Science in the New Zealand Curriculum

Understanding progress from levels 2 to 4

NMSSA
Wānangatia te Putanga Tauira
National Monitoring Study of Student Achievement

MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA

Science in the New Zealand Curriculum

Understanding progress from levels 2 to 4

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Introduction

What is the purpose of this resource?

Imagine that someone has suggested building a solar energy station to help your community become self-sustaining—and maybe even make money later by selling power to the grid. Sounds great, doesn't it? The catch is, it doesn't come free. You all need to contribute. And the area where the station is planned is near some wetlands. What might be the implications? As you and your community explore the options, the great idea starts to seem a little more complex. What do you need to know and do if you are going to talk this idea through and make good decisions? It's likely that you'll need to **engage with science**, to:

- **gather and interpret data** about the possible impact of the solar energy station
- **use evidence** to explain potential impacts
- **critique the evidence** you and your community are looking at to be sure that it is trustworthy
- **interpret representations** of data, such as flow charts and graphs, bearing in mind that the person presenting the data may have organised it to persuade you to their point of view.

The scenario above is just one example of the many ways we use our capabilities in science to "participate as critical, informed, and responsible citizens in a society in which science plays a significant role".[1] Each of the concepts highlighted in bold represents one of five basic capabilities that have been identified as contributing to the science learning area of *The New Zealand Curriculum*.[2] These "science capabilities" weave scientific knowledge with aspects of the key competencies and the Nature of Science strand. They are about what students can do with their knowledge as they put it into practice in "real world" contexts.

The New Zealand Curriculum has achievement objectives that describe the scientific knowledge, understandings, and skills we'd like all young people to develop in their learning through and about science. But we don't currently have a description of what progress in the science capabilities looks like.

This resource takes information and data from the National Monitoring Study of Student Achievement (NMSSA) science assessments and uses them to create indicators of progress in the science capabilities. We can use these indicators, along with the curriculum's achievement objectives, to understand where students are up to in their science learning and what they need to learn next if they are to use science to participate actively, confidently, and usefully in the world they live in and the one they will create.

1 Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington: Learning Media, page 17.

2 Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington: Learning Media.

What are the science capabilities?

The science capabilities[3] were developed after publication of *The New Zealand Curriculum*. They weave the knowledge, skills, and practices that make up the Nature of Science strand with the curriculum's statement about the purposes of science and with the key competencies.

There are five science capabilities:

- Gather and interpret data: making careful observations and differentiating between observation and inference
- Use evidence: supporting ideas with evidence and looking for evidence that supports or throws into question other people's explanations
- Critique evidence: evaluating the trustworthiness of data
- Interpret representations: thinking about how data is presented and asking questions about what it reveals
- Engage with science: drawing on the other capabilities to engage with science in authentic contexts.

The capabilities are future-focused: they show what knowledge about science and the ability to use scientific processes enable people to do. They incorporate the dispositions required to engage successfully in science—the genuine interest and sense of purpose that it takes to participate in and get better at science.

See Part 1 for more detail about the science capabilities.

What will you find in this resource?

This resource describes what we have learned from NMSSA about progress in the science capabilities from levels 2 to 4 of the curriculum. It is intended to provide schools with insights into the skills and dispositions students need to progress across levels 2 to 4 of the science curriculum and beyond.

As you read this resource, you will encounter:

- further information about the science capabilities, with an opportunity to consider what two students' responses to an NMSSA task suggests about their progress
- a set of progress indicators for the science capabilities at levels 2 to 4 of the curriculum
- annotated examples of student responses to NMSSA tasks
- a discussion of science in *The New Zealand Curriculum*
- a description of the 2017 NMSSA science study, with an explanation of how its findings were used to describe progress expectations for science
- a list of recommended resources.

3 Go to Te Kete Ipurangi to learn more about why the science capabilities were developed and what they look like.

PART 1: The science capabilities

Unpacking the science capabilities

The science capabilities help us understand our world and manage our interactions with it. As you read the following descriptions, you may like to think about how you use these capabilities in your own life.

Gather and interpret data

We gather data by using our senses—sight, hearing, touch, taste, and smell—to make observations. Making careful observations can include measuring, noticing patterns, and testing predictions. Observations are influenced by what we already know.

Interpreting data involves making meaning from observations. A conclusion you draw from observations is called an "inference".

Use evidence

In science, explanations need to be supported by evidence that is based on, or derived from, observations of the natural world. Science ideas provide the theoretical framework for interpreting evidence.

Critique evidence

To evaluate the trustworthiness of data, we need to know about the qualities of science evidence such as observations, claims, and tests. We need both methodological knowledge and statistical knowledge to know what sorts of questions to ask about the data and how it was gathered.

Interpret representations

Scientists represent their ideas in a variety of ways, including graphs, charts, diagrams, written texts, and models. Models are especially important representations in science. A model is often used when the idea, object, process, or system scientists want to talk or think about is not directly observable. It enables scientists to develop and work on the idea, object, process, or system, but it is often a limited representation of the "thing" itself.

Language in science usually focuses on ideas, things, and processes rather than on people's feelings and opinions; hence, descriptions often use the passive voice to place attention on the action, rather than on who did it.

Engage with science

This capability requires us to *use* the other capabilities to engage with science in real-life contexts. It involves taking an interest in science issues, participating in discussions about science, and at times taking action.

How well can you recognise progress in the science capabilities?

Here is an example of an NMSSA task about the life cycle of a huhu beetle, along with two students' responses. Before reading on, you may like to test your ability to gauge student achievement in science by attempting the questions below.

1. What curriculum level do you think Iosefa and Wang and are working at: 2, or 4?
2. The students' responses provide indications of their progress in one of the science capabilities. Which capability do you think it is?
3. One of the students scored more highly on this task than the other student. Which student do you think scored more highly?
4. To get to this point in their capability development, Iosefa and Wang will have had opportunities to observe and talk about the life cycles of some familiar insects and to see how the different stages in life cycles are represented in simple diagrams.
   How often have your students had opportunities like these?

