Planning for learning: Building knowledge for teaching primary science and technology

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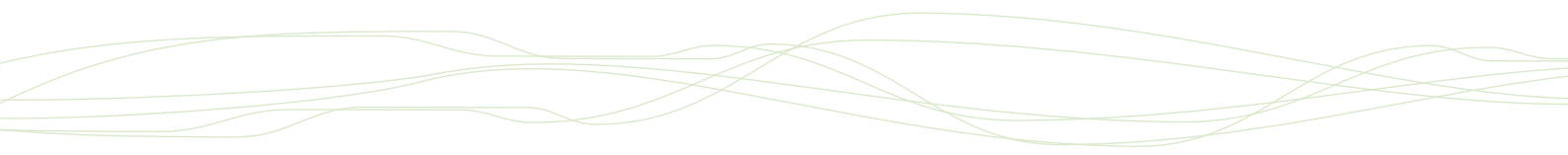
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Introduction

- How might a teacher set about teaching seven-year-olds how to design a game for preschoolers?

- How might a teacher help five-year-old students understand concepts related to sound?

- What could a teacher do when students have technical problems in a technology task or a science investigation?

These are the kinds of questions that prompted our research focus on building teacher knowledge for teaching science and technology in the InSiTE project (Cowie, Moreland, Jones, & Otrel-Cass, 2008). Over three years we explored how teachers learn new knowledge and develop it, and how they used it so that their students had worthwhile learning experiences in both technology and science education. This booklet presents some of the findings related to these explorations. It particularly focuses on the use of science and technology subject-specific planning templates and their impact on helping teachers build knowledge for teaching.

The ideas and examples presented in this booklet may be used as a resource for teachers wanting to explore different ways to plan their teaching of science and technology. They may also expand teachers' knowledge of, and practices in, science and technology teaching.

The booklet is divided into several sections:

- What does research say?

- Preparing for teaching: Using subject-specific planning templates

- Impact of using the planning templates

- Example of a full technology plan

- Example of a full science plan

A blank planning template for teacher use is available on the TLRI website: www.tlri.org.nz/the-classroom-insite-project/

What does research say?

It has been argued that teachers require an understanding of science and technology content to be able to teach science and technology effectively. To teach biology, for example, a teacher needs to know biology ideas. But is that the only knowledge required?

What kind of knowledge is useful for teaching?

In the mid-1980s, Lee Shulman (1986, 1987) and his colleagues proposed a special domain of teacher knowledge that they termed "pedagogical content knowledge" (PCK). They suggested that PCK is:

- a content knowledge unique to teaching—a kind of subject-matter-specific professional knowledge

- the special knowledge that effective teachers use when they alter their own subject content knowledge into learning experiences that make sense to their students, so their students can learn the content

- the knowledge that is developed when teachers blend content/subject-matter knowledge and pedagogical knowledge in such a way that students can grasp the idea being taught, yet at the same time the integrity of the idea is maintained.

When teachers teach science and technology well, they use pedagogically powerful ways to represent the content to their students, and at the same time they take into account their students' preconceptions and understandings. Their students are able to learn the content at levels appropriate to them; yet the content remains true. Effective teachers are able to bring to mind, select and use the most appropriate examples, metaphors, illustrations, activities and demonstrations that will help their students understand. They can clarify subject matter so everyone can learn.

What would be an example of PCK?

For technology, let's take the technological concept of a mock-up. A teacher may understand a mock-up is:

- a scale or full-size nonfunctional model of a structure or device, used for teaching, demonstration, testing a design and/or promotion

- useful in the consumer industry as part of the product-development process, when the size, impression and/or artwork have to be tested and approved

- used by designers, architects and sometimes end users

- used to determine proportions related to dimensions of the piece itself, or to fit into a specific space or room

- useful for testing whether products suit typical human shapes and sizes

- used to test colour, finish and design details that cannot be visualised from initial drawings and sketches.

But what if they were teaching Year 4 students about mock-ups? Then a teacher might first create a problem-solving situation that was pertinent to their students. For example: "Design and make storage containers for a shelving unit in the classroom." They could distil the essence of mock-ups as "Mock-ups are used to test out some features." In the storage container example, a mock-up storage container could be made to test out its size, shape and fit to the storage unit. Students could develop and test out their design ideas by constructing a mock-up from cardboard and evaluating its fit to the storage unit before making the real thing. Here the teacher has planned a problem (designing a suitable storage container) and interpreted the technological concept of mock-up in a way that is appropriate for Year 4 students. It is not easy for teachers to translate and change their own subject ideas to ideas suitable for the level of their own students. If it were, anyone could teach for effective learning.

What happened in the InSiTE project?

Our teachers came to better understand PCK partly because we talked about what it meant as a theoretical idea. Towards the end of the three-year project, we asked the teachers what came to mind when they thought of PCK. They all emphasised the importance of teachers having subject-specific knowledge and knowledge of ways to teach subject ideas and skills:

> It is the essential stuff that helps us teach. If you have a good understanding you can help someone else get a good understanding. You can help them make connections much more than if you don't have PCK. (Tayla)

> PCK is the knowledge that I bring to the task, lesson and/or content of what I am doing. It can be information, ideas and skills. It's marrying those up and being able to help students develop their own knowledge and skills. It is about me using my knowledge to help students learn. (Carol)

> PCK is what a teacher needs to know to effectively teach a unit. It is about teacher prior knowledge, and I have to understand the ideas and how to teach these. (Gail)

The teachers came to understand that PCK was about them knowing the ideas and concepts so that they could teach them to their students. Knowing the ideas for teaching is an important step in the teaching process:

> I have to be able to grasp the concepts and learn about what I want to teach before I teach them to my children. (Jo)

> I have to find out to get a better understanding of the science concepts for teaching. Then I can help students in class understand the concepts. (Tayla)

The InSiTE teachers developed their PCK when they:

• used subject-specific planning templates

• reflected on their personal classroom experiences

• discussed student work with each other

• used each other's recommendations

• used activities that had worked in other classrooms

• planned together

• discussed the InSiTE research findings.

When the teachers and researchers talked together about teaching and learning of science and technology over the three years, teachers enhanced their PCK. When teachers were able to trial their ideas in their classrooms and reflect on those experiences, they were able to enhance their PCK. Time, support and collegiality were critical factors.

In the InSiTE project, the ongoing use of subject-specific planning templates impacted on teachers' PCK for their teaching of science and technology. Why did planning with these templates have such an impact? There were several reasons:

• Teachers had to think about how to transform their understandings of science and technology for teaching.

• Teachers had to think about how to make the subject ideas accessible to *their* students.

• Teachers had to show how they intended to organise, adapt and represent subject ideas for teaching and learning.

• Teachers had to think about and choose the explanations, artefacts, representations, illustrations, models, examples, analogies and demonstrations that would help their students engage in and learn the ideas they intended.

The InSiTE teachers' planning became more focused on the key ideas and practices of science and technology they wanted their students to learn. Their planning became more focused on pedagogical approaches that would help their students learn the key ideas and practices. When the teachers participated in continuing dialogue about their science and technology knowledge, they started to be more precise in the science and technology ideas and skills they wished their students to learn.

☞ Questions for you

• What has been successful/unsuccessful for you in developing your PCK for teaching science and technology? Why did it work/why did it not work?

• How might analysing student work in science and technology impact on your PCK?

• Why might analysing your planning for teaching science and technology impact on your PCK?

☞ What could you do?

• You might like to work with a colleague to reflect on and become more aware of your knowledge of technology and science ideas and skills and how to teach them.

• You may wish to assess your own feelings of competence about your subject knowledge and pedagogical approaches in technology and science. You could list various ideas and skills in various technological areas and science topics and make a note of which areas you feel competent to teach and which you feel uncertain about.

• If you feel you need more support, what opportunities exist for professional learning that match your needs? Could you work with colleagues to develop your expertise?

• If you are confident about your knowledge of science and technology ideas and skills and ways to teach them, could you devise a practical programme of professional learning for less confident colleagues?

