TE IHUWAKA | Education Evaluation Centre

Growing Curiosity

Teaching Strategies to Engage Years 5 to 11 Students in Science

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Contents

Introduction

Science is increasingly important in today's world as people come to rely on science and scientific thinking for almost every kind of endeavour. Critical for our scientific understanding is the quality of science teaching in our schools, and the extent to which students engage with science learning.

A high-quality science education is essential for those who want a career in science. It is also essential for all learners so that they can understand many of the issues that now confront families, communities, and nations – for example, climate change, healthy living, and rapid technological change.

Science education can help young people to be curious but critical, understand how the world around them works, and make good choices.

This report shares teaching approaches and strategies for Year 5 to Year 11 that ERO has identified in a range of schools where students were found to be highly engaged in science. This report should be seen as a resource for leaders and teachers looking to strengthen their teaching of science. It sits alongside our companion reports: *Science in the Early Years: Early Childhood and Years 1-4* and *Shining a light on science: Good Practice in Early Childhood Services*. This report looks at Years 5-11 as they are the critical years for science engagement before learners make final choices on whether to continue in science.

The report is in two parts:

PART 1 provides the background of how science is taught and sets out the key actions that our case study schools have taken to strengthen their science teaching.

PART 2 sets out the case studies in more detail as a resource for teachers and leaders.

PART 1

Teaching Strategies for Science

This section describes the key actions that our case study schools have taken to strengthen their science teaching. To help schools see how these strategies fit into the current context of science teaching in New Zealand, it describes how quality science teaching makes a difference, how science is taught in New Zealand, and how well students are learning science.

How does quality science education make a difference?

Children are naturally curious and eager to explore, question, experiment, and learn about science through their play. Teachers are critical to nurturing this interest and encouraging children to develop positive attitudes to science as they move through school.

Teachers in primary schools can do this by working with the creative explanations that children come up with as they try to make sense of their world. By valuing and encouraging curiosity, teachers in secondary schools can build investigative capabilities and understandings that will serve students well in their adult lives.

Science teaching and learning has changed considerably in recent decades. To help children become scientifically literate (see box) knowledge of science concepts is necessary but not sufficient: students need to know how the big ideas of science shape our understanding of the world and inform ongoing research. They also need to know how to apply science concepts to issues and challenges that directly affect them.

Scientifically literate people:

- *are interested in and understand the world around them*
- *engage in the discourse of and about science*
- *are able to identify questions, investigate, and draw evidence-based conclusions*
- *are sceptical and questioning of claims made by others about scientific matters*
- *make informed decisions about the environment and their own health and wellbeing.*

Ian Milne from The University of Auckland's "What is Scientific Literacy" from The New Zealand Science Teacher (2004)

How is science taught in New Zealand?

The *New Zealand Curriculum* and *Nature of Science*

The New Zealand science curriculum sets out why students study science, the learning area, and the achievement objectives.

There are five strands to the science learning areas: the *Nature of Science*, the *Living World*, the *Planet Earth and Beyond*, the *Physical World* and the *Material World*. The *Nature of Science* is the overarching strand, where students learn about what science is and how scientists work. The remaining strands describe the content that students learn.

The *Science Capabilities*

The ***Science Capabilities*** were introduced in 2014 to help teachers implement the science achievement aims, particularly the overall goal of students becoming *responsible citizens in a society in which science plays a significant role*.

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 for successful engagement in science – a genuine interest and sense of purpose that makes students want to participate in and get better at science.
Each capability encapsulates something that is needed for this ambitious goal to be met.[1]

The science capabilities link:

- the statement from the curriculum about why all students should learn science
- the overarching *Nature of Science* strand of the curriculum
- the four content strands of the curriculum
- the key competencies in the curriculum
- various resources designed to support learning in science.

The national curriculum is designed to enable teachers to weave in local knowledge and skills. The science curriculum will undergo a refresh in 2022, which will increase the focus on local issues.

Science Capabilities and the New Zealand Curriculum bring key competencies and knowledge together

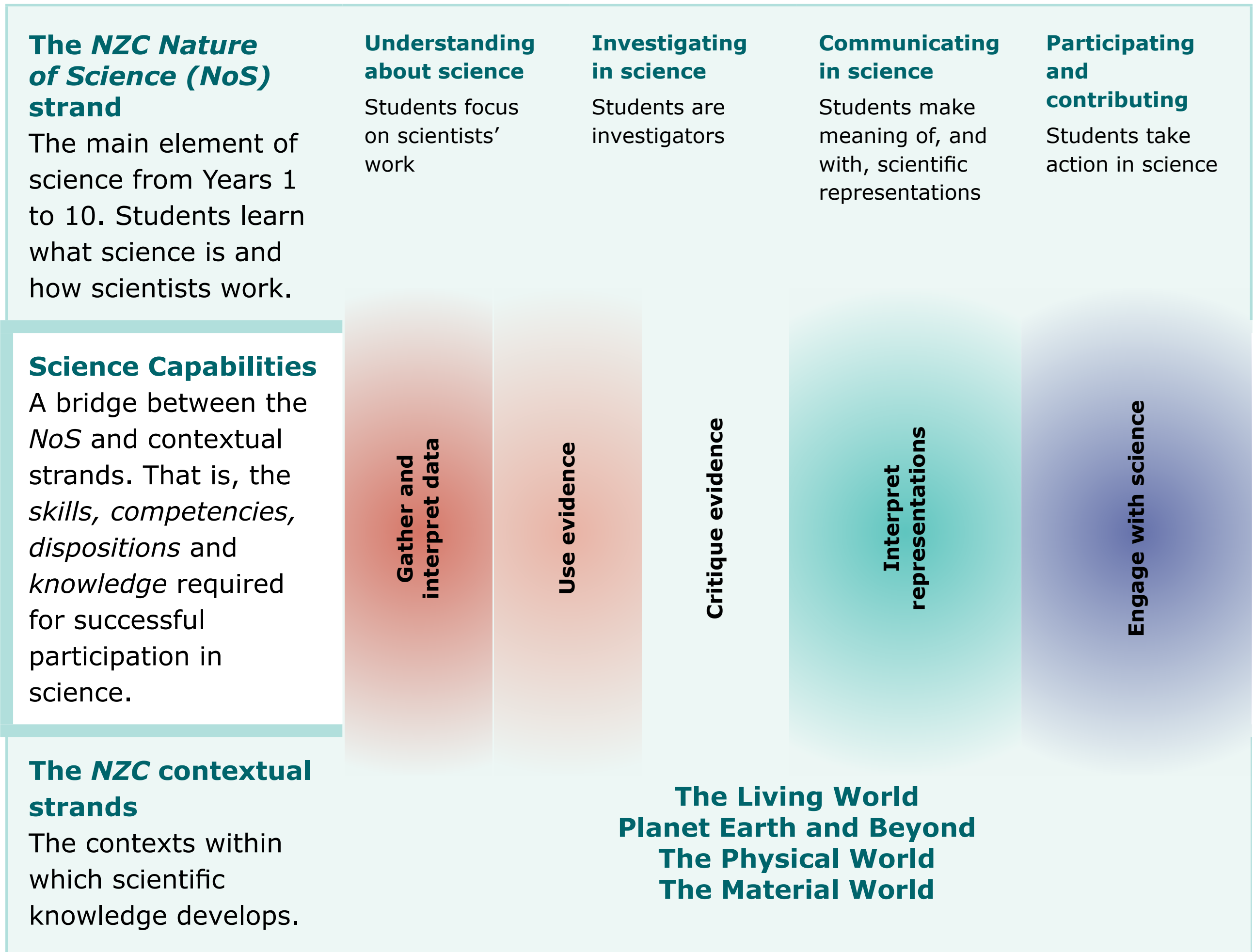


Figure adapted from Insights for Teachers – NMSSA Science 2017

1 Ministry of Education. (2019). Science in the New Zealand Curriculum: Understanding progress from levels 2 to 4 Wellington: New Zealand Government.

The five *Science Capabilities*

Gather and interpret data:

Learners make careful observations and differentiate between observation and inference. Science knowledge is based on data derived from direct or indirect observations of the natural physical world and often includes measuring something. An inference is a conclusion you draw from observations – the meaning you make from observations. Understanding the difference is an important step towards being scientifically literate.

Use evidence:

Learners support their ideas with evidence and look for evidence supporting others' observations. Science is a way of explaining the world. Science is empirical and measurable. This means that in science, explanations need to be supported by evidence that is based on, or derived from, observations of the natural world.

Critique evidence:

In order to evaluate the trustworthiness of data, students need to know quite a lot about the qualities of scientific tests. Not all questions can be answered by science.

Interpret representations:

Scientists represent their ideas in a variety of ways, including models, graphs, charts, diagrams, and written texts. Learners think about how data is presented and ask questions such as: What does this representation tell us? What is left out? How does this representation get the message across? Why is it presented in this particular way?

Engage with science:

This capability requires students to use the other capabilities to engage with science in 'real life' contexts. It involves students taking an interest in science issues, and participating in discussions about science. At times it involves taking action.

How well are students learning science in Years 5–11?

Science is increasingly important but, at the same time, there are signs that New Zealand students are not making the progress in science we would wish.

The most recent national and international reports suggest that New Zealand students' achievement and engagement in science reduces as they move through school.

- In New Zealand, findings from the 2017 *National Monitoring Study of Student Achievement (NMSSA)* highlight a pattern of decreased engagement and achievement occurring between Years 4 and 8. Compared with students in Year 4, students in Year 8 tended to be:
  - less positive about science
  - expressed less confidence as science learners
  - less likely to achieve at or above curriculum expectations (94 percent of students in Year 4 were achieving at or above curriculum expectations, compared to 20 percent of students in Year 8).

  While teachers of students in Year 8 were more likely to have a qualification in science, most teachers (of students in Years 4 and 8) were confident to teach science.

Despite fewer students reaching curriculum expectations at Year 8, principals rated science provision at Year 8 more positively than at Year 4, and more principals indicated science was mainly taught as a regularly timetabled subject at Year 8, compared to Year 4.

- Internationally:
  - The Trends in International Mathematics and Science Study (TIMSS) measure of achievement in Years 5 and 9 found that in 2019, although Year 5 students' scores were 24th out of 54 countries, they had not improved since 1994. New Zealand Year 9 students' science achievement was lower now than in 1994.
  - Results from the 2018 Programme for International Student Assessment (PISA) show that New Zealand students' science achievement was higher than the OECD average, but New Zealand students' scores had declined from previous scores in 2009. New Zealand also has one of the largest variations in science achievement, with a large and persistent gap between the scores of the top 10 percent and the bottom 10 percent.

In the past decade, ERO has published two reports about science in primary schools:

- *Science in Years 5 to 8: Capable and Competent Teaching* (May 2010)
- *Science in the New Zealand Curriculum: Years 5 to 8* (May 2012).

Whilst these reports identified strengths in science teaching, they highlighted the need for:

- a greater focus on how to effectively integrate science into the curriculum and maintain the integrity of science
- more science learning opportunities and greater focus on the *Nature of Science (NoS)* strand, which is the key to making science more engaging and equitable
- increased focus on the development of students' investigative skills
- increased coherence and continuity in science teaching supported by a framework for science teaching and learning that joined the dots between the science curriculum knowledge strands, and the overarching *Nature of Science* strand.

To support leaders and teachers to strengthen their science teaching of Years 5 to 11, ERO has identified approaches successfully used by schools to strengthen their science teaching and is sharing them in this report as a resource all leaders and teachers can use.

Selecting the case studies

Starting from what we already know, ERO set out to find examples of how schools have effectively engaged students in science learning, with a view to answering the overarching question:

What teaching practices can support improved outcomes in science?

As part of its work with schools, ERO identified schools who had recently undertaken in-depth review and development of their science curriculum and teaching that had resulted in increased student engagement in science.

Leaders and teachers at these schools provided additional information about the changes they had made and their impact on students. The case studies in this report describe the strategies and approaches used by these schools.

Some of the case study schools were focusing on the *Science Capabilities*, with the goal of students becoming responsible citizens in a society in which science underpins so much of what we do. Other schools had chosen to focus on developing an authentic or coherent curriculum. In all the schools, teachers were continually reviewing and developing their approaches and strategies.

Teaching strategies in primary schools (Years 5–8)

This section describes eight actions that influenced the improvement of science learning in the selected primary schools:

1. Demonstrating the will to improve student engagement in science
2. Carrying out high-quality internal evaluation
3. Using achievement information for planning and evaluation
4. Engaging in targeted external and in-school professional learning and development (PLD)
5. Effectively managing change
6. Changing the focus of science programmes
7. Using a range of resources
8. Involving others in the community.

For each action, the success factors and the actions that schools took to give effect to them are described in the following sections.

1. Demonstrating the will to improve student engagement in science

In each of the case study schools one or two teachers either triggered the changes or played a significant role in leading them. Passionate about science, these teachers wanted students to develop positive attitudes to science. They saw that science could be used to extend students' natural curiosity about, and interest in, the world around them. They recognised the importance of moving away from programmes that focus on science knowledge, shifting to actively engaging students in meaningful science learning.

These teachers either initiated the changes or were identified by their leaders as in-school science experts. They were most successful when they were supported by the principal and other school leaders and participated in considerable external PLD. They were allocated time to review school-wide science teaching practice and to share their developing knowledge and skills with other teachers. They enthusiastically modelled good science teaching practice with the result that student engagement increased in other classrooms too. In some schools, short-term management positions were created and funded, prioritising science teaching and learning.

2. Carrying out high-quality internal evaluation

Internal evaluation of science teaching and learning successfully contributed to improvements. In some schools this evaluation preceded any developments, while in others it occurred after some changes had been implemented and leaders wanted more information before making further changes. When schools used internal evaluation, teachers were asked about their attitudes to science and about their confidence in teaching science. Students and parents were surveyed to learn their views of the current programme and what changes they would like to see. Developing an understanding of the current state of science teaching and learning was vital for accessing PLD that would effectively target teachers' diverse strengths and needs.

Surveys were usually designed by leaders to gain targeted information. The most successful were designed and analysed collaboratively by all teachers. By being involved they were more likely to understand the issues and commit to changes. Completed surveys were carefully analysed with the aim of determining which teaching strategies and approaches should be consolidated, and which needed to be replaced. In some cases, a survey would be repeated at intervals to gauge how successfully the desired practices were being implemented and embedded, and what impact they were having on student engagement and learning.

3. Using achievement information for planning and improvement

Teachers and leaders in the case study schools made effective use of achievement data. Most were using the New Zealand Council for Educational Research's *Thinking with Evidence* assessment tool to identify improvement priorities and evaluate how any changes were improving outcomes for students. Some leaders were also using achievement data to identify student strengths and next learning steps before planning PLD for staff and classroom teaching activities. By sharing the specific learning outcomes for a topic or lesson, teachers supported students to reflect on their own progress.

Most of the case study schools were sharing information about the science programme with parents and were considering new ways of reporting progress and achievement in science.

4. Engaging in targeted external and in-school PLD

The science leaders in all the schools had enthusiastically participated in long-term science PLD. External facilitation was provided by (amongst others):

- The Science Teaching Leadership Programme (Royal Society | Te Apārangi)
- The Sir Paul Callaghan Science Academy for Professional Development
- Academics from Otago and Waikato universities.

In some cases, the teacher researched what PLD was available, sought funds and permission to participate, and then went on to lead improvements across the school. In other cases, leaders recommended the PLD to the teacher to strengthen their ability to lead changes indicated by internal evaluation. PLD prioritised increasing the teachers' confidence with the *Nature of Science* strand and the *Science Capabilities*.

