Achievement Objectives

Science

Planet Earth and Beyond

- 3.1: Investigate the major features, including the water cycle, that characterise Earth's water reserves.

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 the Ideas

In order to understand lightning, the students will need background knowledge about the water cycle and, in particular, storm clouds. In order to assess and build on the students' prior knowledge, you could follow the suggested learning sequence (or parts of it) outlined in the Developing the Ideas section for "Hard Ice, Soft Ice". "Thunder and Lightning" builds on this learning sequence by introducing ideas about electricity.

The Specific Learning Intentions

The students will be able to:

- build a simple electrical circuit and, with reference to that circuit, articulate simple ideas about static and moving charges;
- transfer their knowledge about static and moving charges to other contexts, such as the build-up and redistribution of charges in thunderclouds and in the human body.

The Key Ideas

- There are two types of electrical charge: positive and negative.
- A static charge can accumulate in an object or a substance, or a moving charge can travel along a conducting path as an electrical current.
- Batteries contain chemicals that make charge available – positive at one end and negative at the other.
- In a simple electrical circuit in which a battery lights up a bulb, a negative charge flows along the wire, through the bulb, and into the other end of the battery, where it combines with the positive charge.
- Like charges repel one another and opposite charges attract one another.
- A negative charge flows through a battery-powered circuit because it is repelled by the negative terminal and attracted to the positive terminal.
- A similar (but very sudden and massive) redistribution of electrical charges occurs in a thundercloud when lightning flashes. Because the positive/negative charge differential within a thundercloud is so extreme, the negative charge arcs through the air along a jagged path where the air has become conductive.

The Main Features of the Suggested Learning Sequence

- You read aloud "Thunder and Lightning", which combines key ideas about the weather and electricity.
- The students explore moving and static electrical charges by carrying out practical activities with batteries and linking the associated ideas to the phenomenon of lightning.
- You assess the degree to which the students can transfer their understanding of moving and static charges to a new context.

Further Activities

Moving and Static Electrical Charges

Part A: Exploring Electrical Circuits

You could carry out the following activity and discussion sequence after the first reading. Suggested focus questions are in italics. Although some students may have prior knowledge about electrical circuits, many will find the topic unfamiliar. The expectation is not that they will be able to give you the entire responses outlined below, but rather that you will use those "model answers" as background information when helping the students to develop their understanding as they carry out and discuss the activity. (Additional background information and activities can be found on pages 4, 5, 15, and 16 of *Invisible Forces*, Book 49 of the Ministry of Education's Building Science Concepts series [Learning Media, 2003] and on pages 68 to 70 of the Ministry of Education's *Making Better Sense of the Physical World* [Learning Media, 1999].)

What You Need

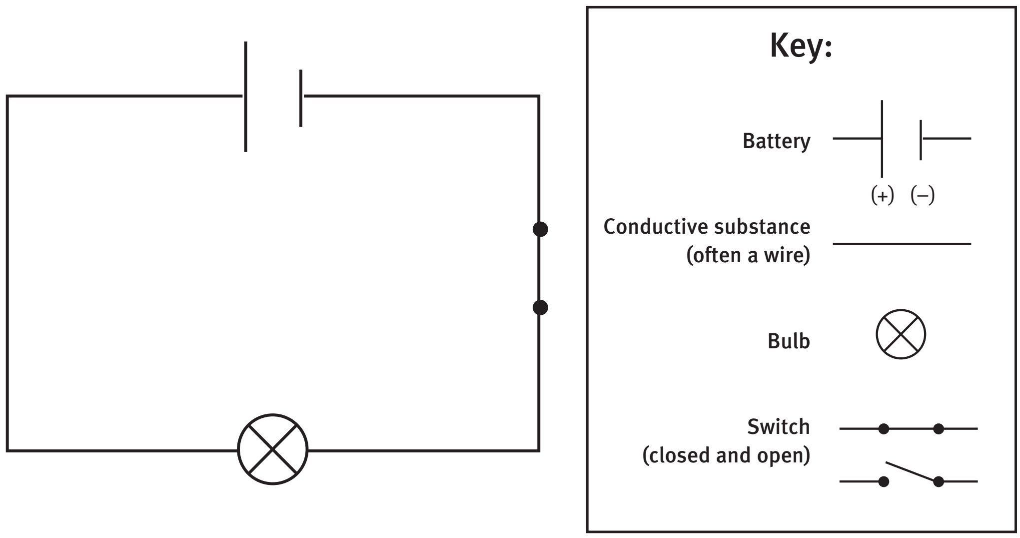
- A 1.5-volt battery in a battery holder
- 3 wires