Preparing for teaching: Using subject-specific planning templates

In the InSiTE project, the use of a two-part planning template was effective in helping teachers articulate and enhance their PCK. If we think of teaching as inquiry, Part 1 of the template is the *focusing inquiry* (Ministry of Education, 2007, p. 35) and outlines the scope of what is important to learn. Part 1 of the planning template prompts teachers to work out the intended learning outcomes (the subject ideas and skills) for their students; in other words, to inquire into what they should focus on and why (Ministry of Education, 2007, p. 36). Part 2 is the *teaching inquiry* and shows the plans for how the teacher will help students achieve the outcomes prioritised in the focusing inquiry. Part 2 focuses teachers on planning the intended teaching strategies and the specific classroom activities and tasks.

Part 1 of the planning template (Focusing inquiry)

Part 1 for technology is shown in Figure 1.

Figure 1. Technology planning template: Part 1, learning outcomes plan

Main task:	Technological area/s:	Level: 1 2 3 4 Year:
Integrated dimensions of technology: •…… •…… •……		

Conceptual learning outcomes (Technological Knowledge)	Procedural and technical learning outcomes (Technological Practice)	Societal learning outcomes (Nature of Technology)
•……. •……. •…….	•……. •……. •…….	•……. •……. •…….
Assessment:		

The science planning template is broadly similar, but the headings relate to teaching science knowledge and practices. Part 1 for science is shown in Figure 2.

Figure 2. Science planning template: Part 1, learning outcomes plan

Main idea:	Science strand:	Level: 1 2 3 4 Year:	
Overarching learning outcomes: • ……. • ……. • …….			

Conceptual learning outcomes (Scientific knowledge and understanding)	Procedural learning outcomes (Scientific practice)	Nature of Science learning outcomes	Technical learning outcomes (Scientific practice)
• ……. • ……. • ……	• ……. • ……. • …….	• ……. • ……. • …….	• ……. • ……. • …….
Assessment:			

Figure 3 describes and illustrates examples of the Part 1 technology planning template.

Figure 3. Description of the technology planning template: Part 1, learning outcomes plan

Main task:	Technological area/s:
What is this? It is the overall technology task the students will undertake and can be creating a model, product or system. It is specific enough that informed, critical thinking and practices can be encouraged. But it is also open enough that creative and innovative thinking and practices can be developed. For example: • design ergonomically appropriate clothing • use an efficient batch production process to make healthy snacks.	*What are these?* They are the area or areas that the main task is nested within. Specifying the technological areas/s (see Ministry of Education, 2007, p. 32) helps to focus the task on particular knowledge and skills in that area/s. For example: structural; control; food; information and communications; biotechnology; materials.

Integrated dimensions of technology:

What are these? These are the "big ideas" and "broad practices" that are derived from and related to the main task. They show technology as a holistic practice where ideas and skills come together so that the main task can be accomplished. These are usually broad statements covering Technological Knowledge, Practice and Nature of Technology and/or societal outcomes.

Example 1. In creating a healthy snack using a production line, students will integrate:

• understandings about how a batch production line works and the specifications for creating healthy snacks (*Technological Knowledge*)
• design, production and evaluation of a healthy snack using batch production techniques (*Technological Practice*)
• justification of how their healthy snack meets consumer needs (*Technology and society*).

Example 2. In designing and making fridge magnets, students will integrate:

• understandings of the various purposes/functions and features of fridge magnets (*Technological Knowledge*)
• design, construction and evaluation of a fridge magnet, taking into account criteria identified (*Technological Practice*)
• justification of how the magnet appeals to a specific consumer group (*Technology and society*).

Conceptual learning outcomes	Procedural and technical learning outcomes	Societal learning outcomes
What are these? These are the specific technological knowledge learning outcomes derived from the big ideas; the detailed concepts or ideas that students will need to know and understand to help them accomplish the main task. For example: Students will understand: • the characteristics of a 'snack' (small size, ingredients/materials, in between meals, not a main meal) • that a production line system is a way of making lots of the same thing quickly. It works by keeping things moving along the line, with something new happening at each stage • that interview schedules, surveys and open questioning are methods of collecting information • that optimisation is a way of maximising material use and minimising waste • the concept of feedback in general and in electronic circuits.	*What are these?* These are the specific technological practice learning outcomes derived from the big ideas. They detail the processes, procedures and technical skills that students will need to know and use when undertaking the main task. They include the strategies for how and when they might undertake the processes, procedures and skills to help them accomplish the main task. For example: Students will be able to: • design and conduct a class survey about which cereals are preferred and why and critique favourites against the food pyramid • identify improvements, including ways that might reduce downtime • set and apply quality standards— fastening must be workable; mask must be flexible; mask must be the right size and fit • select and use tools and/or materials as appropriate for model bridge building.	*What are these?* These are the specific ideas related to understanding and considering the implications of the Nature of Technology and any specific aspects derived from the big ideas related to the interrelationship between people and the technology/ies that are important for students accomplishing the main task. For example: Students will be able to understand: • that aesthetic considerations sometimes give way to cost consideration, and be able to take this into account • that different people respond to different features of cereal packaging; for example, nutritional information, aesthetics, contents • the nature and development of electronic technology in the past, present and future • how traditional Māori food-preservation techniques affected people's lives • that people use music and instruments for enjoyment.

Assessment:

For example: peer assessment using agreed specifications, portfolio

Figure 4 describes and illustrates examples of the Part 1 science planning template.

Figure 4. Description of the science planning template: Part 1, learning outcomes plan

Main idea:

What is this? It is the big science idea for students to understand.

For example:

- Sound is comprised of waves.

- Fossils provide clues to the past.

- Moulds are a type of fungus and are living.

Overarching learning outcomes:

What are these? These are derived from and relate to the main idea, teased out in more detail. They show science as a holistic practice where ideas and skills come together so that the main idea can be understood. These are usually broad statements covering scientific knowledge, practice and Nature of Science outcomes.

Example 1. In building understandings about sound, students will integrate:

- understandings that properties of sound relate to the manner in which sound waves travel through a substance (*Scientific knowledge*)

- an investigation into how musical instruments generate sound waves (*Scientific practice*)

- understandings that scientific knowledge can be used to help people (*Nature of Science*).

Example 2. In building understandings about adaptation, students will integrate:

- understandings about how the features of an animal living on the rocky shore have allowed it to adapt to its particular habitat (*Scientific knowledge*)

- an investigation of how a local ecosystem fosters the interdependence of living organisms, including humans, and their relationship with their physical environment (*Scientific practice*)

- understanding that the nature of experimentation can include making predictions, observing, recording results and drawing conclusions (*Nature of Science*).

Conceptual learning outcomes	Procedural learning outcomes	Nature of Science learning outcomes	Technical learning outcomes
What are these? These are more specific learning outcomes focused on knowledge and understanding of relevant scientific concepts and procedures. For example: Students will understand that: • mould colonies reproduce and grow where the conditions meet their needs • beach ecosystems are a balance of living and nonliving elements, which interact with each other • sound travels as a wave, producing vibrations.	*What are these?* These are more specific learning outcomes focused on the strategic application of procedures and processes, such as those used in science investigations. For example: Students will be able to: • classify living things • generate and identify questions that are suitable for an investigation • confidently make predictions about direction of movement • carry out a procedure by following a sequence of simple steps • record results appropriately.	*What are these?* These are more specific learning outcomes related to, for example, what counts as evidence, and methods appropriate for the communication of scientific ideas. For example: Students will understand and appreciate that scientists: • make categories so they can understand what they see • make predictions then test them • use observation and describe what they see • change their ideas over time as they find and make sense of new fossil discoveries.	*What are these?* These are more specific learning outcomes related to practical techniques and equipment use. For example: Students will be able to: • label observational drawings • label test equipment • develop technical skills for cutting, threading, knotting • connect components of a circuit to make a working circuit.

Assessment:

For example: poster, investigation report, before and after views, short test

For both science and technology, Part 1 of the planning template is used to help identify the possible learning outcomes. Completing Part 1 helps the teachers to identify, clarify and phrase the learning outcomes in a manner that will fit their students.