Following the PLD, the teachers were highly motivated to try the teaching practices they had learned and share them with their colleagues. All went on to facilitate substantial internal PLD in their school. They:

- introduced research for teachers to discuss and critique

- explained the *Nature of Science* strand and the *Science Capabilities*, and suggested strategies designed to focus students on what science involves and how science works
- modelled hands-on experiments at staff meetings or in classes, which teachers could then use with their own students
- assisted teachers and/or teaching teams to plan integrated science units
- shared online resources, science teaching workbooks, and science equipment that teachers could use.

The lead science teachers used surveys and observations made in staff meetings and classrooms to monitor teachers' developing confidence and plan future PLD.

5. Effectively managing change

The lead science teachers structured their improvement actions to ensure that changes were manageable and well supported. In some schools, action plans were collaboratively developed, detailing roles, responsibilities, and timelines. These plans were regularly referred to and progress reported to the board of trustees. One school established a science professional learning group to assist with developing resources, monitoring improvements, and supporting the lead science teacher. In two other schools, changes were trialled and introduced at one year level or in one teaching team before being implemented more widely. All schools were continuing to adjust their science programmes in response to teachers' developing confidence, students' interests, and local science-learning opportunities.

6. Changing the focus of science programmes

Effective teaching programmes shifted the focus from content to developing science capabilities. Instead of laboriously researching topics, students were supported to question, predict, critique, and try things out. They worked with others to test their developing understandings and adapt them to new contexts. Science learning involved a balance of experiments and research. Some schools included activities designed to expand students' engagement with science for citizenship.

New planning templates were introduced to help teachers ensure their integrated or stand-alone science units provided increased opportunities for students to investigate, understand, explain, and apply their learning in meaningful contexts. These templates prioritised the *Nature of Science* strand, included the other science strands, and provided guidance about how to include the key competencies, specific learning objectives, possible scientific investigations, and resources. While teachers were developing new strategies, they tended to keep the contexts quite structured. As they became more confident in their teaching, they were able to adjust contexts in response to the students' interests.

In one school, the contexts, learning sequences, and activities were decided by the Years 5 to 6 students. Teacher guidance supported motivation and assisted students to work together effectively. By supporting their students to follow their natural curiosity, and design an investigation and presentation themselves, the teachers found the students became fully engaged and were *thinking and acting like a scientist*. Teachers saw that facilitating a successful science unit didn't require them to be experts.

Some schools developed a curriculum structure that placed emphasis on coherence, so that students would build on previous learning. These schools created long-term plans that identified the skills students should be developing as they moved through the years.

The aim was to ensure an appropriate level of challenge and avoid unnecessarily repeating topics from year to year.

Teachers (and sometimes students) sought out and used local opportunities and resources to create meaningful learning in a range of settings. Students were also able to learn about the links between te ao Māori concepts and science. Such opportunities helped them see how they might in the future contribute to a better environment or community. Lunchtime clubs and extension activities made provision for students who wanted additional science experiences. Consequently, many students reported that they enjoyed science and appreciated being given increased science learning opportunities.

7. Using a range of resources

Students became more engaged with science when teachers broadened the range of resources used. Science leaders shared with colleagues resources they had used in their classrooms or had been introduced to in external PLD. They introduced kits (for example, 'House of Science') provided by local councils or others.

In some schools, the science leader led a review of their school's science resources. They then used workbooks and equipment to make up kits that matched the topics their students were interested in. Boards of Trustees were kept informed about the improvement strategy and allocated funds to purchase items needed for the kits.

Whether developed by teachers or obtained from other agencies, kits were an effective means of increasing student engagement in science. Students were able to work in small groups, exploring a wide range of topics, and going where their curiosity led them. The use of kits reduced teachers' reluctance to attempt experimental science. Kits offered them a range of activities they could introduce to their students, along with some of the relevant science theory.

Students learning with science kits

8. Involving others in the community

Leaders and teachers used a variety of ways to involve community experts and to report to parents. Surveys usually showed that parents:

- understood the importance of science
- had little knowledge about the science their children were learning at school
- wanted their children to learn more science.

As a result, teachers gave students opportunities to share their science learning online and at parent conferences. They started including information about the child's involvement in science in school reports. In some schools, parents with scientific expertise led learning activities. One school developed a database of parents' science expertise. Parental involvement helped students understand how science is applied 'in the real world' and how it might be relevant to their own lives in the future.

All the case study schools made use of experts and community groups, sourced, for example, from museums, iwi, local council, industry, and conservation. These experts welcomed the opportunity to work with students both in and out of the school. Often, they would suggest others who might be willing to provide further support.

Some of the best learning took place when students sourced experts to answer particular questions. For example, one group of students gained new insights into their questions about sustainability by visiting a local marae. By supporting their students to access external expertise, teachers discovered that they could engage their students in purposeful science learning without necessarily being experts themselves.

Teaching strategies in secondary and area schools (Years 7–11)

Teachers recognised that if they wanted their students to be engaged and successful in senior science, then it was vital that their junior programmes were meaningful, and, at the same time, developing scientific thinking capability.

Three of the case study schools were focusing on building students' *Science Capabilities* while the others were focusing on designing a curriculum that was more authentic and coherent.

While ERO encourages schools to focus on the *Science Capabilities*, we have also included examples to help secondary and composite schools to think about how their science curriculum fits with other parts of the curriculum.

This section describes seven actions that influenced the improvement of science learning in the selected secondary schools:

1. Reviewing science programmes across all year levels
2. Carefully structuring the development of skills and knowledge
3. Linking science to students' lives and interests
4. Catering for individual interests, strengths, and needs
5. Using a mix of teacher-directed and student-directed activities
6. Changing the teaching focus
7. Working closely with other subject departments

1. Reviewing science programmes across all year levels

Science leaders and teachers in most of the case study schools reviewed their programmes with the aim of making changes that would encourage more students to continue with science in the senior school. They understood that, while for some students, science learning is necessary preparation for a career, all students need a level of science literacy if they are to understand and respond constructively to many of the issues they encounter in everyday life. Teachers also wanted to see more students gaining qualifications in science so that they did not find themselves blocked from career pathways that interested them.

Reviews generally focused on the content and coherence of current science programmes, and the extent to which they provided opportunities for students to become critical and creative thinkers.

In some schools, the review was undertaken by the head of department, with teachers then collectively deciding what changes should be made; in others, the review was a fully collaborative exercise. To identify areas for improvement, reviews variously made use of student surveys, teachers' own inquiries, and achievement data for junior students.

Some schools developed detailed action plans that clearly linked the agreed improvements to the school's vision. In others, the curriculum evolved over time, responding to what was or was not working, and to the needs and interests of students.

2. Carefully structuring the development of skills and knowledge

When redesigning their science curriculum, leaders and teachers took care to scaffold learning by building on existing understandings and introducing new skills and knowledge in manageable amounts. Contexts from previous years were not reused, but students were given multiple opportunities to revisit key concepts and practise important scientific skills.

Some schools started the redesign process at Year 7 or 9 and then worked forwards, seeking to lay a firm foundation for Year 12. Others started at Year 12 and worked backwards to Year 9 or 7. In all cases, teachers began by reaching agreement on the skills and knowledge students needed if they were to be successful in Year 12.

3. Linking science to students' lives and interests

Recognising that meaningful contexts are the key to high levels of engagement, schools looked to use local contexts where possible, where students could easily see the interaction between science and their everyday lives. Teachers sought to develop or strengthen partnerships with science-focused organisations and community groups that could potentially provide students with authentic, relevant science learning experiences. Small changes were made to include insights and knowledge from the cultures that learners whakapapa to.

New programmes prioritised in-depth investigations over brief, one-off activities because of the greater opportunities they offer for active science learning. This enabled students to process ideas, interpret different kinds of information, and make use of prior knowledge in new contexts.

Measuring exercise at Marist College

4. Catering for individual interests, strengths, and needs

New teaching programmes gave students increased opportunities to engage in science that tapped into their interests and used their strengths. Use of local resources and experts encouraged them to contribute from their own experiences and understandings.

Teaching was often personalised to cater for diverse interests and needs. Students might be asked to choose or suggest a context they would like to use when investigating a particular science concept. Such opportunities gave them greater agency in their learning and provided the right level of challenge to keep them engaged and achieving.

Students actively participated in group activities. They learned how to use science equipment safely and were trusted to work in small groups while the teacher roved about, asking questions and helping students clarify their thinking. Students valued the opportunities they had to work together and test their ideas with others.

Some schools demonstrated how they varied their programmes in response to the strengths and learning needs of the students. Science and literacy assessment data was analysed and used to determine specific areas that teachers should focus on. In some cases, the data made it clear that teachers needed to give greater priority to building their students' science vocabularies.

5. Using a mix of teacher-directed and student-directed activities

Teachers typically used a variety of activities in well-planned, learning-focused lessons. While the overarching aim was for students to become creative and critical thinkers, teachers recognised that they needed to be given a certain amount of basic information before undertaking independent or group investigations. This usually meant providing printed information or facilitating a simple investigation that introduced the students to the concepts they would need in their own investigations. In other instances, teachers would revise concepts covered in previous years before introducing more complex investigations. Some schools encouraged older students to work with younger students so that the different age groups could learn from each other. Working collaboratively helped to deepen student knowledge and learning.

6. Changing the teaching focus

All the case study schools shifted the focus of their science teaching programmes from knowledge acquisition to development of the skills, competencies, dispositions, and knowledge required for successful participation in science. This meant a renewed emphasis on the *Nature of Science* strand in programmes, topics, and teaching plans. To support teachers to make these changes, new guidelines and planning templates were developed.

Teachers facilitated student thinking by challenging assumptions, asking questions, inviting predictions, and introducing them to relevant scientific investigations. In some schools it was a while before students adjusted to this different approach, where they had to ask the questions and provide their own ideas and solutions. In the end they responded well to the changes and became more enthusiastic about science.

In some schools, assessment practices were changed to align with the new programmes. Some provided students with specific learning intentions that related to both investigative skills and knowledge building. Assessments were broadened to include more than written tests, with teachers also assessing group work, completed projects, posters, videos, and oral presentations. Teachers also kept a record of observations made during practical activities and group presentations, and these provided another measure of progress. One school used open-book assessments so that students could continue to learn even during assessments.

Investigating burning times

7. Working closely with other subject departments

In some schools, science teachers and leaders worked closely with teachers of other subjects. For example, a teacher might introduce a mathematics concept into a science lesson when the students were encountering the same concept in their mathematics class. One school introduced an assessment task that enabled students to gain NCEA credits in both science and mathematics. In another school, teachers from the English department were able to show science teachers how they could support students who were struggling to write scientific reports. Collaboration among teachers helped to establish consistency among the different strategies that students could use to improve student progress and achievement. Some science teachers engaged careers staff to help students understand that science learning was a requirement for a wide range of careers.

PART 2

Case studies of science practice

This section summarises the case studies of science practice in the schools that participated in ERO's study. ERO encourages other schools who are looking to strengthen their teaching of science to try some of the approaches described with the aim of improving science teaching and learning in their own schools.

ERO reviewers visited thirteen schools. All schools were at different stages in their science developmental journey, with areas they were still working to improve. Their approach to science education is summarised in the following case studies:

1.	**MALFROY SCHOOL,** a Year 1 to 6 school in Rotorua	Engaging students in multiple, rich, local learning opportunities
2.	**PEGASUS BAY SCHOOL,** a Year 1 to 6 school north of Christchurch	Growing leadership to enhance student learning in science
3.	**WITHERLEA SCHOOL,** a Year 1 to 6 school in Blenheim	Reviewing and improving student engagement in science
4.	**CHURCHILL PARK SCHOOL,** a Year 1 to 8 school in Auckland	Growing curious minds
5.	**ASHBURTON INTERMEDIATE,** Year 7 and 8 School in Ashburton	Improving student engagement in and perceptions of science
6.	**REMUERA INTERMEDIATE,** a Year 7 and 8 school in Auckland	Ensuring all students engage in high-quality science programmes
7.	**THE CATLINS AREA SCHOOL,** a Year 1 to 13 school in Owaka Southland	Developing a well-structured curriculum
8.	**MENZIES COLLEGE,** a Year 7 to 13 school in Winton Southland	Increasing engagement in and the relevance of science learning
9.	**WAITAKI GIRLS’ HIGH SCHOOL,** a Year 9 to 13 school in Oamaru	Developing authentic, place-based science programmes
10.	**CENTRAL SOUTHLAND COLLEGE,** a Year 9 to 13 School in Winton Southland	Catering for students’ interests, strengths and learning needs
11.	**TAIKURA RUDOLPH STEINER SCHOOL,** a Year 1 to 13 school in Hastings	Developing responsive and well-structured science programmes
12.	**MARIST COLLEGE,** a Year 7 to 13 school for girls in Mount Albert, Auckland	Scaffolding learning through a spiral curriculum
13.	**KERIKERI HIGH SCHOOL,** a Year 7 to 13 school in Kerikeri	Increasing engagement and achievement in science

1. Engaging students in multiple, rich, local science learning opportunities

Malfroy School in suburban Rotorua provides education for students in Years 1 to 6. The school's roll of 333 includes 189 Māori students.

Improvements in science teaching give Year 5 and 6 students opportunities to investigate and understand science concepts and skills as part of a high-quality, flexible programme that uses local resources to enhance engagement.

The school prioritised developing teachers' confidence in science teaching, making teaching resources more easily accessible, and introducing improved teaching approaches. Teachers actively sought out and used a wide range of local resources and experts. These increased both their own and students' learning. Teachers realised they did not need to know everything about a topic. Supported to follow their own interests, students deepened their learning to the extent that teachers were often able to learn alongside them.

Developing teachers' confidence to teach science

The impetus for change began in 2015, when leaders were reviewing the science programme with a view to moving from the teaching of discrete topics to an integrated approach based around students' questions.

The senior school team leader and the teacher in charge of science applied to the Sir Paul Callaghan Science Academy for professional development. During the four-day programme they learned how science was important for both innovation and the economy. They also learned about the theory behind different science concepts and experienced a range of practical activities they could use with their students. They recognised that, while their programme had covered four of the *NZC* strands, it had largely overlooked the *Nature of Science* strand.

The two leaders shared what they had learned with the principal, who worked with them to bring a proposal to the Board of Trustees for additional resources to support whole-school development of the science programme. A science improvement goal was endorsed by staff and included in the School Charter Improvement Plan for 2016-2019. Six more teachers attended the Sir Paul Callaghan Science Academy in the 2016 school holidays. Eventually, almost all teachers attended this PLD.

The two teachers leading these developments also participated in PLD facilitated by Te Toi Tupu. The facilitator provided theory and practical teaching examples, including modelling the teaching of the science capabilities. The teachers shared their learning and resources with those in their professional learning group (PLG).

At the start of 2016, all staff were surveyed to find out:

- how confident they were in teaching science
- how they were teaching the *Science Capabilities*
- what topics they were teaching and how they taught them
- to what extent science was integrated into their class programmes
- any barriers they experienced to teaching science
- what ideas they had about assessment of science.

The survey was repeated at the end of the year and the responses compared and analysed. It was found that science was no longer being taught as a stand-alone subject, but was, at least to some extent, integrated into class programmes. More teachers felt 'very confident' with teaching science, and 'confident' when discussing science-related issues with their students. Teachers did not feel their teaching of the *Science Capabilities* had improved, which probably reflected their increased understanding of what was involved.

The survey is now repeated annually in term three and the findings used to plan further improvements.

Accessing and improving science teaching and learning resources

Greater use of teaching resources was found to increase student engagement in science.

When the science leaders did an inventory of resources early in 2016 they found they had many text and equipment resources that were not being well used. Fortunately, around that time, a local community initiative was launched that provided a solution to their resource management and use problem.

This was the launch by the Te Taumata o Ngāti Whakaue Trust of sponsored House of Science kits. Each of these kits has a different context and includes everything a teacher needs to engage their students in at least six hands-on activities. The kits have bilingual student instructions and a teacher manual, both of which align to the *NZC*.

