



MINISTRY OF EDUCATION

Te Tāhuhu o te Mātauranga

Strengthening engagements between schools and the science community: Final report

Rachel Bolstad & Ally Bull with Sally Carson, Jane Gilbert,
Bill MacIntyre, and Lorraine Spiller



Science in the New Zealand Curriculum

This report is one in a series written for the Ministry of Education by The New Zealand Council for Educational Research in collaboration with Learning Media and The University of Waikato. The work was divided into three strands: Curriculum support for science, science community engagement, and e-learning in science.

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Report prepared for the Ministry of Education

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and Lorraine Spiller

2013

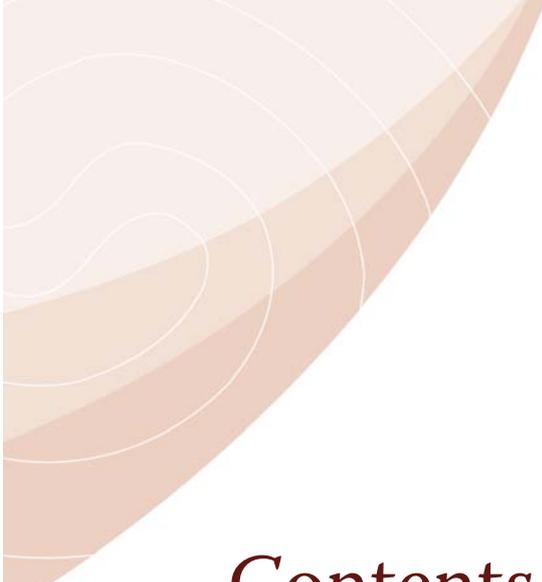
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ISBN 978-1-927231-12-8

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Acknowledgements

Our thanks go out to all the school leaders, teachers, students and members of the science community who contributed to this research through surveys, in focus groups, or as participants in the case studies. Finally, this work would not have been possible without the funding provided by the Ministry of Education.

Executive summary

Introduction

The aim of this Ministry of Education research project was to generate evidence-based recommendations for strengthening partnerships between schools and the science community to support students' science learning and engagement. The research took a future-oriented perspective and was framed by larger questions about the purpose of science education in the context of a rapidly changing 21st-century world. It digs beneath assumptions about *why* learners' and teachers' engagement with the science community is considered important and examines the kinds of approaches that might support future-oriented science education for New Zealand learners.

In New Zealand, as in other countries, schools and science communities come into contact in many different ways, driven by a variety of purposes. The variability of these engagements means it can be difficult to evaluate which types of initiative have the most effective outcomes. This research critically examines the *overall purpose* of such engagements, and then considers the evidence for impacts and outcomes. High-level recommendations are made for a system that supports and encourages future-oriented learning engagements between education and science communities

Methodology

The research was carried out in two phases. Phase one comprised a survey of teachers (n = 301), a survey of science community providers who work with schools (n = 43) and a brief literature review. The second phase comprised five case studies of science community engagement initiatives, covering a spread of types across several different regions in New Zealand. The researchers also undertook a small number of focus-group interviews with

scientists and science educators, and a more detailed synthesis of the literature to provide a framework for the final data analysis.

Why should schools engage with the science community?

There are two major reasons usually given for teaching science in schools:

- to prepare learners for the possibility of pursuing further learning and careers in science-related fields
- *all* learners need to develop some degree of scientific literacy for their own good and the good of society.

These two reasons are frequently intertwined, both in school science and in approaches to school engagements with the science community. They are not mutually exclusive, but they can lead to different things being emphasised in practice.

From the literature we identified at least six arguments for why schools should engage with the science community, which will obviously be related to why we teach science in schools. The first three we have labelled ‘business as usual’ arguments. These arguments provide a sound case for the value of school–science community engagements. However, such arguments do not *on their own* present an impetus for making significant changes in current approaches to school science curriculum planning, teaching and learning. The arguments are as follows.