In technology, after teachers define the main task and the associated technological area/s they wish to focus on, they write the broad overall integrated dimensions of technology showing the big ideas and broad practices inherent in the main task. Then they unpack these integrated dimensions into even more detail as specific learning outcomes.

In science, after teachers define the main idea they wish to focus on, they write the overarching science learning outcomes, showing a breakdown of the big idea and broad practices inherent in the main task. Then they unpack these overarching learning outcomes into even more detail as specific learning outcomes. The specific design of this framework compels the teachers to consider all categories, resulting in a broadening of the range of possible science learning outcomes and the articulation of specific science ideas.

It is like they are peeling an onion and progressively drilling down to a finer grained layer as each piece is stripped off. And yet each layer is related to the next and to the whole.

When teachers complete Part 1 of the planning template, they have to keep the main task in mind to make sure that the overall dimensions of technological practice—or overarching science learning outcomes—and the specific learning outcomes are coherent, connected and consistent. As they flesh out Part 1 of the plan, they think about how the concepts/ideas and skills could come together.

Planning with this template helps teachers think about the ideas and skills they wish their students to learn and to move away from only planning activities for their students to work through. A more balanced programme of science or technology results as teachers develop their PCK and became aware of a much broader scope of science and technology learning. They include Technological Knowledge and Nature of Technology aspects as much as Technological Practice aspects—or, in science, scientific practice and Nature of Science aspects as much as science knowledge aspects. They detail the science or technology learning they are aiming for. Instead of "What will students do?" the objective becomes "What will students learn?"

A closer look at technology planning: Part 1, learning outcomes plan

A closer look at some completed planning from the InSiTE project exemplifies how InSiTE teachers attended to planning technology ideas and skills rather than only planning a technology activity. Jenny planned a percussion-instrument-making unit for her Years 2–3 students. Because her students were going to be in a school musical production, there was an authentic rationale for creating percussion instruments. As well, the students were studying dairy farming in social studies, so

Breaking down and detailing of the learning outcomes in this manner helps teachers know and define science and technology as multidimensional activities. They are articulating them as practical and intellectual pursuits. It helps teachers see where they have gaps in their learning outcomes, and so forces them to find out what could best fill the gaps. Recording specific learning outcomes in each of the integrated dimensions (or, in science, overarching learning outcomes) helps them articulate in more detail the concepts/ideas and practical skills underpinning the main task or idea.

Though science and technology are multidimensional (hence the variety of learning outcomes), they are also holistic. Knowledge and skills are learnt in context and are linked. To develop products and systems or understand science ideas, practical and intellectual resources need to be used together, not individually or separately. The dilemma for teachers is that they need to know what the individual learning outcomes are but also need to be able to bring them together and see them in unity.

Jenny decided to use the farm visit for students to gather material to make their instruments. She wanted to make connections to the land and environment. A further aim of developing her students' environmental consciousness led to Jenny deciding to focus on using found/recycled materials, and she hoped they would be enterprising and resourceful in using what they found. They had also just undertaken a sound unit in science, and these understandings would be key to students knowing how to produce sound-making instruments.

The main task was therefore defined as "Make a percussion instrument from found/recycled materials for our school production" and aimed to develop her students' ideas about and practices related to materials and structures. Here is her Part 1 planning (Figure 5).

< Jenny made use of the connections that existed in her science, social studies and technology teaching. She was making connections to student prior learning and experience. Students learn best when they are able to integrate new learning with what they already understand. Jenny was maximising the use of her students' learning time by making these connections.

Figure 5. Jenny's technology planning: Part 1, learning outcomes plan

Main task: Make a percussion instrument from found/recycled materials for our school production	Technological area/s: Materials, structures	Level: 1 2 3 4 Year: 2–3
Integrated dimensions of technology: Students will: • develop an understanding of appropriate materials and structures that make different sounds in a percussion instrument *(Technological Knowledge)* • design and produce, according to a plan, a percussion instrument using recycled materials *(Technological Practice)* • know that people use instruments for a variety of purposes *(Nature of Technology, Technology and society)*.		

Conceptual learning outcomes *(Technological Knowledge)*
 	
Students will understand:
 	
• how percussion instruments (membranophones and idiophones) are constructed and work
 	
• that materials used to make membranophones and idiophones need specific properties
 	
• that membranophones and idiophones work well when constructed in such a way that they resonate
 	
• that conceptual drawings can show general ideas and/or finished products
 	
• that drawings can be used in action plans to show the proposed artefact, materials and construction methods
 	
• that action plans can identify materials and construction steps.
	Procedural and technical learning outcomes *(Technological Practice)*
	
	Students will be able to:
	
	• research and examine different percussion instruments to identify requirements of design and materials used
	
	• examine other musical instruments to generate ideas
	
	• examine and test appropriate materials for membranophones and idiophones to generate ideas
	
	• establish the specifications for creating membranophone and idiophone instruments
	
	• develop an action plan that identifies how to meet the specifications of the brief:
	  • recycled materials that will be used
	  • structure of the design
	  • methods of construction
	  • construction steps
	  • 2-D drawing of proposed membranophone or idiophone
	• construct a membranophone or idiophone with reference to design brief and action plan
	• develop 2-D drawing skills with annotations; for example, labelling
	• develop technical skills for cutting, gluing, punching, joining, folding, lacing and tying.
		Societal learning outcomes *(Nature of Technology, Technology and society)*
		
		Students will understand that:
		
		• people use music and instruments for enjoyment, work and sharing information.

Assessment: Peer and self-assessment of plans, drawings and photo of the finished instrument, assessed using negotiated criteria		

Jenny also specified the resources her students would need to undertake the task and the aspects for assessment.

What can we see from Jenny's Part 1 plan? We can see that:

1. She defined the main task to provide an overall direction for learning: "Make a percussion instrument from found/recycled materials."

2. She broke down the main task into three broad integrated dimensions of technological practice to identify the big ideas and broad procedures in general terms:

    •   develop an understanding of appropriate materials and structures that make different sounds in a percussion instrument
    •   design and produce, according to a plan, a percussion instrument using recycled materials
    •   know that people use instruments for a variety of purposes.

3. She broke the integrated dimensions into component parts and specified conceptual, procedural, societal and technical learning outcomes.

4. She defined the technology learning in detail and with precision.

5. She focused on the key ideas and skills of the percussion-instrument-making technology that she wanted her students to learn.

6. She specified the materials for the task.

7. She articulated assessment (peer and self-assessment, photo of finished instrument, plans and drawings) and focuses (the criteria).

These learning outcomes **>** were especially written for her Years 4–5 students and therefore show her PCK. For example, she defines drawings in ways that her students can understand—"conceptual drawings can show general ideas and/or finished products".

☞ Questions for you

•   Having read through this example, can you see any advantages or disadvantages in fully itemising the specific knowledge and skills you wish to target when you plan your next technology unit?

•   If there are aspects of technological knowledge and practice for this unit that you are unsure of, is there a colleague who could help you?

•   How would you adjust these learning outcomes so that your students would best be able to understand and accomplish them?

☞ What could you do?

•   Take a teaching plan that you have already used and think about how you could use the insights you gained about the learning outcomes and their suitability to adapt the plan for your current students.

A closer look at science planning: Part 1, learning outcomes plan

Figure 6 is an example of Part 1 science planning developed by Lois for her Years 1–3 students. Her main idea was that fossils provide clues to the past. When she was planning her learning focus, she had to think about her students and what was appropriate for them. She knew there were fossils in the local area and that many of her students had read in the paper that a child of their age had found a large fossil at a local beach. She used their curiosity about this event as a springboard to enhance the relevance of this unit. When Lois was planning, she identified specific learning outcomes in the different categories, identified what she needed to know to teach and identified any gaps in her own knowledge. To

help her close her knowledge gaps, she did further reading, talked with other teachers and consulted the research team about the development of scientific thinking around paleontology.