Teachers in the science PLG were then inspired to arrange their other resources into 'grab and go' kits, each based around a different context and designed for a particular learning level: junior, middle, and senior. This facilitated a more coherent curriculum, encouraging teachers to build on prior learning and thereby reducing unnecessary repetition with its attendant risk of demotivation. Teachers could take a box for two weeks, or a teaching team could take a box for a term, sharing the contents as needed.

New 'grab and go' boxes continue to be developed in response to new contexts and opportunities. Each year the science leaders prepare a pre-budget list of the equipment they need; the Board considers their recommendations and provides appropriate funding to support current science priorities. Comprehensive, easily accessible resources encourage teachers to continue to work on developing their students' science capabilities.

In 2019 the PLG was continuing to focus on the *Science Capabilitie*s, and also on integrating science, literacy, and mathematics.

Each year the school prioritised science for a term, selecting a context that would offer a wide range of learning opportunities. But the curriculum was now sufficiently flexible to allow teachers to do a considerable amount of science in the other school terms in response to students' interests and local opportunities. With greater integration of learning areas, students were now able to engage in authentic reading, writing, and mathematics activities linked to the science context.

The Utuhina Warriors

In 2017, the students came up with the idea that they could be 'Utuhina Warriors' – kaitiaki of the local environment. This initiative coincided with a strong teacher focus on increasing learner agency.

Working with the Rotorua Lakes Council's sustainability advisor, senior students had many opportunities to follow their own ideas and interests. It was through this connection that they decided to clean up the Utuhina Stream area, close to their school.

The clean-up went ahead with help from the Council, some secondary school students involved in a community service programme, and a small number of Police staff. The students were horrified to find that in just two and a half hours they and their helpers had collected 450kg of rubbish, most of which was recyclable.

Some of the rubbish the children collected from the stream

Reflecting on the clean-up, one class asked why people didn't care about streams. Encouraged by their teacher to think collectively about ways of reducing the amount of rubbish that ended up in streams, the students came up with seven different areas to investigate. They decided to include Year 5 and 6 students in their investigations. The teachers wanted to ensure that each of the seven groups comprised only students who were passionate about seeking solutions, so they added an eighth 'opt out' group. These students would do a mix of physical education activities, looking after school gardens and doing school clean-ups. Students joined the group that most interested them and worked on their investigations two to three times a week for over a term. Many of the students that the teachers had expected to join the 'opt out' group joined one of the other groups and became some of the most passionately invested learners.

Teachers used a range of templates and guidelines to help the groups manage their investigations. These included simple job descriptions for different group roles. But it was the students who allocated roles and responsibilities to make maximum use of each person's strengths. Similarly, it was the students who determined processes, came up with the ideas, and decided which of them to pursue.

Each group worked through these eight phases:

- brainstorming ideas
- prioritising ideas
- setting up a taskforce
- planning actions
- presenting the plan and justifying ideas to a student voice representative
- checking how the project is progressing
- reflecting
- preparing and delivering a PowerPoint presentation to explain the project.

One group went to Ohinemutu, where the Utuhina Stream meets the lake, and listened to elders at the marae tell how they had used the stream in the past, but no longer could. The elders were saddened by the pollution but glad that the children were now spearheading the stream's restoration.

At the end of the investigations, 26 students delivered presentations of their investigations and findings to members of the Council's works committee. The students answered questions and asked about the history of the stream and how it was being used. Some were surprised to find that they had the confidence to do this, and to discover that they had the potential to influence others.

Students worked with a local artist to design and paint a variety of large signs that the Council then put up near the stream. It is grounds for encouragement that the signs have not been removed or defaced.

One of the signs the children designed and painted

Aquabots

Another local initiative that has fostered considerable science teaching and learning is the Aquabots competition. A science leader was offered the opportunity to enter students in the competition, supported by the local museum's education programme. To successfully build an underwater robot, students first had to investigate concepts such as buoyancy, navigation, and wave motion.

As well as learning new science concepts and skills, the students learned that if you work hard and do your best you can achieve anything. In 2019, the school's Aquabotics team was selected to represent New Zealand in the 2020 international competition in Washington, DC. In 2020, more students were able to be involved thanks to sponsorship that enabled them to obtain additional kits at no cost to the school.

Looking back, the science leader says that the PLD and reorganisation of resources did initially increase the workload of teachers, but the way students have responded has increased their confidence and their enthusiasm for teaching science.

"The quiet kids who sometimes lacked a bit of confidence have grown into confident, self-motivated learners, and it has all been more than worth it.

I am not a science specialist. I wasn't even particularly interested in science or technology except as a way to motivate my reluctant Year 5 and 6 writers. I am just an ordinary teacher among other ordinary but dedicated teachers. However, I did believe that we could teach through science and the social sciences and make a real difference. I'm lucky enough to be in a school where leaders, teachers, and trustees have the desire to see kids engage, create, discover, fail, conquer, care, and learn real skills and real lessons in real contexts."

2. Growing leadership to enhance student learning in science

Leaders and teachers at **Pegasus Bay School**, a Year 1 to 8 primary school situated north of Christchurch, have focused on developing a learning environment that engages all students. As they reviewed their curriculum recently, it became clear that, in science, they needed to shift the emphasis from gaining knowledge to making science meaningful. This linked closely to their desire to make greater use of student voice and to engage students in authentic learning experiences.

A new leadership role, with a management unit, was created for a teacher to build on current good science teaching practice and introduce new practices that would enhance learning.

Prioritising science as part of the improvement focus

Improvements to the school's science programme were in the early stage of development when ERO visited the school. During the previous two years, leaders and teachers had consulted with the community and, as a result, had identified the kind of learning environment they wanted for their students. It would develop students who would:

- gain, maintain, and use knowledge
- think beyond the given
- relate confidently with others
- understand and value collaboration
- create ideas and opportunities
- learn through the *Nature of Science*.

To bring these qualities to life, the leaders knew they had to extend their range of teaching approaches and strategies.

As part of the review process, teachers and teaching teams had undertaken inquiries into current strengths and issues, with the aim of identifying new teaching opportunities across the different curriculum areas.

The impetus for changing how science was taught came initially from one teacher's inquiry and professional development. This inquiry involved collecting and analysing students' perspectives on their experience of learning science in the school. It found that, while science was being taught to a greater or lesser extent throughout the school, many students were unaware of what it was that they were learning.

It was clear that, to develop the desired learner qualities (see bulleted list above), greater emphasis needed to be put on the *Nature of Science* strand and the *Science Capabilities*.

The teacher in the new leadership role recognised that a first step was to ensure that teachers knew the curriculum well and were fully aware of what it was that they were teaching. An improvement plan focused initially on determining what was currently happening, and then supporting teachers to make small changes to their programmes. The next step involved participating in professional learning and development focused on teaching practices and understanding the *Nature of Science* strand.

In 2019, the lead science teacher developed the following improvement plan:

Strategic learning goals: Develop clear learning pathways across the school to ensure clarity for all students; strategically resource science equipment to ensure maximum benefit for all students

Annual learning goal: Ensure that each syndicate is delivering a transparent science curriculum focus so that students at each year level are fully aware of the science learning that is integrated into literacy and numeracy learning

When	What do we need to change and what do students learn?	Who is responsible?	Indicators of progress (what will we see that has changed in learners'/teachers' behaviour?)
End of Term 1	Share an outline of what has been taught in science and how it links to other curriculum areas.	**Syndicate leaders**	By the end of Term 1, syndicated leaders will know what science is taught and how it links to other curriculum areas.
End of Term 2	As above, and add information about inclusive practices, focusing on engagement of Māori students, gifted and talented students, and students with special needs.	**All staff**	By the end of Term 2 teachers will be able to show how their science teaching links to Individual Learning Plans, caters for diverse learning levels, and uses culturally responsive practices.
End of Term 3	As above, and … students are able to talk about what they have learnt and how it links to science.	**School and syndicate leaders** **Students**	By the end of Term 3, students will be able to explain links to the science curriculum.
End of Term 4	Whānau engagement	**Students** **Teachers**	By the end of Term 4, all whānau will have: • received information about upcoming science events • seen science work uploaded by their child • received invitations to be part of experiential learning.

The lead teacher and the principal formulated a strategic plan and outlined consequential actions. They then established a release schedule that gave teachers time to do peer observations of science teaching methods, both in-school and out-of-school.

The lead science teacher supported colleagues by:

- working with teaching teams to plan science activities as part of integrated teaching units
- sourcing additional science books, internet, and equipment resources
- facilitating professional development sessions in which science teaching was modelled
- developing science planning templates for each year level
- highlighting the *Science Capabilities* as a framework for teaching.

Senior leaders valued the way the lead science teacher supported improvements across the school and were pleased with the early positive impacts for students. As a result, the Board of Trustees approved the teacher's application for significant professional development with the Royal Society | Te Apārangi in 2020. To support ongoing improvements, the Board also provided additional funds for science equipment.

Building on existing good practice

Before embarking on school-wide development of science teaching practices, teachers of Year 5 and 6 were already working together collaboratively to plan science learning opportunities for their students. The science leader, who was part of that team, worked alongside colleagues to demonstrate teaching that involved authentic investigations and fostered scientific thinking.

These teachers developed and used a planning template that included space for teachers to list the science understandings they wanted the students to acquire and the investigations to be carried out. The template, collaboratively completed, focused teachers on identifying the aspects of the *Nature of Science* strand they intended to emphasise. As a result, students were given increased opportunities to learn how scientists undertake investigations.

The specific learning outcomes teachers developed for Year 5 and 6 students

Students will be able to:

- *work successfully in a group*
- *use higher level thinking to make a hypothesis about the outcome of a simple experiment*
- *critique and record steps taken to the eventual outcome*
- *make wonderings about what could be changed to reach an alternative outcome and work towards understanding why the outcome may have changed.*

Using the template, teachers outlined their plans:

- for skills to increase students' understandings about science
- to increase students' investigative skills
- to gain and use content knowledge from related curriculum strands
- to foreground the specific learning outcomes for students.

They also highlighted the focus on *Science Capabilities*.

At the end of the unit teachers discussed and recorded reflections on what was successful and what should change in the future.

Year 5 and 6 students were given clear guidelines about what they were learning and why they should learn it. Their own ideas about how to manage an investigation, and their predictions, were also respected and trialled. Templates encouraged them to record their questions and developing theoretical understandings, and to 'think like a scientist'.

Students stored the records of their learning and their reflections online and were able to share them with whoever they wished, including their parents. ERO spoke to students who enthusiastically shared how much they had enjoyed the experiments they had completed. They were able to talk about the purpose of each activity, to make links to their mathematics, technology, and literacy learning, and to explain how this learning might help them in the future.

Extending students interest in science

The lead science teacher introduced a Friday afternoon science academy for students. Year 5 to 8 students applied to join the academy for specialised science learning. The only prerequisite for joining was that the student had to be interested in science.

The teacher started the academy after connecting with a local environmental group from the Tūhaitara Coastal Park Trust. Members of the trust met weekly with the academy students and they worked together to protect and enhance the local wetland. Academy students were given widely varying learning opportunities – including working with a vet to dissect a cat to understand what cats eat, and their digestive system.

The enthusiasm of the academy students, and, more generally, Year 5 and 6 students, provided excellent teaching models for others to follow. The willingness of leaders and trustees to use in-house expertise to grow and support new leaders, provide for significant PLD, and allocate resources for science equipment, created a strong platform for ongoing improvement in science teaching and learning across the school.

3. Reviewing and improving student engagement in science

Witherlea School is located in Blenheim and has a roll of 396 students in Years 1 to 6.

Following an in-depth internal review, leaders and teachers committed to changes designed to improve the teaching of science. These included a range of approaches and strategies aimed at increasing the teachers' confidence to teach science.

Ninety-eight percent of the parents who responded to a recent survey agreed that science was an important subject. But in previous years, when the focus was on numeracy, literacy, and modern learning practices, science had been largely neglected. The teachers now wanted to re-energise and refresh science teaching, by building on existing pockets of good practice.

To support this goal, provision was made for a teacher to participate in the Science Teaching Leadership Programme (STLP) facilitated by the Royal Society | Te Apārangi. The teacher returned with vital leadership skills and an understanding of how to strategically manage change.

Reviewing the current science programmes and outcomes for students

In 2017–18 the teacher with responsibility for leading improvements in science teaching and learning undertook an extensive review of current strengths and weaknesses. The review investigated the perspectives of students, teachers, and parents, and the impact that science teaching was or was not having on students.

Student data

Student data was gathered from three useful sources: NZCER's Science Engagement Survey, targeted observations, and student discussion groups (see the following table). Data from each source was collated and analysed with the aim of clarifying the current situation and deciding priorities for improvement.

NZCER Science Engagement Survey	Targeted observations	Student discussion groups
The survey was completed by Years 3 to 6 students at the end of 2017. The data was analysed to discover student confidence with: • close observations • interpreting and critiquing data • communicating what they have learned	Observations were made of two science lessons (different class levels). In one, groups of Year 6 students took part in a fizzing and foaming activity. One group at a time, the students were asked about the *Science Capabilities* and then to draw what they had learned. The teacher recorded and analysed data relating to engagement and the capabilities, considering: • observations • inference • using evidence • interpreting evidence	One of the two discussion groups comprised 20 Year 6 students. They were asked: What is science? Who is a scientist? What do scientists do? Why do we do it/learn about it? What science do you remember doing? What science topics do you most enjoy? Have you had any scientists come and talk to you, or have you visited scientists? The students were also asked to 'draw a scientist'.
Possible next steps were developed from each of the data sets, and actions prioritised.		

Some children find it easier to explain their thinking through drawing. In this case, drawings were used to give teachers insight into which *Science Capabilities* the students were using.

Teachers found that drawing helped students clarify their thinking when making inferences, using evidence, and collating ideas.

Teacher data

Four different means were used to evaluate teachers':

- understandings of the *Nature of Science* strand and the *Science Capabilities*
- confidence with, and enthusiasm for, the teaching of science.

STLP teacher survey	The school's own teacher survey	An interview with selected teachers of Years 5 and 6	Observations and conversations during PLD
Well over half the teachers had some understanding of the *Nature of Science* strand; far fewer knew of the *Science Capabilities*.	The survey asked teachers: • what skills and topics they taught or avoided the most • what support they needed • what things should change • how much they enjoyed science • what skills and knowledge they could share with others.	Four teachers were interviewed about their confidence and capability in teaching science.	The leader noted questions, confusions and stereotypes about science, and any change in opinion.

Parent data

At the Term 1 meet-the-teacher evening parents were handed a survey in the hope that a personal approach might get a better response than an online survey. Teachers gave a short talk about the survey, and most parents filled it that evening. In all, 138 out of 200 families responded.

Other data

The lead science teacher also interviewed the lead science teacher at the local intermediate school, which most students went on to attend after leaving Witherlea.

Planning for improvement

The lead science teacher used release time funded by the Royal Society | Te Apārangi to analyse the data that had been gathered and to create a draft school science development plan. Two other teachers joined him on a release day to discuss and finalise the plan, which was then presented to the whole staff at a meeting, where expectations of teachers were discussed and agreed. The plan was then taken to the board of trustees and adopted as part of the school's strategic plan as outlined in the box:

To build on and sustain the amount of science teaching and learning that is occurring at Witherlea:

- Promote the new classroom science kits and exposure to science
- For teachers and students, use scientific vocabulary, including the first two capabilities, observing and inferring
- Create a student Enviro group and involve them in how we can improve the school. Start with a Bio-blitz
- Support Enviro team students to become familiar with the apps iNaturalist and eBird
- Give teachers practical ideas around sustainability teaching
- Continue science tables in classes
- Create a Year 5/6 science club that will work towards the Scitec Fair.

What is a Bio-blitz?