See page 11 for what NMSSA concluded about Iosefa's and Wang's achievement and understandings from these examples.

The life cycle of a huhu beetle

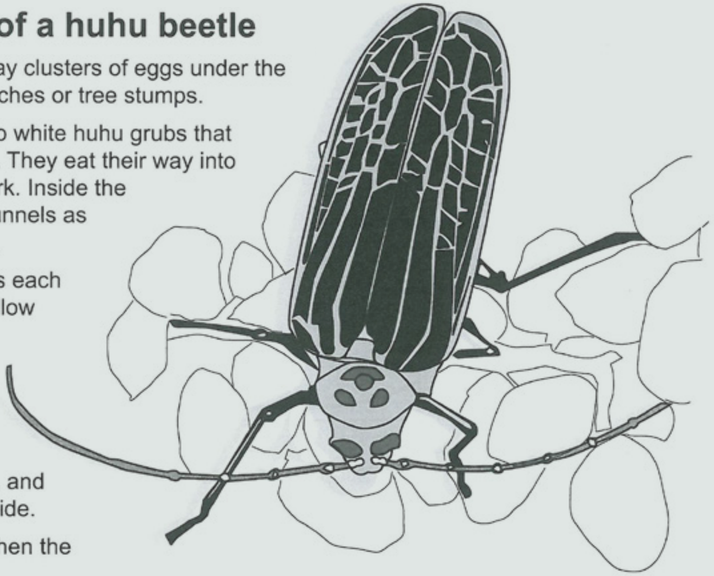
Female huhu beetles lay clusters of eggs under the bark of fallen tree branches or tree stumps.

The eggs hatch out into white huhu grubs that look a bit like maggots. They eat their way into the wood under the bark. Inside the dead tree they make tunnels as they feed on the wood.

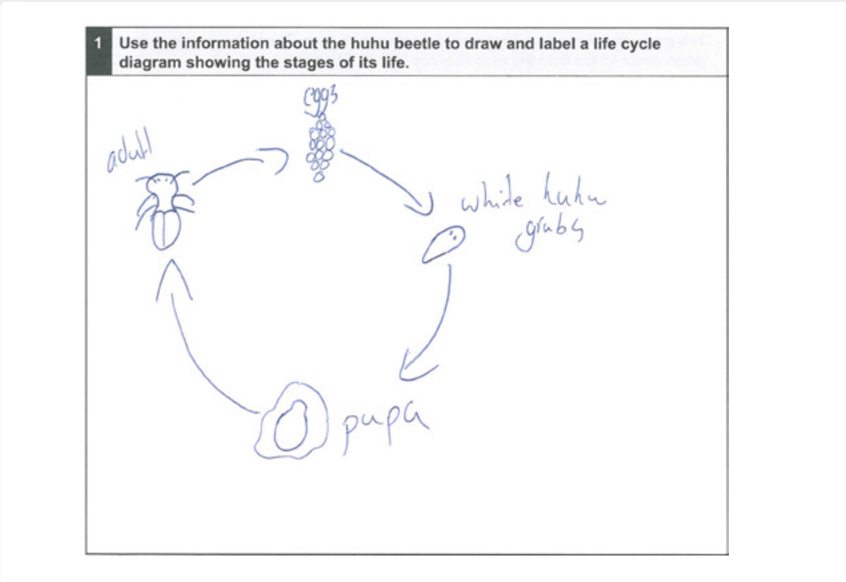
After two or three years each huhu grub makes a hollow space inside the tree and changes into a pupa.

About two weeks later the adult beetle comes out of the pupa, and cuts its way to the outside.

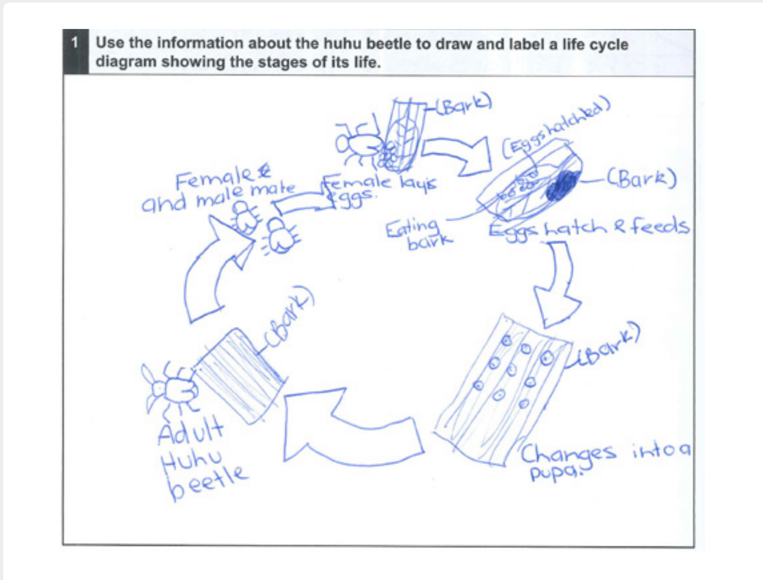
The adults mate, and then the females lay their eggs.



Iosefa



Wang



PART 2: **Progress indicators for the science capabilities**

The diagram on the following pages sets out progress indicators for the science capabilities from levels 2 to 4 of *The New Zealand Curriculum*. It is intended to help you construct a meaningful local science curriculum within the framework of the national curriculum. The pathway each student takes will be unique. However, all students deserve the right to develop the capabilities they need to reach their potential and participate in the world as scientifically literate citizens.

The diagram uses the image of a rainbow to represent the concept of progression and the ways in which the capabilities work together. Each capability is represented by a different "band" of the rainbow. The intensity of each band deepens as students strengthen and broaden their control of the capabilities.