Figure 6. Lois' science planning: Part 1, learning outcomes plan

Main idea: Investigate how fossils provide clues to the past.	**Science strand:** Planet Earth and Beyond	Level: 1 2 3 4 Year: 1–3

Overarching learning outcomes:

Students will integrate:

- understanding that fossils provide a record of previous life and living conditions on Earth and can only form under certain conditions (*Science knowledge*)
- planning and carrying out an investigation related to fossils (*Science practice*)
- understanding that scientists' ideas may be modified over time as they access new evidence (*Nature of Science*).

Conceptual learning outcomes	Procedural learning outcomes	Nature of Science learning outcomes	Technical learning outcomes
Students will understand that: • fossils are the remains of living things or traces of their activities • fossils give us information about the conditions at the time when they were formed • fossils are usually found in rocks • the formation of fossils is a constant natural process.	Students will be able to: • undertake detailed scientific observations through focused examination coupled with discussions, drawing and writing • develop questions appropriate for a scientific investigation • gather information through undertaking observations and conducting experiments.	Students will understand and appreciate that: • scientists discover and study ancient fossils to find out about living things that were on Earth in the past • scientists' ideas change over time as they find and make sense of new fossil discoveries.	Students will: • develop careful excavation skills • be able to follow conventions for scientific drawings.

Management/materials:

Resource—Quinn, P. (2003). *Fossils: Digging up the past*. Wellington: Learning Media (BSC 41)

Artefacts—Fossils, pictures, photographs, newspaper articles, video clips, field trip (Kawhia)

Assessment:

Assessment task—Picture sequence of fossilisation with verbal/written explanation

What can we see in Lois' Part 1 plan?

1. To provide an overall direction for learning, she defined the main idea ("Investigate how fossils provide clues to the past") and the science strand (Planet Earth and Beyond).

2. To identify the big ideas and broad procedures in general terms, she broke down the main idea into three broad overarching learning outcomes:

   - Fossils provide a record of previous life and living conditions on Earth and can only form under certain conditions.
   - Plan and carry out an investigation related to fossils.
   - Scientists' ideas may be modified over time as they access new evidence.

3. She broke the overarching learning outcomes into component parts and specified scientific conceptual, procedural, Nature of Science and technical learning outcomes.

4. She defined the science learning in detail and with precision.

These learning outcomes were especially written for her Years 1–3 students and therefore show her PCK. For example, she defines fossils
< in ways that her students can understand—"Fossils are the remains of living things or traces of their activities."

5. She focused on the key ideas and skills of the fossil investigation that she wanted her students to learn.

6. She accounted for her expectations of what her students could achieve and what she believed they already knew.

7. Her planning shows the connectedness of the science ideas, as well as the way in which scientists work.

8. She specified the resources for the unit, including a book and several artefacts that she would use throughout the unit (fossils, pictures, photographs, newspaper articles, video clips, field trip to Kawhia).

9. She articulated an end-point assessment ("Picture sequence of fossilisation with a verbal/written explanation").

👉 Questions for you

Thinking about your experiences of teaching science, what do you see as the advantages and disadvantages of specifying a main idea and its contributing ideas and practices?

How have you incorporated/how might you incorporate a specific focus on the nature of science and how scientists work in your planning?

👉 What could you do?

Can you take more advantage of local events as a basis for developing a science unit relevant to your students' interests and needs?

Part 2 of the planning template (Teaching inquiry)

Part 2 of the planning template (Figures 7 and 8) helps teachers plan the appropriate pedagogical approaches and strategies that will help students learn the ideas and skills specified in Part 1. Completing Part 2 focuses the teacher on planning learning opportunities aimed at achieving the outcomes they have prioritised.

Figure 7 shows Part 2 of the technology planning template.

Figure 7. Technology planning template: Part 2, lesson plan

	Subtasks		Resources/focal artefacts	Planned interactions	Key student outcomes
	Meso	Micro			
Main task					

The science planning template is almost identical.

Figure 8. Science planning template: Part 2, lesson plan

Main idea	Subtasks		Resources/focal artefacts	Planned interactions	Key student outcomes
	Meso	Micro			

There are spaces to record:

• a sequence of subtasks that contribute towards achieving the main task

• the resources required for each subtask

• the interaction focus for each subtask

• the possible student outcomes and responses.

Why these categories?

Planning the nested subtasks helps teachers:

• articulate the ways the students might achieve the main task and work towards the intended learning outcomes, including how the teachers will create a supportive learning environment

• organise the subtasks in a nested and interrelated manner to make connections to prior learning and experience, and to make connections between days and ideas

• organise each subtask so that it builds on and develops the previous activity, to ensure that each activity can deepen student understandings of the elements that came before it

• think about how to connect the various subtasks in a coherent manner to help students learn particular science or technology ideas and skills.

The planning and making of resources or focal artefacts helps teachers:

• provide structure for lessons

• think about ways to focus student attention on particular aspects and enhance the relevance of new learning

• think about ways to introduce and develop student ideas and skills, especially ways to encourage reflective thought and actions.

Expressing the interaction focus for each subtask helps teachers:

• plan what they might interact with their students about

• think about what they might say when they introduce and work through the various subtasks

• plan the social configurations (individual, group, class) for enhancing learning opportunities

• plan ways to facilitate shared learning.

Planning the possible student responses and outcomes helps teachers:

• run through how their students might respond before they begin their teaching

• go over what their students might do

• think about where their students might have difficulties and/or strengths and plan what they might do in response.

When teachers complete Part 2 of the planning template, they work backwards and forwards between outlining the subtasks, the resources/focal artefacts, the interaction focus and the student responses and outcomes. As they plan each aspect, they think of the impact on learning and adjust their pedagogical approach accordingly. They continually refer to Part 1 to make sure everything is being covered and that there are strong connections between the learning they are aiming for and the ways to get there. The main idea or task is included on both parts to provide an anchor between the two and to help the teacher keep focused on the overall direction for learning.

A closer look at technology planning: Part 2, lesson plan

As an example, a segment of Jenny's Part 2 lesson outline is shown in Figure 10. It details the first three of the nine technology teaching subtasks she planned for her Years 4–5 class for the task of designing and making percussion instruments from materials found on the farm. Each lesson was unpacked into the subtasks of meso and micro tasks. Figure 9 shows three lessons and their division, the resources/focal artefacts, the planned interaction focuses and the key student responses and outcomes.

Figure 9. Jenny's technology planning: Part 2, lesson plan

	Subtasks		Resources/focal artefacts	Planned interactions	Key student outcomes
Main task: Plan, design and construct a percussion instrument from materials used on the farm.	**Meso**	**Micro**			
	1: Introduce what musical instruments are.	1.1 Recap how instruments make sound.	• Range of instruments • Pictures	• Class and group brainstorming to share prior knowledge.	Students' knowledge about sound is confirmed.
		1.2 Recall, discuss and explore why instruments are used.	• People—DJ, musician • CD player, CDs	• Class discussion and sharing of ideas about favourite music.	Students know that instruments play a role in society in entertainment and work.
	2: Investigate different materials used to make percussion instruments.	2.1 Compare different materials and how they make sound.	• String instruments • Metal instruments • Shakers • Worksheet	• Discussion in groups with one instrument: record sounds on worksheet and then share with class.	Students know that specific instruments make different sounds.
		2.2 Compare the same instruments made from different materials.	• Common instruments • Comparison worksheet	• Partner discussion using worksheet and share back with class.	
	3: Identify the features of a percussion instrument.	3.1 Compare and label features of selected instruments.	• Worksheet: features, similarities, how they are used • Instrument pictures	• Discussion in groups with worksheet: share and justify choices. • Discussion about why that feature makes that sound.	Students know what features are needed in order for their instrument to make sound.

What can we see?

- The division of the main task into meso and micro tasks helped Jenny to use her PCK to structure lessons so that links between lessons and within tasks were promoted, and students could make connections between tasks, ideas and lessons.

- The matching of resources/focal artefacts to the meso and micro tasks helped her plan how to provide structure for her lessons and how to focus student attention and develop their ideas and skills. For example, the comparison worksheet for micro task 2.2 focused students on particular percussion instrument characteristics. Jenny's use of tailored worksheets shows she knew how to help her students translate thought into action.