- A switch
- A 2.5-volt bulb in a bulb holder

What You Do

- Ask the students to build a simple electrical circuit consisting of a battery, three wires, a switch, and a bulb. Have them connect the components in series and close the switch.
- Draw a diagram of the circuit on the whiteboard, making sure that the positive and negative ends of the battery are marked as such. The positive and negative terminals are marked in the key below, but, in keeping with scientific convention, the circuit diagram does not include positive and negative symbols.

The simple circuit, drawn with standard international symbols



What is happening within the circuit to make the bulb glow?
A negative electrical charge is flowing through the wire from the negative end of the battery to the positive end. The negative charge moves through the circuit because it is repelled from the negative terminal and attracted to the positive terminal. As the electrical charge passes through the filament of the bulb, electrical energy is transformed into heat and light energy.

- Have the students open the switch to break the circuit.
  What has happened to the charge now that the switch is open?
  Because the circuit is broken, electricity cannot flow through it, and the negative charge has become "static" again within the circuit.

  What happens if you close such a circuit and let the electrical charge flow through it indefinitely?
  As more and more of the negative charge moves through the circuit, it gradually combines with the positive charge at the other end. As the charges move and combine, the chemicals inside the battery change, and less charge is made available to flow through the circuit. The charge differential between the positive and negative terminals (measured in volts) gradually diminishes. When the differential approaches zero (that is, when the terminals are neutral), we say that the battery is flat.

What would have happened if the negative charge had all flowed through the circuit at once rather than gradually?
The bulb would have blown, but if you had an extremely large bulb, it would flash very brightly for a short time as a surge of electricity flowed through it. Very soon, the charge differential would equalise and both ends of the battery would be neutral.

How do you think this activity might relate to the build-up and movement of electrical charges within a thundercloud?
This very sudden redistribution of electrical charges is what happens when lightning flashes. The charges are redistributed either within the cloud (sheet lightning) or between the cloud and the ground (fork lightning). Of course, there is no giant light bulb in the sky. What there is between the positively and negatively charged areas in a cloud is air and mist. The air usually acts as an electrical insulator, preventing the charges from redistributing and neutralising each other. However, when the charge differential is extreme, the attraction between the positive and negative charges becomes so strong that it overpowers the air's insulating qualities, and an electrically conductive "lightning channel" forms through the air.

What You Look For

- Can the students build a simple electrical circuit and, with reference to that circuit, articulate simple ideas about static and moving charges?
- Do they understand that there are two types of electrical charge: positive and negative?
- Do they understand that a static charge can accumulate in an object or a substance and that a static charge can become a moving charge that travels along a conducting path as an electrical current?
- Do they understand that a negative charge flows through a battery-powered circuit because it is repelled by the negative terminal and attracted to the positive terminal?

Part B: Recontextualising the Key Ideas

An effective way to assess whether students have absorbed the key ideas during a learning sequence is to check whether they can transfer their knowledge to a different context. In this case, the students may have experienced a similar but very small-scale charge redistribution in their daily life.

What You Do

- Ask the students whether they have ever received an electric shock when touching a metal shelf or door handle.
  Can you come up with possible explanations for this phenomenon?
  If the students have carried out the activity on page 15 of *Invisible Forces*, which explores friction and static electricity, you could mention that the answer has something to do with that phenomenon. A small static charge can build up in your body when the soles of your footwear rub against such floor coverings as synthetic carpet. This negative charge cannot be earthed because your footwear forms an insulating layer between your body and the ground. However, if you touch an electrical conductor, such as a metal shelf or another person, the negative charge (electricity) jumps across and neutralises the charge differential between you and what you are touching. If this happens, you feel a small electric shock. You might also see a spark and hear a slight crack.

What You Look For

- Can the students articulate science ideas in their own words?
- Do their explanations reflect what they have recently learnt about static electricity and moving charges? (In other words, are they able to transfer their knowledge to a new situation?)
- Can they also distinguish key differences between what happens when lightning flashes and what happens when you get an electric shock from touching, for example, a metal object?

(The main difference is that, because the charge differentials are so small when static electricity builds up in your body, very close proximity is necessary for electricity to move and neutralise the charges – the electricity does not discharge through the air until your hand is about a millimetre from the metal object.)