The progress indicators were developed through analysis of the 2017 NMSSA science study, as described on page 17. The analysis of the NMSSA findings indicates that students working at level 2 can show evidence of development in terms of just two of the science capabilities: Gather and interpret data, and Use evidence. You will find this reflected in the progress indicators and examples.

Progress indicators for the science capabilities

	LEVEL 2 Students are doing and talking, thinking and explaining. They work in everyday contexts to:	ABOVE LEVEL 2 Students are testing their everyday knowledge. They work in a range of contexts, including some that are unfamilar, to:
Gather and interpret data	• make observations about events and objects using their senses • use simple descriptive vocabulary • shape simple explanations, drawing on their observations • ask simple questions about familiar contexts	• make observations about events, objects and simple texts • shape simple but clear descriptions using some precise vocabulary • shape simple science explanations, drawing on direct observations and evidence from sources such as photographs • ask simple science questions that can be investigated • notice and describe simple patterns involving differences • use basic science investigatory practices, including systematic measurement
Use evidence	• make claims without supporting evidence	• make claims and justify them with evidence • use reasoning to get from knowns to unknowns in simple, familiar contexts
Critique evidence		• identify a problem in data
Interpret representations		• interpret simple graphs, diagrams, food chains and life cycles • use simple science conventions to organise data in graphs and tables
Engage in science		

LEVEL 4 Students are building science knowledge. They often work in unfamilar contexts to:	ABOVE LEVEL 4 Students are applying their science knowledge. They work in increasingly complex and unfamilar contexts to:
• make observations about events, objects and formal science texts • shape descriptions that cover some features in detail and include some scientific vocabulary • shape science explanations, drawing on experience and their emerging science understandings • identify questions that can be investigated from a set of alternatives • identify and describe more complex patterns involving similarities and differences • recognise why fair testing is important in gathering data	• make detailed observations about events, objects and formal science texts • shape descriptions that cover multiple salient features in detail and include scientific vocabulary • shape science explanations, drawing on basic science concepts • ask questions that can be investigated in relation to more complex science ideas • describe patterns, trends and relationships from more than one data source • recognise methods for obtaining reliable and valid data
• systematically compare data to justify claims • use logical reasoning to identify simple, plausible explanations	• identify disconfirming evidence • use stronger reasoning and critical thinking to eliminate superficially plausible options
• check data and explanations for differences in patterns	• check data and explanations to identify possible sources of error • identify what is not evidence in a science context • identify features of investigations that ensure they will result in sound evidence
• interpret more formal science representations such as classification keys, Venn diagrams and science models • use science conventions such as arrows in life cycles and food chains • convert representations of science ideas—for example, from tables to graphs or words to diagrams	• distinguish the key ideas in representations • use a range of science conventions including correct units of measurement • construct more complex science representations such as food webs and diagrams showing forces
• recognise and explain a science issue • suggest one side of an argument for a science issue	• identify and justify an action to address a science issue • identify both sides of an argument for a science issue • explain why an action has a particular impact

PART 3: Examples of the capabilities in action

The examples on the following pages are of student responses to tasks in the 2017 NMSSA Science Study. Each is annotated with reference to the progress indicators presented in Part 2.

LEVEL 2: **Oil and Water**

The students are working with the science capabilities *Gather and interpret data* and *Use evidence*. They are still building their foundational knowledge of phenomena and the capabilities that will support their thinking and explanations.

In this example, the students' attempts at science explanations show they have learnt how science talk is different to other types of talk. They understand what it is to observe like a scientist, which requires a different type of looking and clear and precise descriptive language. In order to have reached this point, they will have had opportunities to play, to talk, to develop their curiosity about science, and to practise describing and explaining "what they observe" and "what they think has happened" across different contexts.

Look at page 12 to see how students working at level 4 respond to the same task.

TASK

In this open-ended task, the student is interviewed by a trained NMSSA teacher assessor. The student is asked to use equipment and to explain their thinking and reasoning.

Equipment

Plastic sample cup filled with salt water, stick, cooking oil, dishwashing liquid.

TEACHER ASSESSOR ACTIONS	STUDENT RESPONSES
Step 1  The teacher assessor asks the student to pour some oil into the water in the sample cup and to stir it with the stick. The assessor holds up the sample cup so the student can see what happens and asks, "*Watch what happens. What do you notice?*"	***Molly*** *That there is bubbles inside.* *There are big puddles of water.* *It's all sticky.* *It has dissolved.* *The thing and the water is coming around.* ***Pita*** *It's like a lava lamp.* *They can't mix because the oil's lighter than the water and they are two different substances.* *It becomes bubbly and the oil floats on top because it's lightest.* *It doesn't smell nice anymore.* *It's shiny now and it's thicker where the oil and water surround it.*
Step 2 The teacher assessor asks the student to put some diswashing liquid into the oil/water mixture and to stir it with the stick, giving it a good mix. The assessor asks again, "*Watch what happens. What do you notice?*"	***Molly*** *It is turning to bubbles and the dishwashing liquid is dissolving.* *All the oil has gone.* ***Pita*** *There are bubbles on the top and the water isn't separated anymore but solid.* *The dishwashing liquid sank when I put it in because it's heavy.* *It's more of a solid.*
Step 3 The teacher assessor says, "*If oil spills into the sea—for example, if there is a ship wreck—it can cause a lot of damage to the environment. Use what you have noticed about oil and water to explain how an oil spill might affect sea birds and other sea life.*"	***Molly*** *Because the oil has a lot of chemicals and it can pollute the sea and cause fish to die. If you eat them you might get a disease and die.* ***Pita*** *It will make all the water sticky. The birds and fish will get stuck.*

Talking like a scientist
The student uses simple vocabulary to describe the changes she sees.