A Bio-blitz is an exercise designed to discover everything that is living within a designated area. Two of these took place in 2019. The seniors took part in a regional Bio-blitz and returned to school to lead one.

Students involved in a Bio-blitz

Actions to increase students' engagement in science

During 2018, a range of strategies were introduced to increase teachers' confidence with teaching science. PLD sessions conducted by outside agencies introduced teachers to Māori perspectives, Living Landscapes (covering sustainability science, growing plants, compost, pest control), Bio-blitzes, and the Ministry of Education's Connected instructional series.

The lead science teacher worked with teachers in the classroom. During lessons, teachers were encouraged to try new activities and to ask students lots of questions, allowing them plenty of thinking and talking time. Teachers recognised that, if they kept things simple, they were making space for the students to develop and expand their own theories and ideas. The science leader also helped teachers identify ways to integrate science into other subject areas.

The kits used many of the resources already available in the school

Science resources were organised into kits, and these became available for use in term 4, 2018. The kits contained basic equipment, materials for one-off activities, and a folder with teaching guidelines for a range of activities relating to a specific topic.

Some included digital and traditional microscopes, which allowed students to make more detailed observations and identify flora and fauna by loading photos onto apps such as iNaturalist.

The science leader monitored the use of the kits as part of ongoing review. This helped identify what support and PLD was effective, and where further support was needed. It was clear, however, that introduction of the kits had considerably increased the amount of science teaching taking place.

Science tables were also introduced, with specific themes or items to interest students. They were designed to encourage students to observe and identify things they saw in the playground or collected from home. Most students interacted with the science tables at least weekly, with around a third looking at them each day. The tables provoked lots of discussion and questions.

Teachers focused on developing in students the ability to 'think like a scientist'. This meant a few myths had to be dispelled. The students had to learn, for example, that scientists don't necessarily wear lab coats or work in a laboratory; science is everywhere and uses all kinds of thinking skills; scientists look closely at things, listen, and ask questions. Once the students identified these characteristics they were able to start practising thinking like a scientist.

In 2019, a science club was formed to cater for students who wanted to engage in science extension activities. Students applied to be part of the group by sharing something they knew about science. All who applied were accepted. The club had 30 Year 5 and 6 students who met regularly during Terms 2 and 3.

Students were encouraged to follow their own science-related interests. When the climate change strikes were being held around New Zealand in 2019, a number of Year 5 boys formed a group they called 'the Climate Change Boys'. Members of the group made signs and organised travel to, and involvement in, the local strike. They also sourced predator traps and embarked on a trapping programme at the school.

The Climate Change Boys

Changes in teachers' confidence with science

Ongoing monitoring revealed that changes made in line with the science development plan had led to considerable improvements.

Most teachers had discarded or modified their science-related stereotypes. Resources and ideas were now more accessible and less intimidating. Teachers recognised that they didn't have to know all the theory before initiating a science lesson; rather, they needed to rely more on the students' own wonderings, ideas, and research. As a result, science was being taught more often, and more regularly integrated into literacy learning. Teachers felt greater freedom to sometimes have a spur-of-the-moment or one-off science lesson linked to a student's interest or a local event.

Survey results revealed that teachers now had greater understanding of the *Science Capabilities* and the *Nature of Science* strand. Most were facilitating more science than before. PLD and other supports were to continue to ensure that all students were engaged in and learning science.

4. Growing curious minds

Churchill Park School is a full primary school in Glendowie, Auckland with a roll of 450 students.

During 2015, two teachers and the principal participated in the Royal Society's Science Teaching Leadership Programme (STLP)[2]. The teachers then used the knowledge and leadership skills they had acquired to improve the quality of science teaching and learning in the school. They also worked with school leaders to strengthen educational partnerships with parents and whānau.

Research shows that when leaders promote and engage in professional learning alongside teachers, this has a significant influence on student outcomes.[3] By being involved in the PLD, the principal could clearly see the potential for improvement, and how the two teachers, with the support of other leaders, could bring about change. Given strong collective commitment, it was possible to introduce many positive changes into the way science is taught in the school.

The school adopted a new vision, 'Promoting curious minds', and made major changes to its teaching and learning goals in its 2016–18 strategic plan. The plan included this goal:

> *Grow 'curious minds' through developing innovative learning pedagogies and a scientific, inquiring curriculum.*

Self-review played a key role before and during implementation of improvements. Surveys of students, staff and parents/whānau guided decisions about resource allocation and PLD priorities.

The adjacent box shows the survey used to gauge student engagement in science. Results from the first mid-year and end-of-year survey showed improvement in relation to all but question 4. The improvement was greatest for question 5.

The results from the surveys were analysed and presented to the staff, and next steps determined collaboratively. As developments continued, other teachers undertook team inquiries into different facets of science education and how they could be improved. These inquiries were ongoing, with findings contributing to school evaluations and subsequent actions.

Student survey (Years 5–8)

1. *How much do you like science?*
2. *In class are you encouraged to take time to observe something carefully?*
3. *In class are you encouraged to investigate your own questions?*
4. *Are you encouraged to think about how much you can believe your results?*
5. *Do you use models to explore and explain science ideas?*
6. *Do you have opportunities to work on real-life projects?*

(Students responded to each question with a number between 1 and 10.)

2 For more information about STLP see Corbitt, J., Ako Learn, Ako Teach, *New Zealand Principal*. 34(4), 30-32.

3 Robinson, V. M. J., Lloyd, C., & Rowe, K.J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership type. *Education Administration Quarterly*, 44(5), 635-674.

During 2016, the two lead teachers facilitated intensive PLD at fortnightly staff meetings. Teachers were introduced to hands-on science experiments they could repeat with their students. They also learnt about the *Science Capabilities* and the *Nature of Science* strand. Teachers were encouraged to focus less on the context strands and more on developing citizenship capabilities, with the aim of developing students who were ready, willing, and able to use their science knowledge.

Science for citizenship

To develop Year 5 to 8 students, who were motivated, informed, and involved in local science issues and solutions, teachers began to focus more on science-related thinking, questioning, and acting.

Environmental studies was an area that had a clear science focus and promoted students' scientific thinking. Students became actively involved as kaitiaki of animal and plant life in the local Churchill Park area. Respect for Papatūānuku supported students' understanding of how and why people construct theories and narratives to explain the relationship they have with the environment. Students spoken to by ERO were confident and enthusiastic about their kaitiaki role, how it contributed to environmental sustainability, and how it improved people's lives.

A wide range of science activities engaged students. These included:

- Whitebait Connection – Students undertook water testing in a local stream to provide data for the Council's database. They also planned actions to communicate their concerns about the quality of water reaching our oceans.
- During school camp, students compared the quality of the water in a stream at the camp site with the quality of the water in the local stream. They then suggested possible reasons for the differences.
- Year 7 and 8 students visited Rotoroa Island to investigate the ecological restoration that has been carried out there. They were interested in the methods used to rid the island of predators. They saw the advanced technologies used to gather data about different animal species and predators.
- A senior school inquiry into marine environments prompted students to introduce a plastic bottle challenge as part of a STEAM (Science, Technology, Engineering, Art and Mathematics) activity in which students had to design and construct a plastic raft. Some of the rafts made extensive journeys – one was even shared on national television. This challenge raised awareness of the impact of plastics on marine environments.
- Students studied local beaches as part of a marine inquiry unit. They used the marine metre squared (Mm2 process) developed by Otago University. Students marked out a metre by metre patch, counted all the animals and plants they found there, recorded this data on a datasheet, and uploading it to the Mm2 database. The students were then able monitor how things changed over time. As they investigated and compared different beaches they learned to focus their observations and refine their methodologies.
- An annual beach clean-up led to art activities as a way of communicating findings related to the rubbish collected.
- A survey of birds in students' gardens was integrated into the mathematics programme as an authentic statistical investigation.
- Year 8 students hosted the Science Roadshow at the school as a host Environment School.

The Year 7 and 8 students that ERO spoke to, valued the way science required them to think for themselves and engage in hands-on experiences that were not restricted to the classroom. The *Science Capabilities* were embedded in the school's 'learner qualities' framework, which meant the students could use well-practised and understood learning strategies across the curriculum.

The following is part of the framework used by students and teachers to focus on the *Science Capabilities*. The complete framework includes 'I can' statements for critiquing evidence, interpreting representations, and engaging with science.

Living World | Planet Earth and Beyond | Material World | Physical World

Nature of Science	**Science Capabilities**
Understanding about science	1,2,3
Investigating in science	1,2,3
Communicating in science	4
Participating and contributing	5

Assessment criteria, levels 3 and 4

	Level 3	**Level 4**
SF1: To Gather and Interpret data	I can make accurate observations without being prompted. I can clearly differentiate between observation and inference. I can use more than one sense, identifying components, attributes, changes, and make comparisons. I can use appropriate tools for observation, measuring and recording. I use topic-specific language and phrases to clarify my observations. I can come up with ideas of what might be happening.	I can explain my ideas by linking them to my observations and/ or prior knowledge. I use 'correct' science ideas to make sense of my observations. I can independently ask a variety of questions which lead to further investigation. I can select the most appropriate questions, with valid reasoning, to investigate. I can refine my questions to develop a systematic investigation.
SF2: Use evidence:	I can make clear explanations using evidence to support my claims. I can identify when evidence is not robust. I can compare and contrast conflicting evidence. I can discuss what leads to my opinion.	I can identify data that support a claim and how that same data could support different claims. I can weigh up evidence before making a decision. I can select the relevance of my and others' prior knowledge.

Building partnerships and using community expertise

Parent/whānau feedback provided the impetus for strengthening school–home partnerships focused on students' learning. In an inquiry conducted by a teaching team, many parents reported that their children shared their science learning with them and that they were demonstrating increasing environmental concern. But about 40 percent of parents said they had seen or heard nothing about the considerable environmental work that their children had been engaged in at school. As a result, teachers and leaders established the following new goal:

Foster scientifically-engaged families by making science learning inclusive of the local and global communities.

They chose the following actions to assist with achieving this goal:

- provide opportunities for parents and students to share their expertise and experiences
- involve parents with science teaching and learning
- develop a database of parent and community contacts with expertise
- introduce three-way communication about science learning
- hold a parent open day where students teach parents, focusing on the *Science Capabilities* as a way of talking about science.

School leaders and teachers asked local iwi to be involved in their scientific studies, particularly to draw on their knowledge about the environment. A Māori parent who taught te reo in the school regularly supported teachers with planning to include tikanga and Māori perspectives regarding the environment. As a result of the involvement by iwi and other community members, the students had an increasing appreciation of the wetlands, forest, farm, marine environment, streams, and bird sanctuary in the vicinity of the school.

Teachers took advantage of the wide range of scientific expertise and knowledge in the parent community. Parents were invited to contribute and learn alongside their children in science focus weeks. On a camp for Years 7 and 8, parents helped students gauge and record river flows. The students responded positively to parent involvement and to how the adults valued their scientific findings. This partnering with parents later extended to other learning areas and areas of school life.

Evidence of progress

Leaders continued to use surveys, observations, and analysis of assessment information to gauge how changes were or were not impacting on student outcomes. Data about science kit usage was a useful measure of the amount of science teaching going on, and this contributed to resourcing decisions.

Evidence to date indicates that teachers are now more confident about teaching science, and science teaching and learning is more firmly embedded in all classrooms.

Internal evaluation has found that, as a result of changes made, students had improved on the following six measures:

- ability to observe like a scientist without prompting
- questioning and curiosity about what they were observing
- engagement in observing phenomena and objects in the world
- use of science vocabulary
- accessing a range of science organisations in the community and beyond
- awareness of how their parents use science in the workplace.

The following quotes from Year 7 and 8 students show that they have enjoyed testing their own theories and solving problems themselves:

"My teacher knows how to help us with our understanding but also knows when to leave us alone to do our own thinking."

"I enjoy getting the chance to think together with others or by myself. First, we have to write down what we think or what we already know and then we work in groups to come up with the answers."

5. Improving student engagement in and perceptions of science

Ashburton Intermediate School has a roll of 400 students in Years 7 to 8. Most of its students come from six primary schools, and most go on to the neighbouring co-educational college. Science is taught by all classroom teachers.

A review of science teaching and learning identified strengths, issues, and priorities for improvement. Following the review, a range of carefully considered actions were implemented to improve teacher confidence and student engagement in science. As a result, students now have increased opportunities to learn and apply scientific skills, and to do so in contexts that genuinely engage them.

This case study shares the review process and some of the actions that have led to increased numbers of students succeeding with, and enjoying, science.

High-quality internal review

In 2017, as part of the school's regular review cycle, the curriculum leader and curriculum committee undertook a robust review of science programmes. The review took account of achievement information and data from surveys completed by teachers, students, and parents.

The surveys were drafted by leaders and revised after consultation with teachers. Thanks to an incentive for the class that returned the most responses to the parent survey, the school eventually heard back from 62 percent of its parent community. The surveys provided widely varying perspectives on the weaknesses and strengths of current science programmes.

The responses to the surveys were collated and collaboratively analysed, with the aim of identifying key improvement areas. It turned out that, while many students enjoyed science, there was a significant group who were unengaged and not enjoying science. As a general goal, the school wanted to increase the number of students who were positive about science when they left for high school at the end of Year 8.

As part of the survey, students were asked to indicate whether they:

- *liked or disliked science*
- *would like to learn more science*
- *were given enough support with their Science Investigation (Science Fair)*
- *would like to do another annual Science Investigation in the future.*

They also were asked to indicate which science topics they enjoyed and the parts of science learning they enjoyed the most. Students suggested science teaching improvements to assist with their learning.

The wide range of comments collected during the survey showed students were safe to share both positive and negative perspectives of their engagement with science.

The review found that more science was taught in Year 7 than in Year 8 and considerably more Year 7 than Year 8 students enjoyed learning science. Almost all teachers indicated they would like to participate in science PLD, and many parents requested more information about their child's progress and achievement in science.

Being involved in finalising the survey questions and analysing the response data gave teachers greater understanding of the issues and increased their commitment to finding and implementing improvement actions.

Year 7 achievement data was obtained using the NZCER's Thinking with Evidence test. To evaluate progress and highlight further developmental needs, the students repeated this test at the beginning of the following year. Furthermore, a liaison teacher from the local Kāhui Ako Community of Learning agreed to administer the test again at the beginning of 2019, with the same cohort of students, then in Year 9 at Ashburton College.

When ERO visited Ashburton Intermediate in 2019 they were pleased to see that increased numbers of Year 8 students were in the upper achievement bands, and fewer in the lower achievement bands.

Key outcomes of the review process include the following:

- The teacher leading the developments was provided with a management unit.
- Professional learning for teachers was facilitated by the teacher responsible for science, supported by the secondary teacher from the Kāhui Ako. This PLD was directed at increasing the number of engaging activities and experiments going on, and making use of the resources already available in the school.
- Reporting to parents was increased, providing them with more information about what their child was learning and how they were achieving.

Changing the focus

The science leader participated in professional learning provided by the Sir Paul Callaghan Science Academy, where they were able to see science being taught in completely different ways.

The leader recognised that science teaching didn't necessarily involve expensive kits and equipment. In fact, if students were to connect science with their everyday lives, things should be kept simple. It's more important for the teacher to ask 'why' questions, and use student wonderings as starting points for investigations, than to have access to costly equipment.

The box below outlines a sample science lesson that uses everyday material.

Students used tomato sauce to clean 10c coins.

After they had cleaned their coins the teachers explained that a chemical reaction occurred, which separated the copper oxide from the coin, making it look clean.

The students then asked these questions:

- What is in the sauce that cleaned the coin?
- Will other sauces work?

When they discovered that it was the vinegar in the tomato sauce that causes the reaction that cleans the coin, the students posed new questions for investigation:

- What if we put the 10c coin in straight vinegar?
- Will this work with different types of vinegar?
- Will tomato sauce clean the other New Zealand coins?
- Can we use vinegar to make a cleaning product?