- 1) The science community can provide access to up-to-date scientific knowledge, expertise and access to resources or environments that are out of the reach of most schools.
- 2) The science/STEM (science, technology, engineering and mathematics) community can give learners experiences that are engaging, motivating, interesting or expand their horizons.
- 3) Role models from the science community can inspire learners or help them to see themselves and their identities reflected in science.

The fourth, fifth, and sixth arguments *do* provide an impetus for deeper shifts in thinking about school science teaching and learning, including the potential role and scope for engagements with the science community in this process.

- 4) Science community engagements enable learners to experience authentic and relevant science.
- 5) Applying scientific knowledge to address real-world challenges requires a complex interaction with other knowledge domains, and learning this is as important as learning the scientific knowledge itself.

- 6) Schools, on their own, do not have the resources or expertise to supply all the kinds of learning support needed by 21st-century learners. The resources of the wider community need to be available to learners.

The literature associated with these six arguments suggests that future-oriented science education should be shaped with attention to at least three perspectives on what constitutes important and relevant science learning. These three perspectives are those of the science community, learner(s) and the wider community/society. The six arguments build a case for situating students' science learning in real contexts of genuine relevance to the community. Students should be connected with community partners and supported to achieve and share the real outcomes of their learning work.

This approach has implications for many deeper structural elements of science education in schools. These elements include the way the curriculum is planned and organised, how science learning interconnects with other learning, and what kinds of relationships, time frames and resources are needed to support this interconnection, including resources from the science community and wider community.

Insights from the case studies

Origins and drivers

The surveys and case studies in this report show that different origins and drivers can lead to school engagements with the science community. Whatever their origins and drivers, an essential dimension of effective engagements is the ability of partners to form strong working relationships and to co-develop the details of the engagement initiatives in ways that effectively identify and support learners', teachers' and communities' science-learning needs.

Matching means and ends

The case studies reveal the importance of all parties having a clear idea of the desired purpose(s) or *ends* for engagements between schools and the science community. Clarity of purpose allows the parties to design *means* (contexts, practices) that are in alignment. The purposes or ends can range from the goal of giving younger students engaging, interesting, enjoyable experiences with science to 'awaken their inner investigator', to constructing and supporting pathways for students into particular science-related areas (such as health science), to meeting a more general community need for science-literate community decision makers. Having a shared view of these deeper purposes means that initiatives can evolve as the partners recognise new opportunities, or the next steps towards their goals.

Time, relationships and environments

Several of the case studies illustrate the importance of two temporal aspects: *immersive* time and repeated engagements *over time*. Immersive time, in the form of multi-day, in-depth programmes, gives learners more complete, connected, in-depth opportunities to experience many interconnected parts of the process or context of a science investigation. Repeated engagements over time involve learners having multiple learning experiences with people from the science community over the course of a term, a school year or several years.

Both forms of time (immersive and repeated engagement) seem to be an important factor in developing *relationships*. Most of the case studies commented on learners developing positive, productive, warm and rewarding relationships with their science community partners and, in many cases, with their teachers as well. The benefits of these relationships were reported to flow both ways: the relationships were rewarding not just for learners, but for scientists, university science students, mentors, teachers and other partners. Some of the case studies suggest that learning in environments outside the normal school or classroom context plays a role in fostering productive relationships. Learners, teachers and scientists see one another in new ways.

Key people

Often science community engagement initiatives involve a handful of key people who are brought together to make the initiative work. Across the case studies certain recurring roles seemed to be important. These included:

- co-ordinators (or intermediaries) within the science community who can mediate and liaise between the worlds of science and education
- teachers who have a special understanding of, or commitment to, science education
- members of the science community who are committed to the intentions of the engagement initiative and are open to the flow-back benefits of their own engagement
- people with strong *mana* (status, prestige) and leadership roles in the community, or in particular sectors (philanthropic, health, business), who have the power to inspire support and/or mobilise resources.