Attempting a science explanation
The student shapes a simple explanation, drawing on his experience.

Observing like a scientist
The student makes an observation using his senses.

Attempting a science explanation
The students shape simple explanations, drawing on their observations. They know something has changed, and they use their everyday knowledge and language ('dissolving', 'solid', 'separated') to explain the change. However, these terms have different, more precise meanings in science, so the explanations are not accurate.

Thinking like a scientist
The student makes a valid claim but with no supporting evidence.

Thinking like a scientist
The student makes a valid claim based on what he has just observed.

New Zealand Curriculum: Achievement objectives	
Investigating in science	**Material world**
Students will extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models.	Students will observe, describe, and compare physical and chemical properties of common materials and changes that occur when materials are mixed, heated, or cooled.

ABOVE LEVEL 2: **Food Chain**

The students are working with the science capability *Interpret representations*. They are working towards interpreting more formal science representations such as classification keys, Venn diagrams, and science models.

In this example, the students' answers show whether they have learnt and can use a specific convention for drawing food chains in science—the direction of the arrows indicates the movement of food energy when one organism is eaten by another. In order to have reached this point, they will have discussed and created examples of food chains.

Food chain

Here is a simple food chain.

grass ⟶ rabbit ⟶ stoat

TASK

This is a paper-and-pencil task. Students were asked to identify two pieces of information from a simple food chain (see the top right of this page). Their responses were scored 0, 1, or 2, with 2 being the highest.

STUDENT RESPONSES

Noah (score = 2)

1 Write the 2 things this food chain tells you about rabbits.

1. A rabbit eats grass
2. a stoat eats the rabbit

Using the conventions of science
The student interprets the food chain accurately, correctly reading the direction of both arrows and identifying what they signify for a rabbit (eating and being eaten).

Charlotte (score = 1)

1 Write the 2 things this food chain tells you about rabbits.

1. it eats grass
2. rabbits hide from Stoats

Using the conventions of science
The student interprets one of the arrows accurately. However, she is not thinking like a scientist, as we can't tell from the information given whether or not rabbits hide from stoats.

Hunter (score = 1)

1 Write the 2 things this food chain tells you about rabbits.

1. A rabbit eats grass. ~~and stoats~~ ~~eat stoats~~
2. and it eats ~~x~~ Stoats too.

Using the conventions of science
The student interprets one arrow accurately. However, he seems to assume that the arrows on either side of the rabbit indicate food sources for the rabbit.

New Zealand Curriculum: Achievement objectives	
Communicating in science	**Living world**
Students will begin to use a range of scientific symbols, conventions, and vocabulary.	Students will recognise that there are life processes common to all living things and that these occur in different ways.

LEVEL 4: The Life Cycle of a Huhu Beetle

The students are drawing on their knowledge of simple life cycle diagrams and working with the science capability *Interpret representations*. They are working towards using science conventions more accurately and constructing more complex representations.

In this example, the students' attempts to draw a life cycle diagram show they have learnt some of the conventions for representing ideas in science. They understand that diagrams in science simplify by selecting features of interest and leaving out all other detail, and that particular conventions are used so that everyone can understand the diagram. In order to have reached this point, students will have observed and talked about the life cycles of some familiar insects and seen how the different stages in life cycles are represented in simple diagrams.

The life cycle of a huhu beetle

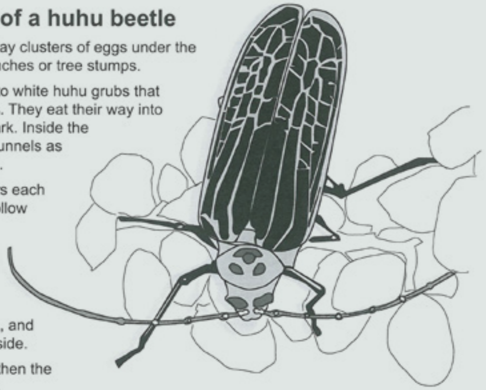
Female huhu beetles lay clusters of eggs under the bark of fallen tree branches or tree stumps.

The eggs hatch out into white huhu grubs that look a bit like maggots. They eat their way into the wood under the bark. Inside the dead tree they make tunnels as they feed on the wood.

After two or three years each huhu grub makes a hollow space inside the tree and changes into a pupa.

About two weeks later the adult beetle comes out of the pupa, and cuts its way to the outside.

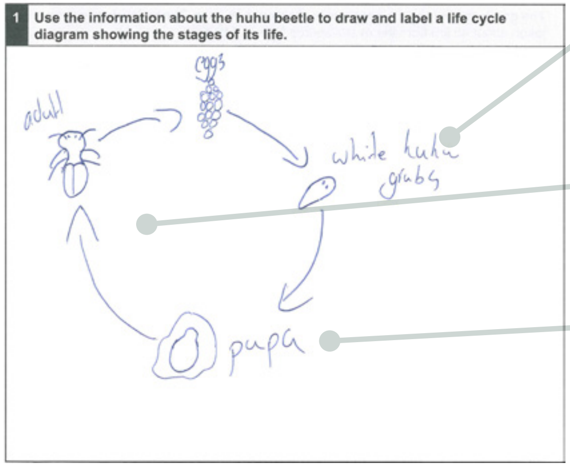
The adults mate, and then the females lay their eggs.