- The detailing of the planned interaction focuses helped Jenny think about how she wanted her students to work together in shared activities and conversations and in a supportive manner.

- The recording of possible outcomes shows Jenny was thinking about what her students might learn. She was anticipating the success of her teaching and thinking about student learning.

- The articulation and linking between the tasks, resources/focal artefacts, interactions and key responses/outcomes shows how Jenny thought she would teach her students what she knew about percussion instruments in ways that were learnable. For example, she planned for the students to examine real percussion instruments to help them work out the essential features before they designed their own percussion instruments. This meso task would help students critically evaluate the instruments to develop pertinent percussion instrument knowledge that they could apply to their own designs.

A closer look at science planning: Part 2, lesson plan

As an example, a segment of Lois' Part 2 lesson outline is shown in Figure 10. It details the first three of the six science teaching subtasks she planned for her Years 1–3 class for the fossils unit. Each lesson was unpacked into meso and micro subtasks. Figure 10 shows three lessons and their division, the resources/ focal artefacts, the planned interaction focuses and the key student responses and outcomes.

Figure 10. Lois' science planning: Part 2, lesson plan

Subtasks		Resources/focal artefacts	Planned interactions	Key student outcomes
Meso tasks	**Micro tasks**			
Day 1: Explore understandings of fossils.	1.1 Focusing activity: Show a fossil and provide time to investigate.	• Fossils	• Group investigation of fossils	Students can explore and tell what they already know about fossils.
	1.2 Generate brainstorm— where could it come from? What is it called? What would you like to find out about this?	• Mind-mapping sheet		
	1.3 Share group brainstorming and collate as a class.			
Day 2: Investigate what fossils are and that they were once living things.	2.1 What are fossils and where are they found? pg. 9	• Pictures • Fossils	• Teacher questions: - What was this fossil? - Where do you think it was found?	Students can describe characteristics of a fossil—once living or once part of a living thing.
	2.2 Gather ideas about what all fossils have in common.			
Day 3: Investigate how fossils are formed.	3.1 Looking at leaf fossils, pg. 10.	• Rotting leaves • Fossilised leaf	• Discussion: make predictions and compare rotting leaves and fossilised leaves.	Students show they understand that: • fossils only form under very defined circumstances • for something to become a fossil it has to be a long way down under the ground.
	3.2 Look at a shell fossil—sand tube with heavy toy at bottom, gradually cover with sand— represent layering of fossil.	• Fossilised shell, pg. 11	• Teacher question: How did the shell fossil become like this?	
	3.3 Making fossils, pg. 11.			

Main idea: Investigate how fossils provide clues to the past.

What can we see?

- The division of the main task into meso and micro tasks helped Lois to use her PCK to structure lessons so that links between lessons and within tasks were promoted and students could make connections between tasks, ideas and lessons.

- The meso tasks are written using vocabulary at an appropriate level for young students. This indicates that Lois knows that she needs to transform her understanding of the concepts into forms that are learnable for her students.

- The matching of resources/focal artefacts to the meso and micro tasks helped her plan how to provide structure for her lessons, how to focus student attention and develop their ideas and skills. For example, she planned an examination of fossil pictures and real fossils as a means for her young students to develop beginning concepts about fossil characteristics, such as having once been living or part of a living thing.

- The detailing of the planned interaction focuses helped Lois think about how she wanted her students to work together in shared activities and conversations and in a supportive manner.

- The recording of possible outcomes shows Lois was thinking about what her students might learn. She was anticipating how her teaching would impact on student learning.

- The articulation and linking between the tasks, resources/focal artefacts, interactions and key responses/outcomes shows how Lois thought she would teach her students what she knew about fossils in ways her students could learn. For example, she planned for the students to examine real fossils to help them know what a fossil was. This meso task would help students investigate fossils to develop pertinent fossil knowledge that they could use to later identify fossils in situ.

👉 Questions for you

- Thinking back on your previous technology teaching, can you recall any occasion where your selection of artefacts impacted on teaching and learning in a positive way? What were the characteristics of the artefacts you used?

- In your planning for science, do you do anything that is the equivalent of identifying a main idea with related meso and micro ideas that you link to what the students might already know about this? If yes, what do you see as the benefits? If no, having read Lois' plan, what might you gain from working in a similar way?

👉 What could you do?

- You might like to choose three or four recent lesson plans and review the extent to which a) the sequence of tasks built on and developed the previous activity; and b) your students developed their learning as a result of the activities. You could then compare your planning with that of a colleague, examining the similarities and differences.

- When you plan your lessons you might like to identify areas of likely difficulty in advance. It can be helpful to discuss with colleagues the ideas and practices they have found students find difficult and the sorts of actions that they have taken to meet these challenges. This is an effective and efficient way of building PCK in a collegial manner. You might like to construct a table with common student misconceptions in one column and the accepted technological explanation in the other so that you know where these areas are likely to occur when you are planning your lesson. You could then spend more time on those areas, particularly probing the ideas students bring to your lessons and why they believe them.

- You might like to examine your recent planning and review how you use different groupings of students (whole class, small group, pair, individual). How important do you think it is to retain the same combinations and ways of working? What is the impact on student engagement of how you manage the transition between different groupings? Are these aspects something you could experiment with, possibly using a colleague as an observer?

Impact of using the planning templates

Overall the InSiTE teachers' science or technology planning using the Part 1 and Part 2 planning templates showed a shift from a previous focus on broad achievement objects in the curriculum to a focus on specific scientific or technological knowledge and skills. As well, throughout their teaching, and after their teaching, they reflected on what was happening in their classrooms and what was happening with their students' learning. They undertook an inquiry of their teaching and student learning. They became discerning practitioners and their ongoing practice and reflection impacted on the development of their PCK.

Detail is important

The two-part planning framework helped our teachers identify the science and technology ideas and skills appropriate for their students, the knowledge they needed in order to teach and the appropriate pedagogical approaches for teaching the ideas and skills. By working with the two parts of the planning framework, the teachers developed and refined their PCK prior to, and in preparation for, teaching in the classroom:

> My in-depth planning in technology produced the best teaching I've done all year. If I went in that depth for everything, my teaching would be better. It helps me know exactly where we're going, what to do and what questions to ask. (Jenny)

The teachers were very positive about working with the planning framework and commented on its usefulness for developing their PCK:

> It has helped with developing personal insight into the steps I need to take to teach science and technology. (Jo)

> It focused me on the learning outcomes, helped me clarify my understandings of the topic and put it into suitable child-speak. (Brenda)

A focus on science and technology ideas

Teachers commented on the advantage to their teaching when their planning was focused on specific science and technology ideas. They deliberately chose activities that would be most likely to develop student understandings and skills. They were careful to locate and define tasks within students' prior knowledge and experience as they saw it. Planning this way helped engage and maintain student focus and interest:

> This helped get the objectives of the lesson across to the class in a systematic yet interesting way, and so that the children are focused and interested. (Glenda)

Because teachers were clear about the science and technology ideas in their units, they became more certain they could tease out the relevant science and technology ideas and principles with their students:

> I knew what I wanted the students to learn and was able to focus the discussion around the growth and reproduction of moulds. (Tayla)

Some concepts need to be deliberately taught, or brought to children's attention. You need to know what you want your children to know. Yes, it made me clarify what exactly were the technology ideas, so that I was better able to help the children. (Lois)

Being open to change

Although the teachers reported several gains by planning in this subject-specific way, this detailing did not restrict what they did in classrooms. Throughout the actual lesson sequence, the teachers modified and refined tasks and activities to take account of the ways the students were responding to them. The teachers remained open to making changes in the light of the progress their students were making:

With this planning I feel quite prepared, but I changed direction to suit children's needs and I might then present ideas differently than planned to establish learning. (Jo)

Having clear learning pathways helps me to predict possible pitfalls. But other incidental teaching may occur once you step into the classroom. (Glenda)

Rehearsing before teaching

The teachers saw that if they rehearsed some of the tasks before they began teaching, they developed their PCK. These dry runs enabled them to explore the knowledge, understandings and skills most salient to the tasks, to assess the appropriateness of the tasks for their students and to foreshadow potential problems. Teachers became more aware of the demands of the tasks, both conceptually and technically:

It was good that I tried out how to make cheese at home before I had the children try this. I found how long it would take and I thought about easier ways they could do it. (Brenda)

Advantages of planning the interrelated tasks and focal artefacts

Teachers noted the advantages of outlining the interrelated main and sub (meso and micro) tasks, and the usefulness of specifying and designing the focal artefacts alongside the corresponding tasks:

Planning with main/meso/micro tasks and the focal artefact helps focus teaching and learning into bite-sized chunks for both the teacher and the students. (Grant)

They commented on the value of selecting and preparing specific focal artefacts/resources designed to focus student attention, to build on student experiences and interests and to develop learning (Figures 11 and 12). Focal artefacts were not added as an aside or afterthought.