Dependence on key people carries risks, however: an initiative may not be sustainable if there is a lack of structural support for initiatives when key people move on. In addition, sustainability will be affected if insufficient resources are available for key people to do the work that is needed.

Sustainability, scalability and long-term relationships

Some initiatives in the case studies illustrate the importance of bedding in deep relationships and partnerships at an organisational or systemic level. These longer-term relationships and processes can allow a school–science community engagement to be maintained, insulated—to some extent—from the limitations of short-term contract funding and a dependence on key individuals. This continuity may involve long-term partnerships between the same organisations and institutions, or it may involve system-level resourcing and co-ordination structures that enable schools and science community organisations to co-ordinate activities that meet certain needs at a particular time.

Synergies and connectivity across the science education ecosystem

Teacher survey data gathered in the first phase of this study suggested that teachers' use of the science community as a resource may be determined by a range of factors, including the teachers' years of experience and their degree of connectedness with the wider science education 'ecosystem'. The case studies suggest opportunities for greater interconnections and synergies *across* initiatives, both at an organic level (key people collaborating and networking to share resources and knowledge) and at a strategic level (looking across science education outreach initiatives to identify opportunities for a more connected and collaborative approach across the system).

Community connections

Some of the case studies illustrate the wider community connectedness that can grow from engagements between schools and the science community. In one case study (The Clinic), parents believed that schools could benefit from expertise held within the wider community: a community link person could support groups of schools to connect with community expertise. Another case study (Science Wānanga) explored aspirations to build engagements with whole communities, *including* schools. Both initiatives point towards a view of school and science community engagements as comprising just part of schools' engagement with the wider community, which provides the support needed by 21st-century learners.

Flow-on effects for school science teaching and learning

Across the case studies there was mixed evidence for whether the engagements had significant and long-term impacts on business-as-usual science teaching and learning. In some cases teachers believed that their engagement experiences *would* have a lasting impact on the ways in which they planned and supported science learning for their students. However—aside from the difficulties of providing the same kinds of expertise, resources and access to environments that the science community can provide—the extent to which these

engagements can have an impact on business-as-usual school science may be limited by at least two factors: teachers' own knowledge and confidence, and the current structural features of school science teaching and learning (encompassing approaches to curriculum planning and assessment), or a combination of both. Some initiatives have identified a need for more focused teacher support and professional learning, or for extended teacher opportunities to network and connect with members of the science community.

Benefits to the science community

Many of the case studies identified benefits to the science community partners. Scientists, lecturers and tertiary science students became better at communicating science: they developed their teaching abilities. They also found it personally rewarding and motivating to contribute to better science learning opportunities for school learners. At least one initiative (Science Wānanga) showed the potential for much deeper reciprocal benefits, such as supporting the science community to learn from the communities they work with, and cultivating long-term research partnerships. A final benefit is the opportunity to contribute to growing the next generation of scientists and other people who will work in, with and alongside the science community.

Research and evaluation

Several of the case studies highlight the need for deep research and evaluation strategies to sit alongside the development and growth of engagement initiatives. Some initiatives already self-evaluate to identify areas where more research or evaluation could support the next steps. But there is a need for more long-term research on the impacts of these initiatives for learners and the benefits of these engagements, both for the science community and for the wider community.

Using research and evaluation strategically to provide value to science community engagement initiatives has resourcing implications. Some initiatives examined in this research had large amounts of evaluation data but limited resources (time or expertise, or both) to process and use these data. Where research and evaluation expertise is a problem there could be value in science community engagement initiatives partnering with people and groups who can provide this kind of expertise. There is also the question of whether a long-term strategy for supporting, monitoring and evaluating the effectiveness of engagements between schools and the science community *across the system* is needed. There may be opportunities for greater pooling of existing knowledge and data held by different parties in these engagements, for example. First, however, a clear view of the *purpose* of gathering or evaluating information like this is needed.