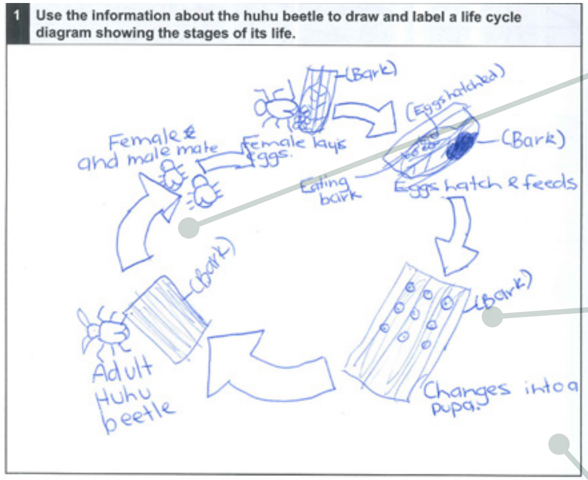
TASK

This is a paper-and-pencil task. Students use the information in a written description of the life cycle of a huhu beetle to create a life cycle diagram (see the bottom left of this page). Their responses were scored 0, 1, or 2, with 2 being the highest.

STUDENT RESPONSES



Iosefa (score = 2)



Wang (score = 1)

Using the conventions of science
The student constructs a life cycle diagram correctly using a range of science conventions: the cycle is arranged as a complete circle; the correct arrows are used; and the diagram has the correct four stages, in the right order and properly labelled.

Working across different representations
The student successfully and accurately converts science ideas in a written text to a diagram.

Using science vocabulary
The student selects the correct vocabulary to label the stages (eggs, grubs, pupa, adult).

Working across different representations
The student converts science ideas in a written text to a diagram. However, the mating process is included in the life cycle and there is additional text about processes that is not necessary for identifying the stages (e.g., "Eating bark").

Using the conventions of science
The student can construct a life cycle diagram using the correct science conventions. However, the solid arrows he has chosen are more properly used to convey the relative size of something such as a force.

Using science vocabulary
The student uses appropriate vocabulary in relation to the life cycle stages (eggs, pupa, adult). However, there is unnecessary text such as the labelling and drawing of the bark, the grub label is missing, and the stages themselves are not clearly labelled.

New Zealand Curriculum: Achievement objectives	
Communicating in science	**Living world**
Students will begin to use a range of scientific symbols, conventions, and vocabulary.	Students will recognise that there are life processes common to all living things and that these occur in different ways.

LEVEL 4: **Oil and Water**

The students are working in the science capabilities *Gather and interpret data* and *Use evidence*. They are drawing on their science understandings of floating and sinking, mixing, and observable changes in materials.

In this example, the students' attempts at science explanations show they have learnt that science talk is about precision and clarity. They have some science language to draw on to describe their science ideas, and they understand what it is to observe like a scientist, which requires precise, descriptive language. In order to have reached this point, they will have had multiple opportunities to practise describing and explaining what they observe across familiar and unfamiliar contexts.

Look at page 9 to see how students working at level 2 respond to the same task.

TASK

In this open-ended task, the student is interviewed by a trained NMSSA teacher assessor. The student is asked to use equipment and to explain their thinking and reasoning.

Equipment

Plastic sample cup filled with salt water, stick, cooking oil, dishwashing liquid

TEACHER ASSESSOR ACTIONS	STUDENT RESPONSES
Step 1 The teacher assessor asks the student to pour some oil into the water in the sample cup and to stir it with the stick. The assessor holds up the sample cup so the student can see what happens and asks, "*Watch what happens. What do you notice?*"	**Niamh** The oil is staying on top of the water. I notice that it is kinda like layered, and there is a little bit of water above the oil I think … The oil is definitely not sinking down or mixing with the water at all. **Christopher** They are in layers, so the oil is higher than the water. There is a small layer of water on top of the oil. **Oliana** The oil has separated from the water. It didn't mix in. It's still staying on the top – I'm pretty sure because the water is more dense and the oil is less dense, so it floats on the top.
Step 2 The teacher assessor asks the student to put some diswashing liquid into the oil/water mixture and to stir it with the stick, giving it a good mix. They ask again, "*Watch what happens. What do you notice?*"	**Niamh** Seems like the oil and water mixture are blending into one. It's definitely less clear because the solution … well, it's not a solution … the little crystals … no, not crystals. I can tell they are bubbles. **Christopher** Blue colour is lighter at the top and gets darker as it goes down. It is all one colour, so the oil and the water have combined. **Oliana** The detergent has bubbled up but has not connected with the oil, because the oil is still on top. The particles in the detergent and the particles in the oil don't expel. They mix together because the detergent has substances in it that connect with the oil.
Step 3 The teacher assessor says, "*If oil spills into the sea—for example, if there is a ship wreck—it can cause a lot of damage to the environment. Use what you have noticed about oil and water to explain how an oil spill might affect sea birds and other sea life.*"	**Niamh** It [oil] stays on the top – so if seabirds come down they land on it and it sticks to them, so it could be harder to fly away. If they put their head in it it could choke them or poison them. Small fish at the surface could think it's food and could come up and get it on themselves or get poisoned. **Christopher** Seabirds go down looking for fish under the water and they hit the oily mass, which suffocates them. Fish die too because they can't breathe.

Observing like a scientist
The student makes detailed observations, describing changes in detail.

Observing like a scientist
The student gives a description covering some features in detail.

Attempting a science explanation
The student uses logical reasoning to identify a simple, plausible explanation.

Talking like a scientist
The student uses appropriate science vocabulary.

Observing like a scientist
The student identifies and describes patterns.

Attempting a science explanation
The student shapes an explanation drawing on her emerging science understandings.

Thinking like a scientist
The student makes a valid claim using logical reasoning. She identifies three harmful effects that are clear, plausible, and linked to her earlier observation.

Thinking like a scientist
The student makes a valid claim using logical reasoning. He clearly explains the proposed effect but does not link it to the evidence from his earlier observation.

New Zealand Curriculum: Achievement objectives	
Investigating in science	**Material world**
Students will ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.	Students will begin to develop an understanding of the particle nature of matter and use this to explain observed changes.

LEVEL 4: **Stream on the Farm**

The students are drawing on their knowledge of how to change a variable of interest while keeping other variables the same, and working with the science capability *Gather and interpret data*. They are working towards a stronger understanding of methods for obtaining reliable and valid data.