I could not have taught without the focal artefacts. The children needed them as well, as a group and independently, to help them with their learning. (Jo)

My teaching was helped with the focal artefacts. It would have been very hard to describe what was required. The artefacts created the focus for all the lessons. (Glenda)

Figure 11. Examining a tong to learn its features

Figure 12. Working as a group and focusing on the worksheet questions

Impact on interactions

Teachers commented on the benefits of planning for interactions before teaching, including thinking about the sorts of responses their students might make. Such forethought meant that they could optimise learning within their assessment-for-learning interactions with students. They were able to carefully think through the language they might use and the questions they might ask:

> It made me think about the correct terminology to use, that I then expected the children to use. (Carol)

> It was helpful to think about what to ask for each time. I knew where to go and I had thought about how my students might respond. (Tayla)

> Thinking about the possible interactions made me think through each stage thoroughly instead of always having to think on my toes, which can often mean missing good opportunities, or not choosing the best way to do something. (Jenny)

Teachers talked about having more confidence in their interactions. Their confidence that they had the requisite PCK proved crucial to teachers being willing

to engage in effective classroom interactions with students. They were confident they could respond constructively to students' growing understandings. Teachers deliberately planned to interact with students and question them about what they were learning, with the intention of enhancing their learning:

> My questions got them to think about things, their ideas, so they could change them on the way. They could improve while they were going. (Tayla)

> Previously I would have thought that just getting an answer from them was OK, now I challenge them in their actual understanding. (Jenny)

They believed that because of their detailed and focused planning, their interactions were more focused and purposeful and their students were more aware of what was to be learnt:

> When I was teaching I could see the benefit of having a clear outline of what I wanted to achieve. It stopped me from going off the point and the children from doing the same. (Lois)

> Lots of discussion to clarify the task helped develop common goals. It is important to develop vocabulary so that all children have an understanding that they can achieve. (Glenda)

Plans were a memory aid in the classroom

Teachers talked about how they used their plans as a memory aid and support while they were teaching. They often had their plan beside them for reference (Figure 13):

> I used the plan throughout the unit. It ensured I didn't miss any important teaching points or stages and I felt comfortable knowing that I could refer to it for confirmation of terms and procedures. (Brenda)

> I often had the plan beside me when I was teaching. I used it a lot. It clearly marked where I wanted to take the children with their learning and what I would need to get them there. (Lois)

Figure 13. Lois with her teaching plan at the ready on the table behind the student

Impact on student learning

Teacher descriptions of student learning were concise and clearly linked to their intended learning outcomes. They were "amazed" at the development in their students' understandings, skills and attitudes:

> I was amazed. At first the students had no idea about the parts or reproduction of moulds. At the end every student had a clear understanding and could talk and represent their ideas. (Tayla)

> Overall the unit was a success. For the children this was their first introduction to food technology. All the children have learnt about prototypes and production lines and they know how to formulate their own prototypes and production lines. (Lois)

Working together impacted on teacher knowledge

When the teachers planned with the planning framework, the framework structured and supported in-depth collaborative discussion and analysis of what might be required to teach and learn a particular science idea and a particular technology task. Planning together (Figure 14) proved to be a successful strategy for fostering dialogue about the PCK required for teaching a particular science or technology topic:

Figure 14. Planning together

> Planning together meant our units were more thought through, so therefore it was better for the students. (Jenny)

> The time to plan at the workshops, and having everyone at the meetings as resource people, were great. (Brenda)

> It has been great to discuss issues with other teaching professionals who are interested in science and technology. I have gained a lot of confidence in teaching science and technology. My teaching, interactions and planning are more purposeful. I can see the bigger picture of these two subjects as not just being an extra to the core curriculum, but an integral part of children's learning. (Lois)

Comparing student work impacted on teacher knowledge

The teachers shared student work that was produced during the units. When they analysed and discussed student work, they were able to think of their own students and where they fitted. They made comparisons between the different portfolios and this helped them think about where their own students might go next and/or what they may have done as younger students. Examining the range of student work helped teachers imagine science and technology learning journeys for their students. Teachers could also see the detail of student learning, including the science and technology ideas inherent in the work. They discussed

how the ideas were developed in the classrooms and learnt about the pedagogical approaches that worked well and why (Figure 15). Examining and discussing student work became important for developing teachers' PCK.

Figure 15. Examining student work

Benefits outweighed the negatives

Considerable skill and knowledge are required for planning in this way, and teachers require time and support to understand how to plan like this. Despite the amount of time and support needed, our teachers believed the benefits of planning in this detailed manner outweighed any negative aspects. Several teachers found the planning frameworks so worthwhile that they had introduced them to their colleagues:

> The planning frameworks have helped me with my thinking. I think they are very worthwhile so I have introduced them to two teachers in my team, and they are using them for their teaching of science. (Carol)

Their colleagues also found that the two-part planning framework helped them hone in on the specific ideas and skills they wanted their students to learn:

> I've used the planning frameworks as scaffolds with my team. They helped them to understand the ideas in their science teaching. Before they wanted to only plan activities. The teachers changed in their planning from focusing only on the activity to focusing on the science ideas, such as germination in plants. (Tayla)

👉 Questions for you

• Would you find it useful to get together with some colleagues and use the planning frameworks to plan a common unit in science or technology? What ideas might you focus on? What activities do you already know that help students learn these ideas effectively? How would working with others help you develop your knowedge for teaching?

- Would you find it useful to get together with your colleagues after teaching science or technology and examine student work from different classes? What are the commonalities and differences? How could you use this information—for your class, for another class, for a particular child, for your syndicate, for your school, at all? What did you learn from looking at a variety of student work?

- Would you find it useful to have a slice of your interactions with students taped and/or videoed by a colleague to see how you promote student understanding of specific science and technology ideas and skills?

👉 What could you do?

- You could work out the ideas and skills you wish to focus on for a science or a technology unit. Then you could change the language of these ideas and skills so that they better match your students' comprehension levels. After teaching each lesson, you could reflect on how effective your teaching was using these translated ideas and skills.

- You could deliberately use some teaching time to talk with students about the connections between this lesson, what happened in the previous lesson and what is to happen in the following lesson. You could then conference with some individual students, or groups of students, to see if this was a useful strategy for helping them make connections between ideas, lessons and days.

- You could have a colleague observe your teaching to see how you promote specialist science and technology language in your student interactions and to what extent this language is then used by students.

- You could have a colleague examine your resources, including your student worksheets, to critique their usefulness for building on student learning, focusing attention and/or developing specific ideas and/or skills.

Example of a full technology plan

A technology unit for Years 4/5 students about designing and creating a lunch box to reduce waste. It focuses on materials technology and structural technology.

Figure 16. Gail's technology planning: Part 1, learning plan

Main task: Design and create a lunch box that will reduce waste.	**Technology areas:** Materials, structures	Level: 1 2 3 4 Year: 4/5
Integrated dimensions of technology: In developing a lunch box, students will: • understand the relationship between lunch-box functionality and materials to keep food fresh and reduce waste • create a user-friendly lunch box that overcomes the problem of having to wrap contents yet maintains food freshness • understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures.		