Hard Ice, Soft Ice

Possible Achievement Objectives

Science

Planet Earth and Beyond

- 3.1: Investigate the major features, including the water cycle, that characterise Earth's water reserves.

Material World

- 2.3: Investigate and describe everyday changes to common substances.
- 2.4: Use simple technology to demonstrate and explain methods which prevent or promote change in materials.

Nature of Science

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

Developing the Ideas

In order to understand storm clouds and hail, the students will need to develop background knowledge about the water cycle. (Many of them will already have sound prior knowledge about this topic, and so you may wish to abridge the suggested reading and demonstration activities.) They will need to understand the different physical states of water on land and in the atmosphere. They will also need to understand something about the behaviour of heated fluids (both gases and liquids).

The Specific Learning Intentions

The students will be able to:

- explore the concept of scientific modelling by carrying out a teacher-led role play and then develop their own role play to model a different but related phenomenon;
- articulate science ideas in their own words as they develop, act out, and explain their role play;
- identify how their own and other people's role-plays model some aspects of the natural world but not others;
- apply their theoretical understanding of hail and snow formation to activities in which they make different types of ice.

The Key Ideas

- Water can exist in three states: solid, liquid, and gas.
- During a change of state, water undergoes one of the following processes: freezing, melting, evaporating, or condensing.

- Water freezes when its temperature drops below 0 degrees Celsius and melts when its temperature rises above 0 degrees Celsius.
- Depending on the way it freezes, ice adopts different physical forms.

The Main Features of the Suggested Learning Sequence

- You help the students to consolidate or develop key ideas about the water cycle, weather, and clouds.
- The students carry out a role play that models the way in which water freezes.
- You read aloud the article about hail and snow formation.
- The students develop and perform role plays that model each process.
- On the basis of key ideas from earlier stages in the learning sequence, they develop techniques for making various types of ice in a domestic freezer.

Introductory Activities

Weather and Water

In order to introduce the topic and to assess the students' prior knowledge before the first reading, you could flick quickly through the *Weather* picture pack, briefly discussing what's happening in each image as you go. (The *Weather* picture pack was distributed with books 29 to 36 of the Ministry of Education's Building Science Concepts series.)

- Before you start, ask the students to think about what things are common to nearly all the photographs of weather phenomena. Air and water feature in all the images, except for the one of a drought, which has no obvious water in it.
- If the students need prompting, you could ask them to look for the water in each image.
- You could also ask them how the water in each image came to be where it is.
- In many of the images, more than one form is shown. For example, both cloud and hoar frost are shown in picture 2.
- Ask the students whether there's any invisible water in the images. Some students may be able to explain the concept of atmospheric humidity.

What You Look For

- Can the students identify water in its various physical forms?
- Can they describe such processes as evaporation and condensation?
- Do they understand the basic features of the water cycle?

Depending on the students' general knowledge and previous learning experiences, you may need to help them develop basic ideas about the physical states of water and the processes of transformation between those states. The following sections provide ideas for this.

The Physical States of Water

In order to summarise the physical states of water and changes between the solid, liquid, and gaseous states, you could work with the students to draw a simple diagram on the whiteboard – for an example, see page 25 of the Ministry of Education's *Making Better Sense of the Material World* (Learning Media, 1998). To consolidate their existing ideas, the students could carry out Activity 1: Disappearing Water on page 26. Alternatively, if they have only rudimentary ideas and require more thorough preparation, a detailed learning sequence can be found in *Ice: Melting and Freezing*, Book 58 in the Ministry of Education's Building Science Concepts series (Learning Media, 2004).

The Water Cycle

With reference to the images in the *Weather* picture pack, ask the students whether they have heard of and can explain the "water cycle". Even if they have not heard of the water cycle, using picture pack images as stimulus material, you could facilitate a discussion in which they talk about what such a term might mean. In order to confirm and consolidate the students' understanding of the water cycle, you could then read them "An Interview with a Glass of Water" and/or "The Water Cycle" in *Connected 2 2002*.

Heating, Cooling, and the Movement of Fluids

Atmospheric convection is a crucial aspect of weather and the water cycle. In order to demonstrate the movement of heated air in the atmosphere, you could carry out Activity 1: Rising and Falling Air, on page 10 of the Ministry of Education's *Storms: Extreme Weather*, Book 50 in the Building Science Concepts series (Learning Media, 2003).