Another change arising from the PLD was a greater emphasis on the *Nature of Science* strand. This meant, for example, giving students increased opportunities to apply concepts to issues and challenges in their own lives, develop observation skills, theorise without jumping to conclusions, and communicate scientific thinking and ideas.

Teachers also revisited and used some of the older Ministry of Education resources such as the Building Science Concepts series.

The science leader facilitated considerable staff PLD, supported year groups with planning and resourcing science units, developed new science kits, and led the introduction of a new teaching and learning plan that focused on the *Nature of Science* strand.

When planning inquiry units, the school used the 'future focus' principle from *The New Zealand Curriculum*, chose a theme and then used the *Nature of Science* objectives to decide how they could include science learning in the inquiry unit.

Changing the focus

During consultation about a two-year programme, it was the change of focus that made the greatest difference.

The science leader promoted the idea that *'science is not only about content knowledge, it's about learning and applying skills taught through the Nature of Science, which is the unifying strand.'*

The leader focused on building teachers' confidence to teach science by focusing on the Nature of Science using contexts that linked with what was being taught in inquiry units.

Managing the teaching changes

In-school professional development focused on:

- understanding the *Science Capabilities*
- engaging with, and discussing, research related to science teaching
- looking in-depth at the *Nature of Science* strand
- planning units that integrated science learning
- questions students could consider when undertaking independent investigations
- determining the characteristics of effective science lessons.

Teachers also explored teaching resources and the five 'E's of the 5E constructivist model of learning promoted in the Science Roadshow workbooks.

Leaders believed that developing the science boxes (kits) led to a significant increase in the amount of science teaching going on. The boxes were made so teachers could pick them up and start right in. The boxes included an information sheet describing the activity, and question sheets to focus teachers and students. There were kits that small groups of students could confidently use to undertake experiments or other investigations.

One box contained equipment for investigating the chemical changes that occur when baking soda reacts with a liquid. In a simple experiment involving vinegar and baking soda in a plastic bottle, the students could see that a gas was being produced by placing a balloon over the opening and watching it inflate. Another box provided resources for students to investigate the acidity levels of everyday products such as Coca Cola, milk, and orange juice (see the photo).

The comments below are from recent staff surveys. They highlight the increased confidence of two teachers.

"For me the kits with the experiments ready to go were really helpful and I used them as the basis for some students as their science investigation. Also, the collaborative planning helped along with the activity to decide the exemplars for what was below/at/above expectation for Year 7s. We put these exemplars together on a Google form so we were all doing the same thing. I found the science learning hub website really useful as well. The PLD staff sessions were great ignition starters and a great way to engage students/staff".

"The Nature of Science activities gave students the confidence to adapt experiments to an investigation by asking the 'why' and 'what if' questions. They used the 'I wonder' questions supplied in the science boxes as a starting point to ask their own questions".

Supporting students' investigative capabilities

The school's science programme has continued to evolve in response to review findings and monitoring of student outcomes.

The teachers of Year 7 students developed and introduced a unit focused on being a scientist called 'Little Einstein'. The skills to be a scientist were taught using activities from the Science Learning Hub, and simple predict-observe-explain activities. Students learned the stages of an experiment, focusing on questions they might ask, materials they would need, establishing a hypothesis, designing a method, and developing a conclusion. They were introduced to changing variables and 'what if' questions.

Students were supported to undertake scientific investigations independently or in small groups. Teachers recognised that lengthier investigations may need to be carried out at home, but the intent was that most students could carry out an investigation with minimal support from parents. Those who were not confident to undertake a science investigation worked together in groups supported by their teachers. All students were given booklets that fully explained each step of an investigation.

In 2018, science teaching and learning changed to ensure that all children had the skills to manage their own or group science investigations. In 2019, all Year 8 students were further supported to undertake more complex science investigations. These students were able to independently use and build on the skills they had developed the previous year.

Another 2018 innovation further focused teachers and students on developing scientific investigative skills. As part of the technology cycle, a newly introduced programme enabled small groups of students to carry out six sets of experiments in the school's science room. The experiments, which had a strong emphasis on *Nature of Science* skills, used kits prepared by the lead science teacher, based on the Making Science Real Series. This innovation continued in 2019.

Ongoing PLD has consolidated teacher understanding of the *Nature of Science* strand and enhanced their questioning skills. Collaboratively working through *Nature of Science*-focused investigations and activities from the Science Roadshow booklets has also increased teachers' confidence as they have engaged in the same processes their students will go through later.

Additional changes were anticipated for 2020 to take account of teachers' increased confidence that they can successfully teach science.

Two students with their completed science investigations

6. Ensuring all students engage in high-quality science programmes

Remuera Intermediate School is an intermediate school in Auckland with a roll of approximately 900 students.

The school makes a priority of developing students' science knowledge and skills. A deliberate strategy was introduced to build teacher pedagogy and knowledge and develop programmes that improve science learning outcomes for all students. The school now uses a wide range of strategies to ensure that every student enjoys practical and engaging science across all the science strands of the *New Zealand Curriculum*.

Changes, designed to make science a strength, began in 2013 when the board appointed a science curriculum leader who had recent experience teaching secondary school science. This teacher worked alongside the mathematics, English, and social science curriculum leaders to develop consistent, high-quality pedagogy across the school. These leaders were tasked with reviewing current practices and developing new practices, policies, and guidelines.

Major science teaching developments in 2014 and 2015 included:

- the development of detailed science teaching guidelines
- a science budget that was sufficient to purchase additional science equipment
- a refit of the science laboratory to increase space for students and provide shelving for resources, new whiteware, and new sink areas
- professional development for teachers to increase their confidence with *Nature of Science* and the other four strands of the *New Zealand Curriculum*.

Regular and engaging science

When ERO visited the school in 2019, learning was focused on term topics that emphasised either the social sciences or science. Over the two years that students were at the school, they encountered four full terms of science, each covering a different context strand but with a focus on *Nature of Science*. Science was integrated into class programmes rather than taught as a standalone subject by a specialist teacher. Pedagogy emphasised problem-solving and fair testing, with students exploring, experimenting, and testing hypotheses. Themes included neuroscience (how learning happens), ecology, sustainable civilisation, forces and motion, sustainable cities (electricity), and scientific advancement.

At first, guidelines for teaching term topics were shared with teachers to support their own learning. However, the PLD strategy subsequently became much more hands-on and high-interest, with the science leader videoing model science lessons for teachers to view, and supporting teachers in their classrooms and with their planning. The science leader worked closely with provisionally registered teachers and staff new to the school to ensure they were ready and able to engage students in the science programme.

Teachers were invited to workshops where they could become familiar with the practical resources, kits, and guidelines that were available. Teachers were able to try using these resources and, as a result, experience what their students could be learning when they used them. Workshop attendance was usually high, even when not compulsory, and teachers reported that they had become more confident to teach science thanks to the workshops.

Detailed guidelines were developed for each of these areas:

- the *Nature of Science*
- achievement objectives for the four context strands
- Māori perspectives
- integrating information technologies
- integrating other curriculum areas
- a suggested sequence for teaching for the learning outcomes
- assessment activities
- print, DVD/video, and website resources.

Teachers were given many more teaching and learning activities than could be fitted into the available time so that they could choose activities that were likely to be of greatest interest. The emphasis was on high-interest, practical activities wherever possible. Units such as the 'Mission to Mars' unit concluded with a student inquiry in which the students showcased their scientific skills by questioning, researching, and communicating as members of a multi-disciplinary team, much as real-world scientists do. Those who wanted to extend their knowledge and capabilities were able to undertake more complex investigations. For example, in Chemical Chaos (aka Matter Matters), extension activities encouraged students to look more deeply into what occurs during chemical reactions, in this way preparing them for a fair-test chemistry investigation.

In some teaching syndicates, teachers planned a small number of concepts and activities and then taught them to each syndicate class in turn. This meant they had opportunities to refine and clarify their teaching – and that the students were introduced to a wider range of concepts and experiments. Most students reported that they enjoyed going to different teachers and participating in lots of different activities, while teachers reported professional growth and increased confidence as a result of being able to refine and re-teach their lessons to different classes within the space of a week.

Additional learning opportunities

Carefully targeted programmes were in place to improve outcomes for groups of students who would benefit from additional science teaching. Two half-year enrichment programmes gave two different groups of students multiple opportunities to experience science in a range of contexts and thereby increase their understanding. The first group comprised Māori and Pacific students who lacked confidence in their ability to understand science. The aim was to increase their confidence to the point where they could achieve success in secondary school and beyond.

About 26 students were invited to join this programme (self-named the 'Polyscholars'), which ran for an hour and a half, one day a week, for two terms. The programme was designed to match the skills and interests of the students in the group. In 2017, topics included building and testing planes, forensic science, eyesight, and researching a famous scientist.

The group visited the Anthropology Department at the University of Auckland, where they played a board game that was developed in-house to teach about the colonisation of the Pacific by Polynesian ancestors. Students reassembled ceramic fragments, sorted a shell midden, and examined replica skeletal remains of ancestors. The students also listened to Māori and Pacific scientists.

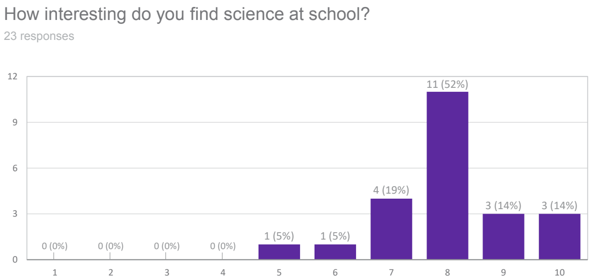
Before each cohort began the programme, they were asked:

- How interesting do you find science at school?
- How do you rate your confidence with science?
- Does anyone in your family or whānau work as a scientist?
- How much would you like to work as a scientist or use science in your job when you grow up?
- What would you like to get out of being in Polyscholars?

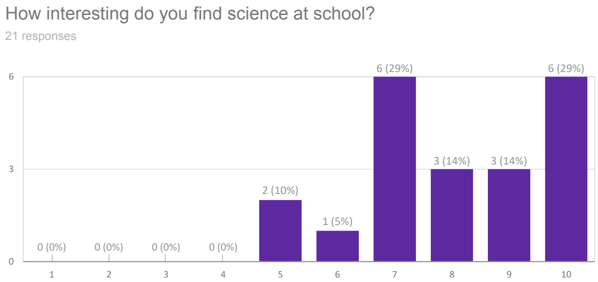
When asked the same questions at the end of the programme, many of the students were much more positive. Some had learned that members of their own whānau and aiga did use science in their work. Below is a comparison of the pre – and post-programme responses to the first question.

How interesting do you find science at school?

Before the Polyscholar programme



After the Polyscholar programme



The second half-year enrichment programme was for students who were highly interested in science and looking for additional learning opportunities. Prior to joining, the teacher interviewed each prospective member to gauge their interest and whether they were likely to benefit from participation. Academic excellence was not a criterion for selection.

This group of about 24 Year 8 students had opportunities to see what a career in science might be like. On one of their field trips they visited a member of an international network of biotech companies that produced a wide range of products. The students participated in a site tour that included an interactive demonstration of how scientists must dress when working in their tightly controlled, sterile laboratories. Students saw scientists from different disciplines working together in the laboratories and in processing, storage, and packaging areas.

Continuous improvements

When ERO visited the school, leaders were continuing to trial new strategies with the aim of ensuring that all students progressed their science learning during their two years at the school.

In 2018, the science leader investigated the impact of collaborative, cross-team science teaching on student outcomes and teacher confidence.

They randomly selected about 130 students from 14 classes, whose teachers liked to work either very collaboratively or quite independently. At the start of the first term the sample students completed the NZCER's *Thinking with Evidence* test, plus a survey about their attitudes to science. The students completed the test and survey once again in term four. The two sets of data were then analysed to see if there was any difference in achievement or attitude. As it happened, there was no significant difference. But it was interesting to note that the mean scale scores of the Year 7 students increased at twice the normal rate. This indicates that the students were benefiting from the school's high-quality science programmes.

7. Developing a well-structured curriculum

The Catlins Area School is a small Year 1 to 13 school situated in Owaka. Most of its students are in the primary school department.

Science leaders had recently engaged in a cycle of in-depth review and development designed to improve the quality of science teaching and coherence of the science programme. They also wanted to increase student engagement with science, and student awareness of the wide range of science-related careers available and the value of science in everyday life.

A teacher from the primary school department worked closely with a teacher from the secondary school department. They collaborated to ensure that the science programme grew students' science capabilities through authentic, interesting learning experiences that used local resources and expertise wherever possible. Primary school programmes were redesigned to ensure that, when science was integrated into topic studies, students had multiple opportunities to engage in quality science learning.

Review and developments

A review of science teaching and learning began at the end of 2016, looking particularly at:

- the quality and coherence of the programme and lesson planning
- the professional knowledge of teachers
- the teaching practices used to engage students in science
- students' involvement in science competitions
- evidence of science learning within mathematics and literacy programmes
- the extent of differentiated teaching to cater for students' diverse learning levels
- the extent to which science programmes supported future careers in science
- the emphasis on science in the school's strategic planning.

The review identified as needs: increasing engagement in science (especially in Years 9 to 11) and shifting the emphasis from acquisition of facts to understanding and applying scientific skills, which involves thinking and questioning more deeply and observing and critiquing more carefully.

The review also identified the following needs:

- including more local contexts in science programmes
- building teachers' capacity to focus on scientific skills rather than the *Living World* strand of the curriculum
- strengthening community connections through the use of local expertise
- strengthening the links between science and mathematics, so that students can successfully apply the same skills in both subject areas
- making science careers opportunities more explicit in careers education programmes
- developing and including science goals in the school's strategic plan.

Since the review and development of goals, significant changes have occurred in Years 5 to 11.

In 2018, the lead teacher for primary science participated in the Science Teaching Leadership Programme (STLP) facilitated by the Royal Society | Te Apārangi. Two teachers collated review data from students, staff, and the community, used this data to develop goals, and then presented a financial proposal to the Board of Trustees for their approval. This review was subsequently used as evidence to support a teacher's successful application for Advanced Classroom Expertise Teacher (ACET) recognition.

The proposals focused on extending understanding and use of the *Nature of Science* strand in Years 5 and above, using a planned approach to ensure seamless learning that scaffolded the development of science skills, attitudes, knowledge and values. The teacher in charge of science in the primary school worked closely with the science teacher from the secondary school. They led PLD with other staff and facilitated teacher-only days with a science focus. They set out rationale, expectations, and guidelines for quality science teaching and learning. They assembled kits and other resources to support teachers. They facilitated shared planning, modelled science teaching practice, and provided opportunities for teachers to observe and provide feedback on lessons. Achievement data showed that many students, particularly those in Year 8, had made considerable gains.

The programme

The planning process ensured that students engaged in science learning each term. Year 5 and 6 science was taught mostly as part of cross-curricular topics or themes. These usually provided scope for science, English, social sciences, and health teaching, but when there were no clear links to science, teachers would use a different context for science. All science teaching focused on the *Nature of Science*, while drawing also on the four contextual strands.

Students collecting data

The following table shows how, in 2019, science was fully integrated in Terms 1 to 3 but separate in term 4.

Extract from the 2019 plan for Years 5 and 6

Term	Topic	Science	Integrated
1	Farming	Ecology – Living World Bees – Living World: life processes and ecology	×
2	Trash to fashion	Material World – fabrics and fibres Uses of common materials and recycling	×
3	Machines	Physical World – simple machines Explore and describe everyday examples of physical phenomena: forces and motion	×
4	Rugby World Cup	Planet Earth and Beyond Environmental awareness – taking responsibility	×

The Years 7 to 9 programme was developed with the *Science Capabilities* in the forefront, incorporating the different science strands and *Key Competencies* within real-world contexts.