Conceptual learning outcomes	**Procedural and technical learning outcomes**	**Societal learning outcomes**
Students will understand: • key attributes of lunch boxes (containers/cases that may have compartments, handles [portable], clasps and seals; made of waterproof/durable materials [may be plastic/insulated vinyl—lightweight]; some require food to be wrapped; aesthetically pleasing [child-likable designs]) • that, as an Enviroschool, we want to find ways to reduce lunch-box waste • that design drawings can guide the making of artefacts, clarify ideas and identify materials, shape and size • that working plans link to "making" and that when "making" ideas may change.	*Procedural:* Students will be able to: • identify attributes of lunch boxes through a product analysis • discuss and develop criteria for designing a lunch box that will reduce waste • draw 2-D and 3-D annotated plans that show the key attributes of a lunch box to reduce waste • create and adapt 2-D and 3-D drawings to make lunch boxes from a selection of given materials, with reference to plans • evaluate lunch boxes against the agreed criteria. *Technical*: Students will be able to: • measure accurately • create graphs • use safe manufacturing processes—hot gluing, cutting • create 2-D and 3-D drawings.	Students will understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures—i.e., understand that lunch boxes can be portable, user-friendly, lightweight, designed to reduce waste and keep our food fresh.

Figure 17. Gail's technology planning: Part 2, lesson plan

Subtasks		Resources/focal artefacts	Planned interactions	Key student outcomes
Meso	**Micro**			
Main task: Design and create a lunch box that will reduce waste. Lesson 1: Undertake a product analysis.	1.1 Find ways to group existing lunch boxes (specially designed/ recycled; compartmental/ noncompartmental; plastic/nonplastic; maintain freshness/ dries out food; food wrapped/unwrapped; aesthetically liked; durable; portable; easy to open/close).	• Students' lunch boxes	• Teacher asks: How do we bring our food to school? Tally graph on board. • Teacher asks: What is a lunch box? Brainstorm and create a definition. • Teacher asks: Are all our lunch boxes the same? Create lists for graphing. • Teacher asks: Do they do the job that we want them to do? Use information to fill out a +/- chart.	Students will: • understand the purpose of and be able to conduct a product analysis appropriate to the design brief. • be able to conduct a survey and graph and interpret the results using a histogram • appreciate that there are many ways to package lunches, including various types of bags, wrapping, sizes.
	1.2 Graph results.	• Graph paper		
	1.3 Draw conclusions regarding basic features.	• Chart for teacher to record conclusions	• Teacher asks: - What do the graphs tell us about our lunch boxes? - Are there things that the graphs do not tell us? - What else would you like to say about our lunch boxes and what we have done?	
Lesson 2: Understand that, as an Enviroschool, we want to find ways to reduce lunch-box waste.	2.1 Group lunch-box waste over a period of time (1 day). Tally the waste collected from the lunch-boxes.	• Lunch boxes • Whiteboard	• Students sit in sharing circle with their lunch boxes in front of them. Teacher asks: 1. Do you know what we mean by "recycling"? What we mean when we say that we are an Enviroschool? 2. Who recycles at home? 3. How do you go about this? 4. Is there anything in your lunch box that you think you could recycle? Teacher lists 5. How could you do this?	Students will: • draw and label contents of lunch box on a given day and include wrappings (use later for a comparative evaluation) • collectively dispose of "waste" products.

2.2 Draw lunch-box contents.	• Lunch boxes • Drawing paper	• Teacher sets task: We are going to draw and label everything that is in our own lunch box so that we can check our waste later when we have eaten all our lunch.		
2.3 Draw conclusions.	• Students' labelled drawings of lunch-box contents • Whiteboard for tallying results and recording conclusions	• Teacher sets task: Now that we know exactly what is in each lunch box, we are going to see if there is anything that could be recycled. • Teacher asks: - What do you think that there is that could be taken out that you don't really need? - What conclusions can we draw?	Count, group and graph disposable waste products; for example, paper/plastic.	

| Lesson 3:
Create product design drawings; clarify ideas; identify materials, shape and size. | 3.1 Discuss and develop criteria for designing a lunch box. | • Criteria chart | • Teacher sets task: We have gathered a lot of information about lunch boxes over the last couple of days and today we are going to begin drawing some plans to make our own lunch boxes.
• Using the +/- chart that we made, what do you think the "best" lunch box might need if we were to design a new plan for one and make it out of the materials that we have in the room? | Students will:
• understand that the criteria becomes a basis for their design (nonabsorbent, size, shape)
• draw 2-D views—top (with/out lids) and showing compartments, side view
• indicate measurements
• add notes to indicate construction materials (from those provided) and any additional information they feel necessary. |
| | 3.2 Draw 2-D annotated plans (special abilities group—make working drawings and make 3-D drawings). | • Planning paper
• Measuring equipment
• Real working drawings | • NB: goal is to maintain freshness, portability, ease of opening, reduce waste.
• Draw on student ideas as to how they might draw a plan—students could explain what is meant by *2-D* and *annotated*.
• Direct discussion using examples of 2-D/3-D drawings. | |

Main task: Design and create a lunch box that will reduce waste.

Lesson 4: Understand that working plans link to "making" and that when "making" ideas may change.	4.1 With reference to 2-D and 3-D drawings, create lunch boxes from a selection of given materials. If necessary, adapt plans.	• Student plans • Range of construction materials: - ice cream boxes - Corflute - foam packaging - bubblewrap - wire - buttons - string • Glue guns • Scissors	• Look carefully at plans. • Gather materials that best suit design. • Have equipment and tools laid out on work space. • Think about what might be easy/a little difficult/a problem. How might we overcome any problems, especially fastenings? • Reassess progress—use Positive, Minus, Interesting (PMI) system to assist in preparation of group report to follow.	In groups of three, follow plans and develop skills: • using interlocking structure • using hot glue guns effectively • creating fasteners.
Lesson 5: Self- and peer assess design using criteria.	5.1 Use self- and peer assessment to assess effectiveness of design against established criteria.	• Criteria chart • Teacher assessment sheet	• Re-establish rules for sharing group presentations so that each member has a role: 1. Explain concept design. 2. Explain product making. 3. Explain problems and successes. • Summarise as a group to get an overall perspective based on initial criteria. • Teacher assessment sheet: Who is still using their lunch box? How does it feel to be using something that you have made yourself? Is it still doing the job for which it was designed? How? Is there anything that needs to be changed? What would you tell others about the lunch box if you were to make an advertisement to sell it? How have you enjoyed the whole process? What would you like to make next time?	Students follow criteria components to critique their own products, self-assess effectiveness and report to buddy and class.

Main task: Design and create a lunch box that will reduce waste.		5.2 Two weeks later: Review contents of lunch boxes as per lesson 2.	• Drawings from lesson 2 • Drawing paper • PMI chart	• Hold class discussion based on: 1. Who is still using their lunch box? How does it feel to be using something that you have made yourself? Is it still doing the job for which it was designed? How? 2. Is there anything that needs to be changed? 3. What would you tell others about the lunch box if you were to make an advertisement to sell it? 4. How have you enjoyed the whole process? 5. What would you like to make next time?	Students redraw contents of lunch boxes repositioned based on their models and make caption/labels denoting changes. Use buddy support. Discuss and record findings in PMI format.

Example of a full science plan

A science unit on adaptation in the strand of the Living World and ecology for Year 7 students.