Because this activity uses water as an analogy for air, you may wish to follow up with Activity 7: Rising Heat on page 75 of the Ministry of Education's *Making Better Sense of Planet Earth and Beyond* (Learning Media, 1999). This activity demonstrates that heated gases rise in the same way as heated liquids. (This use of different scientific models and analogies could lead to a brief Nature of Science discussion about the way in which scientists explore the same topic in different ways in order to test their ideas.)

Tying It All Together

The activities above represent very large-scale atmospheric processes by using small-scale models. Make sure that the students can link the demonstration ideas with what happens in the natural world. Air that's heated by solar energy near the Earth's surface rises through the atmosphere. It cools down as it reaches higher altitudes, and the invisible water vapour in it condenses into a mist of tiny water droplets. The droplets are too small to see individually but, en mass, they are visible as cloud. To round off this initial phase in the learning sequence, the students could carry out Activity 13: Make Your Own Cloud on page 82 of *Making Better Sense of Planet Earth and Beyond*.

Having carried out all or some of the previous activities, the students will have a general understanding of ice formation. They may think, however, that all ice is the same. Also, they may not realise that snow is in fact ice, believing instead that it is in a separate category. "Hard Ice, Soft Ice" introduces the idea that ice can be dense and hard or airy and soft, depending on how it forms. You could use carbon as an analogy for the way in which the same substance can take on radically different forms. Show the students a diamond (if you have one at hand!) and a graphite pencil lead. Many of the students will be surprised to learn that both diamond and graphite are made of more or less pure carbon. These two very different forms of pure carbon result from the way in which the particles (atoms) are arranged together. (You may feel it is easier for your students to understand the word particles rather than atoms.)

A Preliminary Role Play

Mention to the students that ice can be hard and glassy, hard and frosty, or feathery and soft. As with diamond and graphite, it all depends on how the particles (tiny bits of water) are arranged together. The students could then carry out Activity 3: Role Play the Change of State from Ice to Water in section three of *Ice: Melting and Freezing*, Book 58 in the Ministry of Education's Building Science Concepts series (Learning Media, 2004). At the end of the activity, tell the students that they are about to read an article about how two different types of ice form in nature.

Further Activities

A Follow-up Role Play

After you have read "Hard Ice, Soft Ice" to the students or allowed them to read it themselves, ask them to come up with a role play that demonstrates key differences in the way snowflakes and hailstones form. Before they begin to devise their role play, ask them whether they think that they could use the initial role play as the basis of either a snow or hail role play. A hailstone is a small, solid piece of ice, which is quite similar to an ice cube made in a freezer. The initial role play is a suitable demonstration for hail formation because hail develops from small droplets of *liquid* water, layer upon layer of which wrap around the hailstone and freeze onto it. (The layering process would need to be an additional feature that the students build onto the original demonstration.)

In contrast, a snowflake does not form from liquid water. Rather, particles of atmospheric water vapour (a gas) freeze individually onto the growing crystal. The crystal may join up with other crystals and form a large, feathery snowflake.

It would be worthwhile to talk to the class about the previous role play in terms of scientific models. Scientific models are designed to reflect and explain real situations and processes. Emphasise that a model is not exactly like the real thing. Rather, it is a process, explanation, diagram, or physical replica that helps us to understand what is happening. All models have strengths and weaknesses. The "like features" of a scientific model are those aspects of reality that are reflected in the model. The "unlike features" are those aspects of reality that the model does not or cannot demonstrate. Ask the students to explain what aspects of hail and snow formation their role plays illustrate. Are there features of hail and snow formation that their role plays do not demonstrate?

What You Look For

- Are the students able to express science ideas about hail and snow formation in their own words?
- Do they recognise that the original role play is a suitable basis for demonstrating many aspects of hailstone formation?
- Does the role play demonstrate that individual crystals can join together to form a snowflake?

Making Different Types of Ice

By this stage, the students should understand ice well enough to manipulate it in order to produce desired effects. In order to assess this, you could challenge the class to create as many different types of ice as they can. You may wish to stipulate that they should aim for solid, glassy ice; solid, frosty ice; and soft, feathery ice. (Pure glassy ice is very hard to achieve, but a number of ice-making techniques result in a mixture of glassy and frosty ice.)