To understand how scientists gather data, students need to learn about the rigour of science tests. They need to know about the validity of methods and how the design of an investigation impacts on results—that is, how the methods you use affect the reliability of your findings. In this example, the students' answers show they are developing an understanding of the role of variables in testing. In order to have reached this point, they will have experienced and talked about fair testing processes in a range of familiar contexts.

Stream on the farm

It is likely that the cows have been in this stream. The water is dirty, the stream bank is muddy and has collapsed in places, and the grass along the bank is short.

TASK

This is a paper-and-pencil task. Students look at a photo and design methods to answer questions about it. Their responses were scored 0, 1, or 2, with 2 being the highest.

For question 1, the highest possible score was 1.

For question 2, the highest possible score was 2. To score a 2, the student needed to identify a specific data-gathering method, for example testing a sample of the stream for water clarity, pH levels, temperature, oxygen levels, or types and numbers of living things.

STUDENT RESPONSES

Harry (score = 1 for Q1 and 0 for Q2)

1 How could the farmer find out if it really is the cows that are causing the damage?

He could put the cows in a different paddock and see if it gets better or worse.

2 What is one way the farmer can find out how healthy the stream is?

He could see if the cows would drink it or if fish would die in it.

Hine (score = 0 for Q1 and 0 for Q2)

1 How could the farmer find out if it really is the cows that are causing the damage?

Compare two different streams, one clean, one dirty.

2 What is one way the farmer can find out how healthy the stream is?

Drink the water and see if he gets ill or feels odd.

Aaden (score = 0 for Q1 and 1 for Q2)

1 How could the farmer find out if it really is the cows that are causing the damage?

To have half of them in the river area and the other half else wear to see if anything else changes with hygine or the enviroment.

2 What is one way the farmer can find out how healthy the stream is?

By taking a sample in a glass (clean) and testing with a machine to see how clean the water is. Or by washing something and seeing if it makes an impact to anything living or still.

Investigating like a scientist
The student recognises the importance of fair testing. He is manipulating an independent variable (the cows) to gauge its effect on a dependent variable (the stream).

Investigating like a scientist
The student understands that scientists and others test things, but his answer is limited because cows might not be discerning of healthy vs unhealthy streams.

Investigating like a scientist
The student appears to recognise the importance of fair testing. She is using a clean stream as a controlled variable and comparing the two streams to provide information on the impact of the cows on the dirty one. However, she has omitted important detail about the presence or absence of cows for each stream (i.e., she has not specified the cows as a key variable to be managed).

Investigating like a scientist
The student understands that testing can provide answers, but her answer is limited because she has not considered whether testing to see if someone falls ill is ethically acceptable.

Investigating like a scientist
The student is still developing his understanding of fair testing. The stream is a key variable. Moving some of the cows to another area might show what impact the cows have there, but it will not help identify what is happening to the stream.

Investigating like a scientist
The student knows that scientists use specialised equipment to test things. His answer suggests he understands there is pollution we can't see with our eyes.

New Zealand Curriculum: Achievement objectives

Investigating in science	Living world
Students will ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.	Students will explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced.

PART 4: **Science in the New Zealand Curriculum**

The purpose and organisation of the science curriculum

Science in the New Zealand Curriculum emphasises the importance of science learning in giving students the capabilities they need to participate actively in the world as citizens. It describes four purposes for science, each of which contributes to this central purpose.[4]

By studying science, students:

- *develop an understanding of the world, built on current scientific theories;*
- *learn that science involves particular processes and ways of developing and organising knowledge, and that these continue to evolve;*
- *use their current scientific knowledge and skills for problem solving and developing further knowledge;*
- *use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment.*[5]

The science curriculum is intended to serve all these purposes. The Nature of Science[6] strand is the overarching, unifying strand. It's about learning what science is and how scientific knowledge is created and used in the world. It consists of four sub-strands that evolve over the levels of the curriculum:

- understanding about science: students explore key ideas in science, scientific knowledge and explanations, and the culture of science
- investigating in science: students learn about the nature of scientific investigations, the dispositions and attitudes that support investigations (such as curiosity and scepticism), how to carry out an investigation, and how to interpret observations
- communicating in science: students develop knowledge of the vocabulary, conventions, and symbol systems of science, including its numeric systems, and they use this knowledge to communicate their own and others' ideas
- participating and contributing: students learn to bring a scientific perspective to decisions and actions, as appropriate.

Four other contextual strands—the Living World, Planet Earth and Beyond, the Physical World, and the Material World—offer contexts within which students can make progress in science. From Years 1 to 10, all students should experience science learning in each of these contexts. Beyond Year 10, students should have opportunities to specialise in one or more science disciplines, such as chemistry or biology.

Where do the science capabilities fit in to the curriculum?

The following table shows the relationship between the five capabilities, the four Nature of Science sub-strands, and the four contextual strands.

Nature of Science								
Nature of Science sub-strands	**Understanding about science** *When the focus is on scientists' work*			**Investigating in science** *When the focus is on students as investigators*			**Communicating in science** *When the focus is on making meaning of scientific representations*	**Participating and contributing** *When the focus is on taking action in science*
Science capabilities *The knowledge, skills, competencies, and dispositions required to participate successfully in science*	Gather and interpret data	Use evidence	Critique evidence	Gather and interpret data	Use evidence	Critique evidence	Interpret representations	Engage with science
Contextual strands *The contexts within which scientific knowledge develops*	The Living World Planet Earth and Beyond The Physical World The Material World							

4 For an interesting discussion of the purpose of science and the qualities of rich science education within the context of *The New Zealand Curriculum*, see *The Future of Science Education in New Zealand* (Royal Society of New Zealand / Te Apārangi, 2014)
5 Ministry of Education, 2007, page 28.
6 You can find introductions to the Nature of Science strand on Te Kete Ipurangi and the Science Learning Hub.