Figure 18. Carol's science planning: Part 1, learning outcomes plan

Main idea: Adaptations help an animal survive in its environment.		Science strand: Living World—ecology	Level: 1 2 3 4 Year: 7
Overarching learning outcomes: In building understandings about adaptation, students will integrate: • understandings about how the features of an animal living on the rocky shore have allowed it to adapt to its particular habitat *(Scientific knowledge)* • an investigation of how a local ecosystem fosters the interdependence of living organisms, including humans, and their relationship with their physical environment *(Scientific practice)* • understandings that the nature of experimentation can include making predictions, observing, recording results and drawing conclusions *(Nature of Science).*			
Conceptual learning outcomes	**Procedural learning outcomes**	**Nature of Science learning outcomes**	**Technical learning outcomes**
Students will understand that: • beach ecosystems are a balance of living and nonliving elements that interact with each other • different organisms have different requirements and have adapted to particular environments • the rocky shore provides each type of living thing found there with food and shelter • salinity changes because of evaporation and tidal variations • exposure to air leads to dehydration • zonation occurs to reduce competition.	Students will be able to: • follow steps of experimentation • identify correctly the highest and lowest point of the rocky shore • source, use and record relevant information.	Students will understand and appreciate the nature of experimentation: predicting, observing, recording, drawing conclusions. Students will be able to: • compare results with other people to come to a uniform set of results • explain why there may be variations in results.	Students will be able to: • make and record observations • present findings/results (graphs, diagrams, tables, observation sheets) • draw and label a diagram that follows science conventions.
Assessment: Picture sort, individual and group cross sections of the rocky shore (ongoing), student definitions of *adaptation*			

Figure 19. Carol's science planning: Part 2, lesson plan

	Subtasks		Resources/ focal artefacts	Planned interactions	Key student outcomes
	Meso tasks	**Micro tasks**			
Main idea: Adaptations help an animal survive in its environment.	Day 1: Explore prior knowledge of what students think the term *adaptation* means as it relates to plants and animals.	1.1 Have students record their ideas on what they think the term *adaptation* means in relation to living things. Students share examples.	• Pictures of animals found on rocky/sandy shore	• Students work individually to record their knowledge in books. • Groups record ideas generated by brainstorming and share findings with class.	Students can explore and record what they already know.
		1.2 Gather students' ideas of where and why animals would be found in a particular environment.	• Pictures of animals found on rocky/sandy shore	• Students work in groups to decide where animals should be placed—i.e., the sandy or rocky shore. • They fill in their decisions on t-chart. • Students write a summary explanation of why they would put a particular animal in either the sandy or the rocky environment.	Students continue to explore what they already know.
	Day 2: Identify the different zones found on the rocky shore.	2.1 Have students identify the different zones found on the rocky shore—low, mid, high.	• Laminated chart of zones • Laminated labels with correct names for each zone • Pictures of animals found on rocky shore	• Students work in groups of four. • Each group has chart of cross section of rocky shore. • Groups identify low-, mid- and high-tide zones by adding labels. • Groups allocate animals to particular zone. • Groups record why they have put animals in a particular zone. • Groups given information to process and then use to check the accuracy of their labelling.	Students understand that there are distinct zones found on the rocky shore.
		2.2 Gather students' ideas on what the conditions are like in the various zones.		• Individuals draw diagram labelling zones and write or draw where they think animals are found. Individuals draw up a table showing different zones and write descriptive words into columns that describe their ideas on the conditions found in each zone. (Will return to this after camp.)	Students explore their ideas on the conditions found in the various zones.
	Day 3: Explore the rocky shore environment.	3.1 Find and identify rocky shore animals.	• Identification sheets	• Students are allocated a particular area. • They find, observe and record what they find, describing habitat and visible features. • Students sketch their area. • They use information sheets to identify animals. • Class gets together as group to discuss findings.	Students can identify: • animals living on the rocky shore • high/low tide lines • the zones • the habitat of animals that they find • external features.
		3.2 Make observations and record information.	• Sheets for recording information		

Day 4: Identify, clarify and explore the major environmental factors that shape the lives of animals living on the rocky shore.	4.1 Have students identify and describe the conditions in each of the zones.	• Chart with columns previously used in lesson 2 • Information recorded on camp	• Students revisit chart used in lesson 2 on zonation and placement of animals. • Students change placement of animals to refine ideas. • Students work individually to refine their ideas on conditions found in each zone. They add or delete ideas. • Students form into groups to share ideas and discuss findings. • Class has a discussion. Teacher records statements either on whiteboard or chart to build up a description of each zone.	Students have refined their ideas on conditions found on a rocky shore and where animals are found: • each zone on the rocky shore has a particular environment • in environments there are factors that must be overcome for animals to survive there • dehydration is not just a human problem • salinity concentration varies according to tide variation and evaporation.
	4.2 Identify the major contributing factors that would influence which animals live on the rocky shore.		• Students retrieve relevant information on conditions from chart; for example: - wave action - changes in tides. Students discuss the other factors that may influence the lives of animals living on the rocky shore; for example: - predators - competition from other animals for food and space. • Students discuss how each factor may influence the lives of the animals living there. • Students record information in books (this could be in the form of a mind map).	
	4.3 Explore salinity by carrying out an experiment.	• Copy of experiment	• Students carry out desalination experiment. • Students make observations. • They record findings. • Class discuss results and how this relates to the rocky shore—for example, change in salinity. • Students add this to chart.	

Day 5: Explain the term *adaptation* and identify adaptations animals have that allow them to live in a particular environment.	5.1 Explain the term *adaptation*.		• Collect student ideas on the term *adaptation*. Make a class definition of term.	Students have a clearer understanding of the term *adaptation*.
	5.2 Identify adaptations animals have that allow them to live in the rocky shore environment.	• Adaptations chart • Pictures of animals • Information on animals	• Class refer back to conditions on the rocky shore. Recap. • Teacher models process: takes example of limpet and identifies the features it has that allow it to adapt to the conditions. • Put on to chart ("Adaptations"). • Students form into groups and are allocated an animal. • Students fill in chart identifying features their animal has that enable it to survive. • Each group is given information on animal to assist with task. • Groups report back and add to class chart. • Students put this information into their books to refer to. • Extra: Students complete sheet: "Factors affecting the lives of rocky shore animals".	
Day 6: Explain the term *adaptation* and identify adaptations animals have that allow them to live in a particular environment.	6.1 Dissect a fish/crab	• Fish/crab • Identification sheets showing external/internal features	• Class reviews the term *adaptation*. • Students sketch fish/crab. • Students label their sketch, identifying the adaptations that enable the fish/crab to survive in its particular environment. • Students write an explanation for each one—for example, "Fins allow fish to swim." Use identification sheets to help with this. • Students dissect fish/crab. • Students find and identify internal organs; for example, heart, liver, swim bladder in fish. • When dissection is complete, students write down organs and explain their significance to the animal's survival. Use identification sheets to help with this process.	Students are able to: • transfer knowledge of adaptations • sketch and label a drawing appropriately • identify the major organs of fish/crab and what they are used for.

Day 7:	Create a habitat.	• Science books	• Class reviews the term *adaptation*.	Students can:
Apply knowledge and understanding of the term *adaptation* and how adaptations relate to an animal's survival.			• Students create, draw and describe a habitat that supports life.	• transfer knowledge of adaptations
	7.2 Create an animal to live in the habitat.		• Students create, draw and describe an animal that has adapted to live in the designed habitat.	• show their knowledge about adaptation.
	7.3 Explain how the animal's adaptations help it survive.		• Students explain the adaptations that help the designed animal to survive.	

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In this resource, teachers' real names are used in the "Teachers Talking to Teachers" stories. Otherwise, names are pseudonyms.

The InSiTE research was undertaken between 2005 and 2007 when the revised curriculum (Ministry of Education, 2007) was not finalised. Therefore the teachers involved in this research based their work on the previous science and technology curriculum documents (Ministry of Education, 1993, 1995). However, given the changes indicated in The New Zealand Curriculum *(Ministry of Education, 2007), we have made links to it where possible without distorting the integrity of the findings themselves.*

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Teaching science and technology to primary school students is not simple. Teachers need to be able to take science and technology concepts and present them in ways that enable students to learn.

Using the two-part planning template described in this booklet can help teachers move from simply planning activities for students to do, to planning what and how students will learn through a coherent series of lessons.

This booklet outlines some findings related to teacher knowledge for primary teachers that were derived from a Teaching and Learning Research Initiative (TLRI) project, The Classroom InSiTE Project: Understanding Classroom Interactions to Enhance Teaching and Learning in Science and Technology in Years 1–8. The project involved working in classrooms over three years with Years 1–8 teachers when they taught science and technology to their students. The project aimed to identify, investigate and enhance ways of teaching science and technology.