Feathery ice crystals result if you pour about a centimetre of boiling or very hot water into a receptacle, attach a lid, and place the lidded receptacle in a freezer. Water vapour condenses and freezes onto the sides and lid of the container, forming small, feathery crystals. You can continue to grow these crystals by adding layer after layer of boiling water to the bottom of the receptacle, allowing the mix to freeze thoroughly between each application. Another variation on this theme might involve dangling a water-soaked piece of rough string from the lid. Ice crystals form on both the main piece of string and on any small fibres that extend from it.

The students might also try making a thin layer of ice, crushing it up, pouring more, very cold water onto the mixture, and refreezing it. This process could be repeated a number of times. Depending on how finely the students crush the ice each time, they will end up with a chunky, frosty form of solid ice. The frostiness results from air bubbles that become trapped within the crushed up, refreezing ice.

What You Look For

- Is there a clear purpose in the students' plans?
- Are they able to make simple, reasoned predictions about the types of ice that will result from their strategies?
- Do their ideas reflect what they have learnt about ice through previous reading, discussion, and activities?

You could also demonstrate that if you add different substances to water then freeze it, the resulting ice has different textures. For example, the students could try freezing salt water and different types of milk. The appearance and texture of the resulting ice depend on the type and amount of dissolved substances in the water. This supports the idea that when water and air are mixed together in different proportions, the resulting ice has different physical properties.

Time Zones

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 story problems which involve whole numbers, using addition, subtraction, multiplication, or division (Exploring computation and estimation, level 2).
- 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).

Science

Planet Earth and Beyond

- 2.3: Use their ideas to investigate major objects in our solar system and very noticeable environmental patterns associated with these objects.
- 3.3: Locate and use information obtained from space exploration to clarify, challenge, and extend their ideas about the general nature and behaviour of the Earth, its moon, and the other planets in our solar system.

Developing the Ideas

Many primary school students find it hard to understand that clock times vary in different parts of the world at any given moment. "Time Zones" provides an opportunity to link mathematics concepts (Measurement strand) with science concepts (Planet Earth and Beyond strand) within a single, authentic context.

After the students have read "Time Zones", allow plenty of time for discussion. You could pick up on the penultimate paragraph in which the narrator says that she and her father will need to explain the concepts to Carlo again. How might the students explain the concepts to an eight-year-old?

You could use a globe to explore the ideas raised in the story. (You will probably be able to move quite quickly through the concept of celestial shadows causing day and night. Time zones and the International Date Line may, however, require more detailed consideration.)

From reading the story, the students should understand that the Earth is a rotating sphere and that the Sun shines on one side at a time. From this key concept, they will understand that the time must be different in different parts of the world.

Try using New Zealand and Britain as examples.

- In a darkened room, use a torch or a bright lamp to represent the Sun and ask a student to turn the globe so that it is the middle of the day in New Zealand. Ask what time of day it is in Britain.
- The students will see that Britain is in the middle of the darkened side, and so it is the middle of the night there.
- Ask the class which way they will have to turn the globe so that the Sun is setting in New Zealand. (The Earth turns from left to right if viewed side on. For this reason, the Sun appears to rise in the east and set in the west.)
- Once the globe is positioned so that the Sun is setting in New Zealand, ask the students what is happening in Britain. (The Sun is rising.)

You could then progress to considering time zones.

- Keeping the globe visible for reference, ask the students to estimate times in different parts of the world and record their estimates in a table.
- For example, if it is midday in Wellington, what time is it in Sydney? Mumbai? Cairo? London? New York? Los Angeles?
- Check the actual times by using one of the time converters available on the Internet. The following sites are two of many possibilities for this:
  www.journeymart.com/tools/Time.asp
  www.iagora.com/itravel/tools/conv/time_cnv.html

Note that the actual times will be affected by daylight saving, but the point of the exercise is only to get a roughly correct estimate. If the students are within an hour or two of the correct time, you will know that they have absorbed the key ideas.

A recording chart such as the following example would be very useful.

Place	Estimated time	Actual time
Wellington	12.00 midday	
Sydney (Australia)		
Mumbai (India)		
Cairo (Egypt)		
London (England)		
New York (USA)		
Los Angeles (USA)		

- Add a chosen day to the New Zealand time and then ask the students to add the corresponding days to the others.

- Do they realise that in New York and Los Angeles, it will be day before? This concept is explained in the story. Can the students explain it in their own words?