What is the place of literacy and numeracy in science?

Literacy and numeracy are foundation skills for learning in science. However, students need more than basic literacy and numeracy if they are to engage with and communicate scientific ideas and explanations. To practise science, they also need to engage with the specialised language, symbols, and representational systems of science and to use its conventions. This is the aim of the "Communicating in science"[7] sub-strand.

Clearly these discipline-specific skills and understandings are integral to the "Interpreting representations" capability. They are also woven through all the other capabilities, for example:

- **Gathering and interpreting data** includes using these skills to write descriptions, shape explanations, ask and answer questions, recognise and explain patterns, and work with data
- **Using evidence** includes using these skills to think through and justify or refute claims and explanations
- **Critiquing evidence** includes using these skills to make judgments about the trustworthiness of different kinds of data
- **Engaging with science** includes using these skills to think through, discuss, explain, and justify scientific issues and actions.

How can we understand progress in science?

Progress in science is described in the achievement objectives of *The New Zealand Curriculum*. The achievement objectives draw from extensive research in New Zealand and overseas to describe the way knowledge and skills develop in science. Broadly speaking, the achievement objectives describe a shift from engaging all students in a range of experiences within the Nature of Science strand to the more specialised knowledge and skills associated with the disciplines of biology, chemistry, and physics. However, they don't attempt to describe progression in terms of the dispositions and competencies required to participate successfully in science: that is, the capabilities.

7 Go to Te Kete Ipurangi for more on this and the other Nature of Science sub-strands. See also the discussion of the "Communicating in science" sub-strand and links to examples on the Science Learning Hub.

Resources on Te Kete Ipurangi[8] provide some insight into what progress in the capabilities looks like. They provide examples of learning opportunities designed to support students to develop the science capabilities. However, they focus more on the framing of the task than on what to look for in the students themselves. The progress indicators and examples presented in this resource are intended to help fill that gap.

The discipline-specific literacy and numeracy skills required for science are described in the achievement objectives for the "Communicating in science" strand and interwoven into the capabilities, especially for "Interpreting representations". However, they are supported through the progress students make in literacy and numeracy across the curriculum, and especially in mathematics and English. The achievement objectives for mathematics and English, and the Literacy Learning Progressions[9] and Learning Progression Frameworks[10], help us to understand expected progress in language, literacy, and numeracy. The English Language Learning Progressions[11] are a valuable support for understanding the progress of English language learners.

8 Follow the links under the five science capabilities to find these resources. See, for example, the suggestions for gathering and interpreting data.

9 Ministry of Education. (2010). The *Literacy Learning Progressions*. Learning Media: Wellington. The Literacy Learning Progressions (https://literacyprogressions.tki.org.nz/) describe the literacy knowledge, skills, and attitudes that students draw on to meet the reading and writing demands of the curriculum.

10 The Learning Progression Frameworks illustrate the significant steps that learners take to develop their expertise in reading, writing, and mathematics from Years 1 to 10. They underpin the Progress and Consistency Tool (PaCT).

11 The English Language Learning Progressions describe expected progress in reading, writing, speaking, and listening. They help us understand how to support English language learners to access the academic language of the curriculum. They can also be used to support learning for students with additional learning needs.

How can teachers support students to make progress in science?

When students begin school, they bring a foundation of scientific knowledge and experiences with them. This knowledge is developed through their day-to-day interactions in the home and community, and with their natural and physical environment.

In the first years at school, it is the job of the teacher to build on this foundation. In terms of scientific knowledge and experiences, this means offering rich opportunities for learning in the context of familiar everyday experiences. For example, students might learn to group plants and animals into science-based classifications. They might look at what is different about various leaves and what is the same. Both skills are needed in classification.

As students get older, they need opportunities to extend their learning in a wider range of contexts that become increasingly complex and unfamiliar, and they need to encounter concepts that are not easily observable or intuitive. For example, it will take some years before students who have observed the life cycle of a frog in a local pond are ready to learn about the life cycle of a microbe or a star. To get to this point requires multiple opportunities to learn about what a life cycle is and careful teacher support to understand that something so tiny or so enormous as to be invisible might yet have a life cycle.

The language of science

All students bring the language, literacy, and numeracy practices of their homes and communities to their learning in the classroom.[12] At school[13], they need to use these resources as they explore science concepts and practices and engage with and create scientific texts. As they get older, they must learn and apply the specific language, literacy, and numeracy practices of science and scientific ways of representing knowledge, such as diagrams, graphs, and equations.

The academic language of the science curriculum is important for talking and thinking about science, as well as for reading and writing in science. It includes everyday words that have a completely different meaning in science. These words need to be deliberately introduced, modelled, and incorporated in interactions around science.

Oral language is central, not just to literacy, but to all our learning. Before students can write or read about science, they can talk about what they have observed and listen to explanations. To make progress in science, students need many opportunities to talk about science, from sharing observations to planning investigations, giving presentations, and engaging in debate. The science classroom should not be a quiet place!

The outcomes of the 2017 NMSSA science study include an *Insights*[14] report that shares what the study revealed about how to enhance teaching and learning in primary schools. The report offers practical information about learning in science, the literacy and numeracy skills that this requires, and the relationship between science knowledge and the capabilities. Teachers and school leaders will find it useful to read the *Insights* report alongside the progress indicators and examples in this document.

There are many other resources online and in communities that teachers and schools can draw on for help. Some of them are suggested on page 18.

12 See ESOL Online for resources to support learning for your English language learners.

13 Curriculum Update 23 discusses literacy across the curriculum. The Writing Hub on TKI also has examples and case studies of literacy across the curriculum, some focusing on science: see these teacher support materials on teaching writing and these. NZ Maths offers resources that often link strongly to science.

14 You can read the *Insights* report, along with the study's findings, on the National Monitoring Study of Student Achievement website.