Planning was responsive to students' interests and current events. For example, the 'Year of the Periodic Table' gave rise to a *Material World* topic while the ban on supermarket plastic bags provided a science/technological topic. This latter topic had students considering other materials and their environmental impact. Deciding to take action, some students developed a 'borrow a bag' scheme in partnership with their local swap shop and supermarket, turning second-hand curtains into shopping bags and placing them in the supermarket for community use.

Leaders expected that all Year 11 students would take science. They learned via self-directed tasks and teacher-directed practical activities. Year 10 students completed NCEA Level 1 general science credits alongside Year 11 students.

The school introduced a semester of general science for Year 10 students, followed by a semester of horticulture. This approach helped engage students in science because it linked to their interests and used local resources.

During Years 10 and 11, students were supported to:

- develop their science capabilities
- apply their learning to new contexts
- develop robust study skills
- work successfully with external agencies
- work with junior students on science topics.

Students were able to talk to ERO about the importance of the *Science Capabilities* They understood that science is part of life and relevant to many areas of their own lives.

Assessing science achievement and progress

A range of assessment data was used to track student progress and refine programmes. This included:

- the NZCER's *Thinking with Evidence* test to evaluate learning needs and to provide a basis for reporting to students, parents, and board about achievement and progress
- the Science Engagement Survey
- teacher observations of skills and knowledge made during individual and group activities
- students' observational drawings and use of science tables.

Teachers maintained an assessment record for each student, noting what they had covered, what they had learned, and what they should focus on next.

Students were encouraged to take increasing responsibility for their learning. They regularly used rubrics to assess their own progress, evaluate strengths and weaknesses, and determine next steps. Students up to Year 11 participated in the Science Award Trust science badges scheme, which engaged them in a wide variety of topics. Students who had completed tasks helped others, practising the use of scientific language to explain the relevant concepts. The students were encouraged to question, problem-solve, be persistent, and find another way if the first didn't work.

The school trustees were well-informed about science and responsive to students' learning needs. Recognising that the teaching of science needed to improve, they were keen for the teacher-in-charge to participate in the Royal Society's Science Teaching Leadership Programme (STLP). When ERO visited the school, trustees spoke about how science programmes were now more cohesive, with Years 5 to 10 laying a foundation for success in the senior secondary years. They appreciated the opportunities students and parents had to work together on different projects and reported that the children were now more enthusiastic about science, viewing it as 'cool'.

Working with others

Local environmental and community experts were used to support rich learning opportunities. Students worked with the Department of Conservation, Forest and Bird Society, Curious Minds | He Hihiri i te Mahara, Otago Museum, and Otago University on activities such as planting for the Yellow-eyed Penguin Trust and monitoring birds and pests.

A strong focus on service gave students opportunities to participate in events that benefitted the community and the environment. These events encouraged science learning in meaningful contexts.

School-wide themes and activities offered opportunities for younger and older students to work together. These included:

- conservation of bats in partnership with the Catlins Bat Project
- planting and filtration in partnership with The Yellow-eyed Penguin Trust
- simple machines in partnership with Otago Museum
- plastics reduction (plastic-free lunches, 'borrow a bag' scheme)
- environmental clean-ups (a 'student army' took on specific leadership roles and worked towards specific outcomes).

When ERO visited the school, improvements continued to be with the aim of fulfilling the school science vision.

> *The Catlins Area School's values of tenacity, care, achievement and service will underpin our science delivery. Our students will engage in Nature of Science investigations so that they can 'participate as critical, informed and responsible citizens in a society where science plays a significant role'* (*New Zealand Curriculum,* page 17).

Learning about trapping bats at a bat camp

8. Increasing engagement in and the relevance of science learning

Menzies College is a Year 7 to 13 secondary school in Wyndham, a semi-rural town in eastern Southland.

Science teaching and learning in Years 7 to 11 has recently undergone considerable change as a fairly traditional programme has given way to one that is focused on students' interests and the local environment. The changes were introduced to increase engagement, put students more in control of their own learning, and support students to actively process, interpret, and apply science understandings in different contexts.

The local environment provides students with numerous opportunities to engage in science in meaningful settings. They often have considerable science knowledge and interests gained from recreational and farming experiences. The school now uses this knowledge and these interests as a foundation for developing their science investigative skills.

In 2016, the newly appointed lead science teacher wanted to understand why some of their students had negative attitudes towards science and chose not to continue with it in Year 11. They wanted to make changes to the junior school programme to ensure that, as students went into the senior school, they had the required skills and were using them.

When reviewing the existing Year 7 to 10 programmes, it became apparent that students were repeating the same topics over the four years, and that teachers had limited scope to respond to the diverse strengths, interests, and needs of their particular students. The focus was on developing scientific knowledge, with some teaching of investigative skills. It was also clear that, by the end of Year 10, some students had very limited understanding of how to conduct a science investigation. These students were generally disengaged, did not expect to succeed with Year 11 science, and, unsurprisingly, were opting out of senior science.

Although some were initially hesitant, the teachers committed to implementing a more engaging teaching approach. They had to learn to allow students to try things for themselves even if this meant they might fail, or come up with alternatives, to be more flexible and less wedded to the plan book, and to introduce new material when the students were ready, not when the scheme or the plan told them to.

Further changes saw students being given greater responsibility for their learning, and agency to choose a focus context. Teachers were given freedom to determine when assessments should be undertaken and what should be assessed, based on the direction learning had taken.

A flexible, project-based science curriculum

At the end of 2016, teachers in the science department worked together to plan a curriculum that would increase engagement through the use of more authentic learning contexts, and build students' confidence to:

- suggest a hypothesis
- prioritise ideas
- make predictions
- undertake observations
- accurately record results

- draw conclusions
- understand scientific methods.

The teachers discussed how they could better scaffold learning; they agreed what mastery of the science investigation skills looked like at each year level; they looked in-depth at the learning objectives for the *Nature of Science*, which reinforced for them why it was important that the different context strands should not be viewed in isolation.

Following collaborative revision, the science programme put less emphasis on one-off experiments and more on project-based learning, where students worked in groups to undertake longer-term inquiries. In Years 7 to 10, students focused on one broad theme each year. Teachers supported them to broaden their perspectives and pursue multiple lines of inquiry linked to the theme. In this way, students were able to develop their science investigation skills in thematically-linked biology, chemistry, and physics contexts.

Overarching science themes

Year 7 – *the stream*

Year 8 – *New Zealand*

Year 9 – *dairy farming*

Year 10 – *sustainability*

Following introduction of the year's theme, students began by brainstorming investigative possibilities. As they began to value their own ideas, and as they realised their teacher would support them to test their theories, they would broaden their thinking and pursue more challenging investigations. They learned how to successfully work together in groups to try out and test their ideas.

The following table lists some of the directions that students have pursued for each of three themes.

Year 7: The stream	Year 8: New Zealand	Year 9: Dairy farming
Nature of Science focus – observing, recording interpreting. The local environment – three rivers, trees, fish, insects, pollution, forestry. Life cycles of insects. Plant growth – connection with local farming practice.	*Continuation with Nature of Science focus.* Viruses – Covid 19. Introduction to sustainability – pest control – making tracking tunnels and deploying them. History of pests. Differences in waterways – Mataura River, oxbow lake, Mimihau River – in terms of water chemistry and insects. Why is Southland so good for dairy?	*Nature of Science and local environmental choice.* Research aspects around any aspect of dairy farming – Genetics, grass, fertilisers, physics of milking as examples. Grass growth – biology/ chemistry. Rainfall/photosynthesis, plant reproduction. Milk fats – chemistry – making cheese and butter. Milk products.

Teachers could see that the students' motivation increased when they were able to frame their own questions, make their own predictions, and suggest their own ideas for investigation or trialling. While some students initially had trouble making decisions and generating ideas, the authentic contexts meant that most soon discovered they could transfer what they already knew from first-hand experience over to their science learning.

The theme for Year 10 and 11 science was 'sustainability'. Students engaged in a range of projects that included trapping possums at various localities, using CO_2-powered traps to control rats in a local reserve, propagating native trees, and monitoring water quality and fish life in the Mimihau River.

Following changes to the curriculum as described, the number of Menzies College students taking Year 11 science increased.

In 2019, all Year 11 students participated in one of the three science classes. In one, a weekly class for students who had not previously engaged with science, students pursued investigations and worked towards NCEA credits using contexts such as possum trapping, water quality monitoring, shearing, and whitebaiting.

Investigations involving sustainability issues

Students in Year 8 designed tracking tunnels made from cardboard, which they deployed following a session with experts from Environment Southland. The students then identified the different footprints and tried to estimate the number of pests at each locality.

Recognising an opportunity, students in Year 10 undertook to create a 200-metre walkway to a local reserve. They contacted Environment Southland, met with roading and floodbank engineers to discuss possible issues, met with environmental planners to discuss suitable plantings, and met with the owner of the land to hear his concerns.

In another project, supported with a start-up grant from an environment fund, students carried out investigations into the giant kōkopu population in an oxbow lake just five minutes from the school. Students set nets, caught and photographed individual fish, then weighed and measured them before releasing them. Ideas were generated for increasing the population. Weekly water analysis monitored pollutants in the habitat and a plankton net was used to see if there was sufficient suitable food for juvenile fish.

Students measuring Giant Kōkopu

Another ongoing investigation was prompted by the Association of Freshwater Anglers. They believed that there were hardly any trout left in a local river. A teacher and students worked with the Southland branch of Fish and Game to prove or disprove the assumption.

Amongst other things, the students learned:

- to persevere when results don't appear quickly
- how to catch, weigh, and monitor trout
- to keep accurate data records, experimenting with different ways to get the best results
- to question their own data to increase their knowledge
- to consider causes and effects in the wider environment
- as much from failure as from success
- how to contribute to a solution that improves outcomes for people and the environment
- how to share their knowledge with experts and younger learners
- new leadership skills
- the importance of sustaining the environment.

The students involved in this investigation were awarded Environment Southland's Action in Environmental Education Award for 2018.

One boy who had previously been somewhat disengaged in science was asked to lead the group collecting the trout catch data for one day. He was given the responsibility for determining if the river level meant it was safe to take the required measurements. The boy decided it was unsafe to get the data but worried that he had ruined the experiment because of the missing data set.

The next day the class and the teacher congratulated the boy and the group and determined that safety should come first. A missing data set is not as important as harming a person, species, or the environment. The boy learnt that his common-sense leadership approach worked, and he became more confident about contributing to future science investigations.

Working with experts in the community

Opportunities for authentic, project-based learning were enhanced as a result of relationships with community contacts and experts. For example:

- Hokonui Rūnunga provided suitable locally sourced trees with the right genetics for revegetation done in connection with the walkway project.
- The Southland District Council gave permission for students to trap possums and rodents as part of a pest control programme and showed continuing interest in the students' projects.
- Development of a close relationship with a local dairy farm opened up opportunities for senior students to gain future employment experiences.

9. Developing authentic, place-based science programmes

Waitaki Girls' High School in Oamaru is a school for girls in Years 9 to 13. The roll is approximately 400.

In 2018, the science staff collaboratively reviewed and redeveloped their programmes with the aim of fully engaging students in highly authentic learning.

Teachers now make full use of resources and experts from the local community, and they work regularly with teachers from other learning areas to ensure that cross-curricular connections are reinforced, and students are able to apply their science learning in different contexts.

Continuously improving science programmes

Science leaders and teachers describe their purpose in the following vision statement:

Science Vision

We see our students as those who are:

- engaged in science
- reflective, resilient learners
- independent, life-long learners.

We will enable our students to have a level of scientific literacy which allows them to make sense of science in their everyday lives.

Each year the science staff establish goals linked to this vision together with strategies to achieve them. As an example, see the following goal (one of three) for 2019.

GOAL 1: Engagement
Observation: In order for students to be engaged in science, the contexts which they are working need to be meaningful for them.
Improvement strategies to achieve the goal **Process:** Use student voice and teacher observation to trial new learning contexts in Years 9 to 11 science. **How:** Develop and use resources which are meaningful and culturally responsive to our students. Use staff expertise to increase the use of STEM in Years 9 and 10. Link to our Enviro-schools work by using sustainability and the environmental contexts. Modify the assessment mode in Year 11 to better assess the skills and knowledge introduced during the unit (starting with Microbes in 2019). Continue to develop the use of the Surface Pros.
Key progress indicators We will: • see increased engagement and achievement in topic work • observe rich learning conversations • see improved test assessment results.
Reflection: Completed at the end of the year.

One goal has been to develop science-specific literacy tasks and use them to develop the literacy skills of Year 9 and 10 students. Another goal has been to make the teaching of skills that students learn in both science and mathematics more consistent. Science teachers worked with English and mathematics teachers to increase students' confidence when reading and interpreting scientific texts, experiments, and graphs. Year 11 mathematics and science teachers coordinated the teaching of graphing and linear relationships. English teachers also worked on getting students' writing skills up to the standard required by Level 1 science.

Working across subject areas

In Years 9 and 10, students were given targeted literacy tasks to assess and develop their scientific literacy. This included daily 'quick writes', where they used teacher-provided words to write a brief explanation of a concept currently being taught in class. They then read their explanation to a buddy, and, if they wished, to the class. (This practice was also used in English classes and the local intermediate school.)

In Years 9 and 10, measuring and other practical tasks helped develop numeracy skills that are part of the number strand in mathematics. Science and mathematics teachers fostered such synergies. They would, for example, try to be consistent in their use of terminology, or ask how a particular mathematics strategy might be applied in science, or highlight that unknowns and variables in mechanics behave exactly the same as in algebra.

In Year 11, two NCEA courses were offered. The first was assessed using a mix of internal and external standards; the second was entirely internally assessed. The teacher teaching the second course worked closely with colleagues teaching parallel courses in mathematics and English as the same students often took all three.

Many Year 11 students were able to complete two internally assessed standards (AS90935 and AS91036) that were jointly facilitated by their science and mathematics teachers. The science assessment required students to carry out a practical physics investigation, which they were then able to reuse to meet in part the requirements of the mathematics standard.

A mathematics teacher highlighted the benefits of working so closely across departments:

> *"Using data gathered in science is much more meaningful as the girls can understand far better why they are doing it rather than us finding some spurious context to collect data that hopefully has a correlation. This allows us to collect data that has causality and allows us to teach the difference between correlation and causality. It is the control of other variables that is so important to this aspect of statistics and the scientific process does exactly the same thing we are aspiring to do. The fact that you have done teaching about the context makes it so much easier for the girls in our learning area to discuss what they see in the data and what it actually means."*

Teachers felt that strategies such as working across departments, differentiating teaching, modifying tasks and finding new ways to explain concepts to students had all contributed to the high retention rate for students taking science through into Year 12.

Engaging students, growing confidence, and building the science capabilities

Teachers used a detailed framework to plan units that would engage students and build their science capabilities. It required them to consider:

- the main focus of inquiry
- the learning intentions
- the *NZC* principles
- the school's values
- the *Key Competencies*
- *NZC* achievement objectives
- home and community engagement
- Māori and Pacific contexts, pedagogies, and practices
- Science-specific vocabulary.

Early information indicated that many Year 9 students were nervous about science and worried they were not well prepared to succeed. So, teachers planned for the first unit to focus almost exclusively on the *Nature of Science*, including activities that would engage students, build their confidence, and encourage them to *think like a scientist*.

This first unit covered:

- safety in the laboratory
- getting to know the laboratory equipment
- developing measurement and observation skills
- fair tests
- types of scientists
- famous New Zealand scientists
- creating and reading tables and graphs
- briefly reporting on a topical science issue.

At the beginning of Year 10, the emphasis was gain on *Nature of Science* and building the students' science capabilities.