- A key point that will help students to make day and time conversions is: *If we cross the International Date Line when travelling eastwards, we change the date back one day. If we cross it when travelling westwards, we change the date forward a day.*
- You could show the students a world map with time zones marked. Some differently formatted versions are available on the following Internet sites:
  http://aa.usno.navy.mil/faq/docs/world_tzones.html
  www.travel.com.hk/region/timezone.htm
  www.convertit.com/Go/ConvertIt/World_Time/Time_Zones_Map_Small.ASP
- Ask the students why they think the world is not divided into time zones by straight lines. (The irregular zones fit country boundaries more conveniently.)
- You could pose a range of practice questions.
  If it is 5.00 a.m. in England, can you find a country where it is 2.00 a.m.?
  If it is 3.00 p.m. Tuesday in New Zealand, what time and day is it on the west coast of the United States?
  If you wanted to contact a friend in New York and wish them happy birthday on their Saturday at 6 p.m., what would be the correct time and day to phone from New Zealand?

Further Activities

Adding and Subtracting Time

Mum's flights home give a good context in which the students can practise adding and subtracting time, with the added element of different time zones. You could print out various flight schedules from the Internet, remove either the arrival or the departure time, and ask the students to fill in the gaps according to the hours in flight.

Working through the example in "Time Zones" will provide a good model for this:
- Mum left Auckland at 11.45 a.m. on Monday, but what time was it in Los Angeles when she left?
- In September, if it is 11.45 a.m. in New Zealand, in Los Angeles it is 4.45 p.m. on the previous day.
- So if Mum flies for 11 hours 50 minutes, what time will it be when she arrives? (The time in Auckland will be 11.35 p.m. on Monday, and the time in Los Angeles will be 4.35 a.m. on Monday.)

When viewing in-flight hours and when adding times, students must realise that 11:50 does not represent 11.5 (eleven and a half). Rather, it represents 11 hours and 50 minutes or $11\frac{50}{60}$ ($11\frac{5}{6}$) hours.

Links to the Number Framework

The students will have different strategies for adding time. Encourage them to share and discuss these. The following examples reflect the types of strategy that might be employed by students working at Stage Six of the Number Framework (Advanced Additive Part–Whole). At this stage, the students can use a wide range of ways to partition numbers for estimating and solving addition and subtraction problems mentally. The Ministry of Education's Numeracy Project materials are available on the NZMaths website in the Numeracy Projects section at **www.nzmaths.co.nz/Numeracy/project_material.htm**

11.45 a.m. + 11:50	= 11.45 a.m. + 12:00 – 0:10
	= 11.45 p.m. – 0:10
	= 11.35 p.m.
11.45 a.m. + 11:50	= 11.45 a.m. + 11:00 + 0:50
	= 10.45 p.m. + 0:50
	= 10.45 p.m. + 0:15 + 0:35
	= 11.00 p.m. + 0:35
	= 11.35 p.m.
11.45 a.m. + 11:50	= 11.45 a.m. + 0:15 + 11:35
	= 12.00 midday + 11:35
	= 11.35 p.m.

Some students might find it helpful to use an analogue clock when making these addition calculations. You could demonstrate the calculations above and any others your students suggest on a model analogue clock as well as writing them in digital form.

Links to Figure It Out

The level 4–4+ theme book *Getting Around* (Learning Media, 2003) includes a range of activities that explore the mathematics of distance, time, and travel. Of particular relevance is the activity Time Zones on pages 16 and 17. This activity involves students working out flight times on the basis of known arrival and departure times in different time zones. You could use this as an assessment activity.

Science Links

Many of the science concepts underlying the story relate to the way in which the Earth spins on its axis. This is the topic of a level 3 science exemplar on TKI called Daily Views. This and other online exemplars can be accessed via the science kete.

Day and Night: Views from the Southern Hemisphere is a digital learning object through which students can explore how the movements of the Earth and Sun result in the shadow patterns that cause night and day. The learning object also allows students to interactively explore the monthly lunar cycle. Day and Night can be accessed via the science kete on TKI, or you can go directly to: **www.tki.org.nz/r/science/day_night/dswmedia/index_e.php**

The students could go on to explore how the Earth's tilt and its orbit around the Sun cause seasons. For background information and student activities that explore the seasons from a meteorological and astronomical point of view, see pages 67, 68, and 91–100 of the Ministry of Education's *Making Better Sense of Planet Earth and Beyond* (Learning Media, 1999).

Oops!