PART 5: Using NMSSA to develop science capability indicators

The 2017 NMSSA science study

The NMSSA is designed to assess student achievement at Year 4 and Year 8 in English-medium and state-integrated schools. It focuses on two learning areas per year, studying them in five-year cycles. NMSSA's most recent assessment of student achievement in science was conducted in 2017. The study was developed by a project team made up of people from the University of Otago and the New Zealand Council for Educational Research, supported by a panel of curriculum experts.

The project team based their framework for the 2017 NMSSA science study on the science capabilities because, by definition, these describe multiple ways in which students might show what they know and can do in science. The team began by developing a framework for a Science Capabilities Scale[15] that describes how students' science capabilities increase in sophistication as they progress through the early levels of *The New Zealand Curriculum*. A set of tasks for students in Year 4 and Year 8 was designed using the framework to inform the objectives of each task. Each task was intended to assess student achievement in relation to at least one of the capabilities. The resulting scale enabled NMSSA to determine the relative difficulty of the assessment tasks, and each student's overall level of achievement in relation to the scale and the curriculum.

The assessment was made up of two parts:

- **Group-administered assessment**: A group-administered paper-and-pencil assessment that involved students interacting with stimulus material, such as diagrams, drawings, photos, and descriptions
- **In-depth assessment:** A selection of activity-based assessments and interviews, involving a randomly selected sub-set of the NMSSA sample. Tasks were designed for individual students or as group activities. Responses were usually open-ended and involved the use of equipment. Students completing these tasks were prompted to explain their thinking and reasoning.

In 2017, nationally representative samples of about 2,100 students from 100 schools at each of Year 4 and Year 8 completed the group-administered tasks. A subset of about 800 students at each year level completed the in-depth tasks. The tasks were administered by specially trained NMSSA assessors.

15 You can examine the Science Capabilities Scale and learn more about how the study was conducted on the National Monitoring Study of Student Achievement website.

Prior to rolling out the full assessment programme, the NMSSA project team ran a pilot study. This revealed that Year 4 students were more likely to attempt an answer when the focus was on one of three of the science capabilities: "Gather and interpret data", Use evidence", and "Interpret representations". Consequently, most of the tasks for students in Year 4 focus on these capabilities. At Year 8, students were able to answer across the full range of the science capabilities.

Developing progress indicators for the science capabilities

The progress indicators presented in this resource were developed by interrogating the findings of the 2017 NMSSA science study to find out what they reveal about the progress students make as they build and extend their capabilities at different curriculum levels. This involved looking closely at the tasks and at student responses to the tasks. Expert "on balance" judgments were made that will need to be tested further over time.

The process of constructing the indicators reinforced the following points:

- The capabilities interweave and overlap. For the sake of manageability, it was sometimes necessary to choose a "best fit" for a particular progress indicator.
- The science capabilities include knowledge, and so knowledge and the capabilities develop together. For example, for students to gather and interpret data, they need to learn to shape science explanations and to do this, they need to be able to draw on basic science concepts.
- There are key concepts that students need to understand to get from one place in their learning to the next (for example, the concept of "fair testing").

The process has also raised some questions. For example:

- To what degree is our ability to understand what students know and can do constrained by their proficiency in written or spoken English?
- Are there aspects of the capabilities we are not recognising because we are not measuring them?

Recommended resources

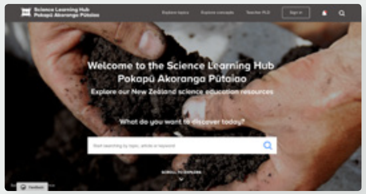
The New Zealand Government funds a number of resources to support curriculum design and implementation in science. Printed copies of some of these resources are available free to teachers from Down the Back of the Chair.[16] All are available online.

Science Online helps teachers unpack the requirements of *The New Zealand Curriculum*. It also explores the exciting opportunities that arise when we think about the science capabilities and how they help young people gain the citizenship skills they need to participate within and contribute to their world. Science Online itself offers links to other resources (http://scienceonline.tki.org.nz/Content-resources-and-rich-stories) that teachers may find useful in planning their science programmes.

The **Assessment Resource Banks (ARBs)** developed by NZCER offer formative assessment resources for students working at levels 1–5 of *The New Zealand Curriculum* in science, mathematics, and English. They are accompanied by a wealth of articles and examples to support teacher understanding of these learning areas and to show how teachers can use the ARBs in task design.

The **Building Science Concepts** series was developed some years ago but retains value in offering approaches to exploring science concepts within the contextual strands. The series was developed with close reference to how students learn in science and to the relationships between important concepts in science. It provides a means for teachers to refresh their own knowledge of science and to help students develop theirs. The books include diagnostic activities. The ARBs site includes a page on which the 64 Building Science Concepts books are listed with links to related assessment resources.

The **Connected** series consists of articles for students and support materials for teachers. Its purpose is to promote scientific, technological, and mathematical literacy so that students can engage in a critical and informed manner with real-life science and technology-related issues and authentic, context-based mathematical explorations. It also supports literacy learning in these areas. There are three issues each year, aligned to levels 2, 3, and 4 for students in Years 4–8. All articles are available on Google slides and some have additional digital content. The teacher support materials include links to a wealth of additional information, including websites in New Zealand and overseas.



The **Science Learning Hub | Pokapū Akoranga Pūtaiao** is an extensive and growing set of science education resources. The Hub's intention is to link New Zealand scientists with school students, teachers, and community audiences. The developers use a range of media to tell the stories of research and development in New Zealand science. Additional content shows how teachers can use the stories as contexts for creating relevant, engaging classroom programmes.

16 See Down the Back of the Chair.

NMSSA
Wānangatia te Putanga Tauira
National Monitoring Study of Student Achievement

MINISTRY OF EDUCATION
TE TĀHUHU O TE MĀTAURANGA