In 2019, 82 percent of Year 10 students taking the NZCER's Thinking With Evidence test bettered their scores from the year before. The teachers arranged additional support for the 10 students whose scores had dropped.

Authentic place-based learning

Science programmes now aligned with the schools' charter goals, which called for authentic, place-based learning and the fostering of resilience, independence, and life-long learning. Programmes were increasingly localised and contextual, providing experiential learning opportunities.

Students were engaging in science units that included some project-based learning. For example, Year 9 students worked with a research scientist in connection with a unit focused on Oamaru's little blue penguins, and they learned about energy transformations using playground equipment at a local park.

In another unit, students selected and researched a sustainability issue of interest. They were supported to develop research skills to:

- spot misinformation
- disprove some scientific claims
- present their learning in a compelling way.

Another unit was inspired by a topical local issue. Following the closure of Oamaru's landfill, rubbish was being trucked to Christchurch. Year 9 students researched the materials used to create a landfill site, costed the build, and then constructed a model. Acting as civil engineers, each with different roles, their brief was to plan a site that would hold the maximum amount of fill with the minimum amount of leachate.

Year 9 students also explored pseudoscience and how it is used to market products and ideas. They explored climate change misinformation and how and why it is spread. They critically examined websites to evaluate their trustworthiness, and then tried their hand at marketing their own ‘product’ using persuasive techniques and pseudoscience.

At the end of the year, Year 9 students were challenged to come up with their own projects, based on the sustainability theme, to be completed individually or as a group. Projects included rubbish clean-ups, auditing rubbish in a local park often visited by tourists, and visiting a supermarket to get ideas for palm oil-free snacks.

Students sharing their findings from project-based learning

The Year 10 enviro agriculture programme focused on agriculture through an environmental lens, which required students to engage with a wide variety of farmers and professionals. The course started at the top of the catchment area for Waitaki River, took in a major irrigation scheme (The North Otago Irrigation Company) and ended at the mouth of the local awa. Along the way, students met and worked with farmers on different types of farms. The aim was to build a holistic view of farming in the community, and of North Otago’s agricultural sector. The girls also gained insight into the range of science and other careers available in the rural sector.

The Year 11 programme built on this local knowledge. Wherever possible, teachers involved farmers and relevant professionals. For example, in conjunction with AS90160 (Demonstrate knowledge of the impact on the environment of primary production management practices), farmers and environmental managers spoke to the students about farm environment plans and their relevance for day-to-day farming. This enabled students to explore farming from both production and environmental perspectives.

Year 11 students studied microbiology in the context of cheese making, by visiting a local cheese maker. The microbiologist explained how milk from local farms was turned into award-winning cheese – all this in a factory just ten minutes’ walk from the school. Students saw how a new blue cheese was created using mould found in baleage from a nearby farm.

Enthusiastic and able Year 10 students participated in various extension activities, both in and out of school. The STEM (Science, technology, engineering and mathematics) club met once a week to co-construct activities and experiments that members then undertook. They investigated STEM career opportunities and pathways. Two STEM club members worked with students from other schools in a course facilitated by Otago University. One student did a project on microplastic ingestion by bivalves; another investigated crab behaviour and whether it influenced group size.

10. Catering for students' interests, strengths, and learning needs

Located in Winton in rural Southland, **Central Southland College** is a co-educational secondary school catering for students in Years 9 to 13.

Teachers in the science department worked collaboratively to ensure that the junior science programme was structured to enable the maximum number of students to succeed in senior science.

High numbers in senior classes and consistently good results were attributed to high-interest learning activities and effective learning partnerships.

Collecting and responding to achievement information

Teachers used reading data from Assessment Tools for Teaching and Learning (AsTTle) and data from the NZCER's Thinking with Evidence test to give an indication of Year 9 and 10 students' science and literacy strengths and needs. Differentiated programmes built on the students' current science understanding and skills and made appropriate demands on their literacy capabilities.

Regular assessments identified how students were progressing in terms of skills and knowledge, and reinforced high expectations.

Year 9 assessments focused on strands from Levels 3 to 5 of the *New Zealand Curriculum* while Year 10 assessments covered skills and knowledge from Levels 4 to 6. Teachers developed assessment schedules for each curriculum level and introduced exemplars to provide staff and students with clearer guidance. Assessment data was regularly discussed and moderated at departmental meetings.

The primary purpose of assessment was to monitor students' developing scientific skills and capabilities and to inform future teaching, but assessment data was also used to evaluate the impact of programmes on student outcomes.

Sources of assessment information included:

- research assignments
- written or digital tests
- group work
- videos
- posters.

Students were involved in and valued the assessment process. They used a template to keep track of their achievements on each module. They learned to recognise when they had achieved the designated specific learning outcomes (SLOs). In science, they were also given an effort grade every week, which was then shared with their parents. These grades linked back to the school's values and the *Key Competencies*. Students, spoken to by ERO, said the effort grades were useful for keeping them on track and motivated. They liked the system that was in place to reward those who achieved positive comments and results.

In line with the school's decision to adopt a bring your own device (BYOD) policy, science teachers had successfully adapted to digital learning. They were teaching digital skills in all classes and ensuring that all students could use the relevant applications. They were using the Google suite of applications and were subscribed to Education Perfect (EP) for both classroom and homework activities. All Year 9 and 10 students completed an introductory digital skills assessment at the start of the year. Year 9 students also completed a digital test on science skills. Research topics were available online. The end-of-year exam for junior year groups was digital. While senior classes were being taught in a digital environment, teachers were mindful that external NCEA assessments were still paper-based.

Assessment results were analysed and used as the basis for annual science department goals. In 2019, data showed that most students were achieving well on *Processing and Interpreting Evidence* but not so well on *Evaluating the Scientific Process*. Goals for 2019 included:

- continue to give priority to further raising achievement for boys and Māori students
- determine and implement new ways to teach the skills needed to evaluate the trustworthiness of data
- develop digital learning opportunities to improve students' outcomes.

Engaging science programmes

Students engaged in learning carefully structured to link to the *Principles, Values, Key Competencies,* and *Strands* from the *New Zealand Curriculum*. The teaching plans also outlined exemplars and progress indicator descriptions for each aspect of the *Nature of Science* included in the module. The module plans deliberately provided the flexibility to focus on the *Nature of Science* through using contexts that linked to students' interests and also took account of recent news items and events.

Students were given many opportunities to use local experts and resources to engage with science in a range of different settings.

Some students investigated how a local industry was using native plantings to remove sediment and nutrients from water before it entered a stream. They also investigated the geology of the area, along with the history of the rock types and how the waterway had changed over time.

Younger students investigated the health of local streams and the influence of farming over time.

Students working with dry ice

As part of a microbes unit, Year 11 students investigated the Mycoplasma Bovis outbreak in dairy cattle and measles outbreaks in the community.

Teachers fostered a wide range of partnerships and contacts, locally and nationally, to extend students' science learning. They sought scholarships and other additional funding so that students from this small rural community could widen their field of interest.

As a result, many students participated in extension learning activities such as camps, field trips, competitions, and national forums. They also benefitted from participation in the Otago Waterwise Programme and Rotary Science forum in Auckland and from activities facilitated by the Universities of Otago and Canterbury.

The heads of the science and English departments set out to see what they could achieve by collaborating closely to teach a Year 9 class. They focused on improving the students' literacy skills by teaching them how to structure writing, using science explanations as the context. They used similar starter activities and tried to use the same terminology when describing text features. By doing this, they were able to support students who needed more time, and extend the able students, and the students learned that literacy skills are not just for the English classroom.

While science was not compulsory in Year 11, it was clearly prioritised. The deans encouraged all students, except those with valid alternate pathways, to continue with science well into the senior school. Students were well supported by the Careers Department to ensure they understood what learning they needed for a particular vocational pathway or career. Many came from, and would work on, family farms; these students were well supported to see the importance of all aspects of science for their future working life. Others were enthusiastic about employment options in the community and region if they achieved science qualifications. The practice of entering all Year 10 students for one NCEA Level 1 Achievement Standard further motivated students by showing them they could succeed. All students spoken to by ERO were very positive about science and clear about the importance of science for their futures. Few students did not take science in Year 11 and high numbers continued into Year 12.

Students were supported to see themselves as capable learners of science. Their opinions were asked for and valued; regular surveys were used to improve teaching and learning. For example, teachers wanted to know what students thought of recently introduced digital assessment practices. The students said they took up too much time, so the teachers made changes that reduced the time involved.

Students told ERO that they had many opportunities to talk with their teachers about any learning concerns. They said that their teachers made learning fun, and that they really appreciated their teachers' efforts and care.

11. Developing responsive and well-structured science programmes

Taikura Rudolf Steiner School is a co-educational integrated school in Hawke's Bay catering for students from 6 to 18 years of age.

Over the past two years, science teachers at the school had worked closely with teachers from other Rudolf Steiner schools to improve their programmes, with the aim of responding more fully to the diverse strengths and needs of the students. As part of this redevelopment, they tried to describe the skills that the students needed to be successful in senior secondary school science and beyond.

The teachers also wanted to ensure that students had greater clarity about which *Science Capabilities* to focus on and what was required of them. They believed that, if their learning objectives were clear, their teaching would be more sharply focused, and the students would have greater agency in their own learning.

Note that although the school has students in Classes 1 to 12, this study focuses on Classes 6 to 10. To avoid confusion, ERO refers to these classes as Years 7 to 11.

Back mapping the curriculum to scaffold learning

Although many students were achieving high levels of success in science before the recent changes, it was realised that this success may have been overly dependent on the experience and knowledgeability of the current teachers, who had been able to get by with fairly minimal guidance from their department's curriculum document. This document briefly outlined the topics to be covered and what teachers should do. It described outcomes and expected test results, and the likely content of bookwork. To promote continuing, effective, responsive teaching, it was clear that more detailed guidance should be provided.

The teachers worked together to make the links between the Rudolf Steiner curriculum and the five strands of the *New Zealand Curriculum*.

When discussing how to structure their revised curriculum, they focused on the following:

- What do we want our students to know and be able to do?
- What knowledge and skills might be missing?
- What do teachers need to know and be able to do to support student learning goals?
- What are the critical benchmarks for students' progress?

The teachers wanted to ensure that teaching was consistently of high quality and that it had a stronger practical emphasis. They also wanted to ensure that learning objectives were inclusive of the *Nature of Science* as well as content knowledge.

By starting with Year 11 learning objectives and working backwards, they restructured the science programme so that it would challenge students while building on knowledge and skills gained in previous years.

After deciding the learning objectives for each year level, they devised a number of different topic studies to match the objectives. They then developed guidelines to be shared with the students. These included learning objectives, content, relevant key capacities,[4] and achievement criteria.

4 The Steiner School uses Key Capacities which are similar to key competencies.

Responsive programmes


Using local resources

ERO observed a Year 11 science lesson where all students were highly engaged. In the introductory discussion, the students asked many questions and extended the topic well beyond what the teachers had originally planned. The teacher avoided answering the questions, instead inviting the students to suggest answers or question further. While a short practical activity was in progress the teacher talked with individual students, checking their use and understanding of new terminology. At the end of the lesson the teacher briefly checked how the students felt they were progressing in relation to the objectives, which they had in their guidelines, and foreshadowed the next focus. Students confidently shared what they had achieved and what they still needed to work on. Most of the students, spoken to by ERO, said they enjoyed science and were keen to continue with science in Year 12.

Science programmes were revised each year to respond to the strengths and needs of the students in each year group. Before planning the Year 11 programme, teachers would collate and analyse information about the progress and achievement of the current Year 10 students. They also had access to an online document used to track the strengths and needs of Year 10s. Teachers would also estimate how much support the students would need with literacy and numeracy to succeed in the science programme.

Preparing Year 8 students for future success in science

Although the school is basically separated into primary and secondary sections, the Year 8 teacher worked closely with secondary science teachers to support a seamless transition to Year 9. In Year 8, students learned science in the context of integrated units. Twice a week they also undertook investigations in the science laboratories, with a secondary science specialist and their own teacher. When ERO was in the school, Year 8 students were engaged in a chemistry unit that integrated science, technology, and mathematics. The unit had been planned by Year 8 teachers with the support of a secondary teacher.

Laboratory lessons were planned and taught collaboratively by both the primary and secondary teacher. ERO observed two teachers teaching a Year 8 class. They worked together seamlessly, with one making links to what the students had learned previously and the other ensuring that they understood the safety requirements and were confident about managing the chemicals and the task. During the lesson, students were encouraged to think deeply into the reactions taking place when making charcoal. They recorded and then described what they had observed.

Year 8 students, spoken to by ERO, said they liked science and did lots of experiments. They used lots of equipment and liked working together in small groups. Many of the students at the school were achieving success in science, with all Year 13 science students achieving excellence or distinction in NCEA in 2018.

12.Scaffolding learning through a spiral curriculum

Marist College is an integrated Catholic secondary school for girls situated in Mount Albert, Auckland that caters for students from Year 7 to 13.

The science curriculum was developed through a sustained period of review and improvement. The biggest improvements in the Years 7 to 11 science programmes were introduced to reduce senior students' barriers to achievement.

The science teachers worked together to implement engaging, hands-on programmes for all students. Teachers accessed or developed resources to introduce students to basic concepts and then encouraged them to undertake investigations to support their skill and knowledge development.

Science in Years 7 and 8

The changes introduced during the past few years were designed to increase the number of students achieving success in science in the senior school. Teachers recognised that to do this they had to ensure students were engaged in, and enthusiastic about science through having their interests and strengths catered for from the time they started at the school. As a result of the improved science programmes, the interest shown in science, along with the number of students gaining success in the senior school, has increased.

The first changes occurred for Year 7 and 8 students. Before the changes, Year 7 and 8 science programmes were included in integrated topic units taught by homeroom teachers. The science teachers reviewed the content of the integrated units and saw that, while science was included, often the focus was more on the other curriculum areas. This meant that students in Year 9 and 10 were introduced to a lot of new science skills and contexts in order to prepare them for science courses in the senior school. Leaders decided to have science taught by specialist teachers in Years 7 and 8. This led to the development of a spiral curriculum allowing for the more gradual introduction of skills across an increased range of contexts.

Teachers in the science department wanted to introduce a programme that focused on the *Nature of Science* and where students learnt what science was all about and could see ways to apply their science learning to life situations. After investigating a range of resources, the teachers selected the Spotlight books and Exploring Science (two series of resources from the United Kingdom) to use and adapt for their students. The teaching resources that accompanied the Spotlight books supported the teaching of the *Nature of Science* objectives and provided detailed planning ideas and notes that teachers adapted to suit their students.

Teachers guided students' learning in science with instruction of basic concepts before encouraging them to pursue their own or group enquiries to support their developing knowledge. For example, Year 7 students investigated natural and synthetic fibres. Initially, students tried simple experiments. They used a shell to rub and extract harakeke fibres. Working in small groups they tested the strength of the fibre.

These experiments gave them a starting point to design their own investigations such as comparing harakeke fibre with silk thread. Later, students chose to determine whether natural or synthetic fibres kept you warmer or drier. They were expected to make predictions and justify how they had made their results reliable to ensure a fair test.

Differentiated teaching and learning also helped motivate and engage students. Students were able to work in small groups and select from three different learning levels. The amount of instructions provided for each activity varied to take account of the students' confidence with science. For example, when investigating burning times, some Year 7 students selected a worksheet focused on word equations about burning fuels. These students followed and completed detailed, step-by-step instructions and records related to the simple investigation. Other students investigated different burning times depending on the amount of air available. The most confident students planned their own investigation without using the prompts on the worksheet.