Possible Achievement Objectives

Mathematics

Geometry

- Model and describe 3-dimensional objects illustrated by diagrams or pictures (Exploring shape and space, level 3).
- Draw pictures of simple 3-dimensional objects (Exploring shape and space, level 3).
- Describe patterns in terms of reflection and rotational symmetry, and translations (Exploring symmetry and transformations, level 3).

Developing the Ideas

Before reading the story to the students, ask them whether they have been on an aeroplane before. How do passengers know which is their seat? The seats are named in a co-ordinate system involving numbers and letters. In a co-ordinate system, two or more elements combine to indicate a precise location. In this case, numbers indicate the rows of seats and letters indicate the seat locations within each row.

After the reading, tell the students to assume that the aeroplane had 10 rows of seats and that the seats in each row were labelled A, B, C, and D. Which letters do the students think indicate window seats? (A and D because they are at either end of each row.) Remind them that the characters in the story were sitting in the following seats: little girl 1C, old man 10D, woman 3A, and young man 8B.

Ask the students to draw a seating plan to show where each person was situated. The plan should resemble the following diagram.

South **North**

1D	2D	3D	4D	5D	6D	7D	8D	9D	10D
1C	2C	3C	4C	5C	6C	7C	8C	9C	10C
1B	2B	3B	4B	5B	6B	7B	8B	9B	10B
1A	2A	3A	4A	5A	6A	7A	8A	9A	10A

Ask the students to consider what happened to the relative position of the seats as the plane went through its various manoeuvres. Firstly, what happened when the plane turned around and flew in reverse? The front of the plane became the back. Thus, each seat was rotated by a half turn about the white square.

This can be demonstrated if the students:
- draw the seating plan;
- make a photocopy of the seating plan on an overhead transparency;
- place the transparency over the original plan;
- rotate the transparency through a half turn.

You could discuss the manoeuvre using mathematical terms.
- Ask the students how many degrees are in a half turn/half circle. Some of them will probably know that a half turn is 180 degrees and a full turn is 360 degrees.
- Ask them which seats traded positions with 1C (10B), 10D (1A), 8B (3C), and 3A (8D).
- You could ask them to draw a revised seating plan for this arrangement. A quick way of achieving this would be to photocopy the overhead transparency in its new orientation and re-mark north and south in the correct positions on the photocopy. (The numbers and letters will be upside down, but the photocopy will still be a useful record of the first manoeuvre.)

South **North**

10A	9A	8A	7A	6A	5A	4A	3A	2A	1A
10B	9B	8B	7B	6B	5B	4B	3B	2B	1B
10C	9C	8C	7C	6C	5C	4C	3C	2C	1C
10D	9D	8D	7D	6D	5D	4D	3D	2D	1D

- Remind the students that the next move was to flip the aeroplane upside down.
- Ask them to work out which seats will be trading positions with 1C, 10D, 8B, and 3A. They can work on this in small groups. The manoeuvre corresponds to a 180-degree rotation about the mid-line represented by the aisle.
- Again, this can be demonstrated by manipulating the overhead transparency of the seating diagram.
- The relevant trades are 1C (1B), 3A (3D), 8B (8C), and 10D (10A). Ask the students to draw a plan of the revised seating after the upside-down flip.

South									North
10 D	9 D	8 D	7 D	6 D	5 D	4 D	3 D	2 D	1 D
10 C	9 C	8 C	7 C	6 C	5 C	4 C	3 C	2 C	1 C
10 B	9 B	8 B	7 B	6 B	5 B	4 B	3 B	2 B	1 B
10 A	9 A	8 A	7 A	6 A	5 A	4 A	3 A	2 A	1 A

- Remind the students that the pilot then righted the aeroplane so that each passenger was seated in their previous position.
- Compare the last seating diagram (of the aircraft flying upside-down) with the first diagram.
- Ask the students what rotation and/or reflection would be needed to return each seat to its original place – a vertical flip about the midpoint between rows 5 and 6.

Further Activities

Other Ways of Modelling the Situation

The students could make a model of the seating plan by joining multi-link cubes in a 10 by 4 block. They could use sticky dots to label the seats of the main characters. They could also add wings and a tail section to their multi-link model.

The students could represent the manoeuvres by drawing their multi-link model plane on isometric paper, with the orientations that result from the various manoeuvres drawn from the same point of view. An example of the second manoeuvre might look something like the following diagram.