Years 9 to 11 Science

Considerable changes were introduced in Years 9 and 10 to build on the success of the for Years 7 and 8 students. Teachers across the science department revised the Years 9 and 10 programme to enable the same high interest, multi-level teaching that emphasised the *Nature of Science*, that the students had enjoyed earlier. Teachers developed lesson plans and student workbooks for each topic, similar to those used in Years 7 and 8. The programme also focussed on developing students' knowledge of key concepts and vocabulary from the *Living World, Material World*, and Physical World strands. Teachers also continued to ensure the curriculum successfully built on learning from the previous year. Each year students revisited previous learning related to laboratory skills, scientific methodology, thinking, symbolism, and knowledge, to deepen their scientific understanding of the material world. Students had regular opportunities to reflect on their learning and engage with the *Science Capabilities*. They were provided with Specific Learning Objectives for each topic.

The example here shares the Specific Learning Objectives students reflected on at the beginning and end of the Year 10 students' study on "changes in New Zealand rocks and plants over time". Teachers used these responses to compare with other assessment data and determine the next teaching steps.

Specific Learning Objectives

	By the end of the unit, I should be able to:	**Before**			**After**		
		☺	😐	☹	☺	☺	☺
1	**New Zealand rocks**						
	Recall a theory of how Earth formed.						
	Describe the processes that change rocks and form new rocks.						
	Classify New Zealand rocks as sedimentary, volcanic or metamorphic.						
	Understand why sedimentary rock is likely to contain fossils.						
2	**Our changing planet**						
	Explore evidence for tectonic plates and movement at plate boundaries.						
	Explain tectonic plate movement in terms of convection currents in the mantle and sinking crust.						
	Understand that earthquakes and volcanoes are evidence that the tectonic plates are moving.						
	Give evidence that suggests the today's continents once formed super continents: Gondwana and Pangaea.						
	Understand how rocks break down over times when exposed to the weather.						
3	**New Zealand's plants and animals**						
	Know the difference between an epidemic and a native species.						
	Describe some special features of New Zealand fauna and flora.						
	Understand how New Zealand plants and animals evolved their special features.						
	Describe the threats to the diversity of species in NZ today.						
	Plan some activity to protect the Auckland region's to protect native fauna and flora.						

Target/ Goal for this Topic:

Teachers recognised they could help keep students engaged in science by highlighting what they had learned during each topic, to increase their sense of optimism about how well they could succeed in future science activities.

Students had many different options to select from when deciding the best options for them in Year 11.

In Year 11, science was compulsory at the school. Students were able to select from three different science courses that were open to all students. Most students undertook a general science course to develop an understanding of the *Living, Physical,* and *Material Worlds* through an investigative approach. Science at this level used everyday life examples and challenged students to use scientific methods in their thinking.

Some students could do one or more of the extension sciences courses that were designed for those students who intended to study tertiary science. The third option, a Life Science course, had a human and mammalian theme, covering topics from microbes, digestion and respiration in mammals, investigating and reporting skills, and genetics. All three options enabled students to continue into NCEA Level 2 Biology or Life Science courses in Year 12.

A focus on equity and excellence

Teachers in the science department identified an equity issue where many students who enrolled at the school in Year 9 (new students) were not as confident in science as the students who had begun at the school in Year 7. Historically, anywhere between three and 30 students began at the school in Year 9 while the remainder mostly enrolled at Year 7. The teachers recognised that the inequity occurred because the cohort of students starting at the college in Year 7 had regular and high-quality science that may have differed considerably from what the new students had experienced.

One teacher looked in-depth at the issue to try to reduce the disparity so all students could experience success in senior science. In 2016, the teacher undertaking the inquiry carefully tracked all 122, Year 9 students' assessment results for one year. Very few 'new students' were ranked in the list of the top 50 students by the end of Year 9. The teacher then focused on new students in one Year 9 cohort to:

- critically evaluate what was currently being done in one class
- develop strategies to improve the success of low-achieving new students
- evaluate the success of these strategies throughout the year.

The teacher identified that the new students' assessment results were similar to other students when considering the end of topic results but were lower than others when comparing all results from the end-of-year test. The findings suggested that more time was needed for the new students to consolidate new skills and information, and that they would also benefit from learning useful study skills.

The new students' opinions were also sought and considered in order to contribute to changes to improve the science programmes. The students suggested the need for more practical activities, teacher notes and study guides as well more opportunities to find things out for themselves.

In a subsequent inquiry, the teacher targeted a small group of 10 new students by working closely with them and monitoring their progress from Year 9 to 11. The aim was to determine how well changes introduced across the science department, had benefitted the new students who were not confident with science in Year 9. When the inquiry was undertaken teachers of Years 9 to 11 students in the science department had introduced the following changes to improve outcomes for all students. Teachers were:

- differentiating their teaching to cater for all students' interests and prior knowledge
- regularly checking in with new students and others needing additional support to help them understand what was happening and what they could do next
- providing students with resources they could use during class and then as study guides in the future
- focusing more on developing students' science vocabulary.

The results for one Level 1 NCEA standard showed changes had impacted positively on the new students. The five students in the class that had started at the school in Year 9 achieved the standard, two gained merit passes, and two achieved excellence in Year 11. The remaining student had left the school.

High numbers of students study science in the senior school. The girls who achieved particularly well in science at the NCEA level, talked to ERO about their learning and success. Many acknowledged that they believed they might not have continued with science if the programmes had not been as interesting and the learning had not been presented in ways they could easily understand or ways that could challenge them. Students viewed science as an integral part of their learning. Almost all students ERO spoke with could talk about the place of science in their daily lives and their desire to know how things work. Some students spoke about problem solving and being able to think about problems in a local and global context. They made links with science across learning areas and explained the importance of science for them both through and beyond school.

Year 9 students investigating light while using their teacher made workbooks

13. Raising students' engagement and achievement in science

Kerikeri High School in Northland, has a roll of over 1500 Year 7 to 13 students.

The recent improvements in Year 7 to 11 science were developed to ensure a high number of students were enthusiastic about science through all year levels. Teachers wanted to make sure that no students had their career aspiration blocked through a lack of science qualification necessary for their future education and/or employment beyond school.

The science programme changed to ensure students:

- could learn in a structured way where learning built on the skills and contexts that they had encountered previously
- had many engaging and hands-on learning and assessment opportunities
- had choices to enable them to learn new concepts through undertaking experiments and investigations that interested them
- had opportunities to work across the age groups to benefit their own and other students' learning
- had different pathways to select options that matched their interests and future aspirations.

The assessments had also changed to focus more on the *Nature of Science* and ensure assessment activities were contributing to learning and were not demotivating students.

High-quality self-review effectively contributed to the improvements and the monitoring of new practices. Teachers looked in-depth at students' achievement results across all year levels to fully determine what was working for students and what required changes. Even when a small number of students had not succeeded, emphasis was given to determining the areas students had found difficult or had enjoyed before modifying or not continuing a course. As part of the self-review, students' workload was also carefully considered along with their views about content, assessments, and text choices.

Some goals teachers focused on as part of their curriculum review and improvements are listed here. Teachers aimed to:

- continue to review and develop the teaching programmes to find a balance between preparing students for NCEA progression without programmes becoming repetitive and losing their originality
- develop an overview of courses without too many structural constraints that clearly related to *New Zealand Curriculum* and fostered progress and flexibility for students
- focus on pedagogy and good practice to ensure work is relevant to *New Zealand Curriculum* and included *Key Competencies*, especially at junior levels
- continue the work on assessments for junior students to focus more on the *Nature of Science* and to further motivate students.

Developing coherent transitions to keep students engaged and succeeding

The curriculum was carefully designed to ensure students could manage the amount of new learning that built on what they had learnt previously. Students in Year 9 repeated and extended topics they had already explored in Year 7. Likewise, Year 10 students revisited topics from Year 8. The teachers had worked collaboratively to ensure new activities and experiments that were introduced to Year 10 students were not merely repetitions from Year 8, but further extended students' thinking. They also ensured students had opportunities to briefly recall what they had learnt two years ago before introducing the more complex skills and knowledge.

The practice of carefully scaffolding learning to ensure success in future years, effectively supported early success for many Year 11 students. For example, in Year 10, as part of a medical science topic, all students investigated their different breathing rates. Students were able to select the physical activity they wanted to do to test their own breathing rates. Teachers carefully mentored students to develop ways to use and share their developing scientific, mathematics, and literacy skills as they designed, undertook, and presented their investigations. Students received feedback about their work which fully explained their strengths and possible next steps. In Year 10, the students worked as a group in preparation for completing the actual standard individually in Year 11.

In Year 11, the students also completed work related to a medical science topic. However, this time they focused on investigating heart rates. Teachers found students required little mentoring and worked more independently to design and complete an investigation to achieve the relevant NCEA standard. The early and considerable success with the Level 1 NCEA standard also helped build students' confidence with their own science ability. Additionally, the topic also successfully linked to and supported students gaining literacy and mathematics NCEA credits early in the year.

Teachers demonstrated high expectations that encouraged all students to succeed in science. Teachers successfully developed an additional process to reduce Year 11 students' dependence on internal assessments. Starfish (catch up) assessments at Year 11 were introduced for those students who needed additional support to earn Level 1 NCEA. These catch-up assessments were offered after the Year 11 science examinations were completed.

Thinking about science assessments

The assessment practices changed to considerably reduce testing, help increase learning time, and avoid demotivating some students. The newer assessments were designed to increase the focus on the *Nature of Science* techniques, to assess communicating, reporting, and research skills in portfolio type or open book assessments. Other assessment strategies were introduced such as those involving records of teacher observations, assessing students' presentations, and assessing completed posters and other work. Most written test in Years 9 and 10 changed to the 'open book' tests to encourage students to revise their previous learning. Year 7 and 8 common assessment types are shown here.

Year 7 Common Assessments

Term	Name of topic	Assessment type
1	Laboratory Skills and Safety	Written test
2	Physical World: Forces and Levers	Build a model & booklet
3	Material World: Materials Science Fair	Portfolio Assessment Science Fair board
4	Living World: Habitats & Biodiversity	Build a model & booklet

Year 8 Common Assessments

Term	Name of topic	Assessment type
1	Material World: Everyday Reactions	Written Test
1 or 2	Living World Classification Physical World: All charged up	Research Assessment Written Test
2	Physical World: Sound	Sound system design/ Purihua Practical
3	Science Fair Physical World: Magnetism	Science Fair board Research Assessment
3 or 4	Technology: Biotechnology	Portfolio Assessment

Engaging and practical learning and assessment opportunities

Students were provided with many practical science learning experiences. Teachers recognised that students learnt more when they were interested in the contexts. As a result, they could see how the learning linked to their everyday lives and had opportunities to test their own hypotheses and ideas. The programme provided considerable practical learning opportunities.

A Year 9 community-studies project in science successfully fostered tuakana/teina relationships and linked to the parts of the *Nature of Science*. The annual project, developed in partnership with the community, involved clearing an area around a local stream and planting new species. As part of the scrub clearing, the Year 9 students made and used pitfall traps and collected a wide range of insects. Before trapping the insects, students had a Skype meeting with scientists from the Ministry for Primary Industries to discuss their scientific method. Students also made pooters to help them catch and collect small insects.

The trapped insects were later taken to Year 7 students' classes where together the students from the two different year levels classified and studied the different insect types. The insects were also taken to Year 8 classes where students from the different year levels together investigated how insects thrive together in different communities.

Year 7 students also had opportunities to pass on their learning to younger students. As part of their science they had two visits to the local primary school to help them to collect and classify beetles.

An example of a highly practical science project occurred in Year 7 where students had to use their own ideas and make a model of a playground as part of the Forces and Levers study. They had to explain the force or the levers of each of the apparatus they had introduced into their playgrounds. Most students put considerable effort into their models and parents were often fully involved in learning with and supporting their child with the project. The models and the explanations were assessed, and prizes were awarded for the most outstanding presentations. Year 7 students also designed boats and waka as part of the water studies.

Keeping Year 11 students engaged in science

Although science was compulsory in Year 11 at Kerikeri High School, the teachers wanted all students to be enthusiastic about their continued involvement in science. The course options were carefully designed to cater for students' learning preferences, and future education and careers. Students were also made aware which options could help them gain future qualifications for their chosen careers. Many students kept their options open by enrolling in the General Science course that used observation and experimentation to describe and explain the world around them.

One option was specifically targeted for students who were not keen on writing. The Physical Science option was often taken by students wanting careers as engineers, mechanics, electricians, and in architecture and some aspects of medicine. However, it was also an option for students wanting additional science qualifications. For example, they could also take the other stand-alone Biological Science option designed to support students wanting future careers in science, technology, medical and veterinary practices, forestry, biotechnology, food technology, conservation, genetics, physiology, and forensics.

A further option was an internally assessed science course where students were supported to successfully use basic science concepts in their everyday lives. Students could take this course before undertaking a Level 1 science course in Year 12. The course also had considerable emphasis on plants, cuttings, and grafting which could assist students to gain employment in the local horticultural industries.

ERO observed a range of Years 7 to 9 science lessons and found students highly engaged in hands-on independent and group learning activities. Students felt their teachers had high expectations of them and had adapted their course to help them succeed. The students appreciated the opportunities to learn from each other and older students. They also recognised the benefits they gained from teaching younger students.

Conclusion

We have explored the strategies and approaches that a selection of schools had taken to increase students' engagement in science. All the schools were at different stages in their science developmental journey, but had implemented innovative or progressive ideas that were having a positive effect. Across the schools, we identified the key influences that contributed to improved outcomes in science.

In primary schools key influences were:

1. A planned approach to strengthen students' engagement in science

Teachers recognised the importance of moving away from programmes that focused on science knowledge, and instead focusing on engaging students in meaningful and purposeful science learning. The lead science teachers structured their improvement actions to ensure that changes were manageable and well supported. New planning templates were introduced to help teachers ensure their integrated or stand-alone science units provided increased opportunities for students to investigate, understand, explain, and apply their learning in meaningful contexts.

2. Targeting external and in-school professional learning and development

Following the professional learning and development (PLD), the teachers were highly motivated to try the teaching practices they had learned and share them with their colleagues. All went on to facilitate substantial internal PLD in their school.

3. Increasing the breadth of science experiences offered

Students became more engaged with science when teachers broadened the range of resources used. Science leaders shared with colleagues, resources they had used in their classrooms, or had been introduced to in external PLD. Some of the best learning took place when students sourced experts to answer particular questions. For example, one group of students gained new insights into their questions about sustainability by visiting a local marae.

4. Collecting and using a variety of information for planning and evaluation

Most of the case study schools were using the New Zealand Council for Educational Research's *Thinking with Evidence* assessment tool to identify improvement priorities and evaluate how any changes were improving outcomes for students… Students and parents were surveyed to learn their views of the current programme and what changes they would like to see.

In secondary schools key influences were:

1. Reviewing science programmes across all year levels

Science leaders and teachers in most of the case study schools reviewed their programmes with the aim of making changes that would encourage more students to continue with science in the senior school… Reviews generally focused on the content and coherence of current science programmes, and the extent to which they provided opportunities for students to become critical and creative thinkers.

2. Refocusing on the *Nature of Science*

Teachers facilitated student thinking by challenging assumptions, asking questions, inviting predictions, and introducing them to relevant scientific investigations… Assessment practices were changed to align with the new programmes.

3. Carefully structuring the development of skills and knowledge

While the overarching aim was for students to become creative and critical thinkers, teachers recognised that they needed to be given a certain amount of basic information before undertaking independent or group investigations… Teachers would revise concepts covered in previous years before introducing a more complex investigation.

4. Responding to learners' interests, strengths, and needs

Students might be asked to choose or suggest a context they would like to use when investigating a particular science concept… Teachers sought to develop or strengthen partnerships with science-focused organisations and community groups that could potentially provide students with authentic, relevant science learning experiences.

We hope that leaders and teachers can use this report to consider how they can strengthen science teaching and learning opportunities in their school.

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