Summary and conclusions

There are already many different kinds of initiatives and engagements between schools and science communities in New Zealand, and there is already a great deal of research and development that can inform the future of school–science community engagement initiatives. The major challenge is how to integrate what is already known. How can we advance our collective thinking and abilities to see the next step for the future of engagements between the education and science communities?

This research suggests that it is now time to take a whole-system perspective. From this viewpoint, all relevant stakeholders in educational and science community engagements will need to contribute to decisions about how to shape a science education ecosystem that supports many types of engagements at multiple levels of the schooling system to meet the different needs of learners, teachers, schools and communities, and to address wider national needs for a science-engaged and knowledgeable population.

We conclude this report by highlighting the factors that appear to be important in enabling schools and science communities to work together to support student learning and engagement. We also discuss how these ways of working might be strengthened. Suggestions for supporting a whole-system approach to future engagements between the science community, schools and the wider community include:

- providing strategic leadership to support knowledge development, sharing and the co-ordination of school–science community engagement initiatives
- strengthening networks of science-connected teachers
- strengthening networks of people working in intermediary roles across existing school–science community engagement initiatives
- further investigating ways to ensure equity of opportunity for all learners across all New Zealand schools
- identifying the key socio-scientific issues that have relevance to whole communities across New Zealand; with adequate secure funding, specialist science educators and scientists could work together to develop high-quality resources that could be adapted to suit specific communities
- committing to, and resourcing, well-designed longitudinal research to evaluate the effectiveness of initiatives.

1. Introduction

This is the final report for a Ministry of Education research project about engagements between New Zealand schools and the science community. The project was carried out by a research partnership led by the New Zealand Council for Educational Research in collaboration with Learning Media and the University of Waikato. It was one of three inter-related research projects funded by the Ministry of Education related to improving achievement in science education.¹

This science community engagement research project aimed to:

- identify the range and variety of ways in which people and groups from the science community² interact with schools (teachers and students) to support students' learning of and engagement with science
- generate evidence-based recommendations for strengthening school–science community partnerships that can support school students' science learning.

Taking a future-oriented perspective

This research project took a future-oriented perspective, framed by larger questions about the purpose of science education and the nature of science practice in a rapidly changing 21st-century world (Bull, 2011b; Gilbert, 2012; Office of the Prime Minister's Chief Science Advisor, 2011). Our goal was to develop evidence-based recommendations for strengthening the relationships between the school sector and the science community in ways that support

¹ The related projects are Curriculum Support in Science and E-Learning in Science.

² **Science community:** people and organisations whose major purpose is to engage in the practice of science and/or provide professional support for the practice of science, and/or promote science engagement and learning among school-age learners.

Science community engagement: working relationships and interactions between people in schools (teachers and students) and the science community (as defined above) for the purposes of supporting science learning and engagement. This could also include multi-party engagements in which scientific organisations work with schools *and* community partners, but *only* if the partnership includes school learners.

and sustain *future-oriented* science education for New Zealand learners (see Bolstad & Gilbert, 2012).

Future-oriented educational research goes beyond describing what is currently best practice: it aims to help develop a view of ‘next practice’. Such future-oriented research does not seek to *predict* the future. Rather, it aims to use research to support informed thinking and conversations about the future among people in the science community and all players in the education system—people in schools (teachers, learners and school leaders), educational policy leaders, families and wider communities. A future-oriented approach demands that all these people and groups be able to engage with research knowledge about current practice, *as well as* have the opportunities to think about the future of education and develop their understanding of what kinds of learning are needed in order to succeed and flourish in the 21st century (see Bolstad & Gilbert, 2012; Leadbeater, 2011).

This research undertook to draw together what is already known about engagements between schools and the science community, with a view to developing insights into what next steps might be needed to further strengthen science learning for young New Zealanders, with support from the science community.

Methodology

The research process is outlined in Figure 1. The first phase of the project, carried out between January and June 2012, scoped the field. This phase comprised a survey of teachers, a survey of science community providers who work with schools, and a brief literature review. Findings from the first phase were discussed in an interim report (Bull, Bolstad, & Spiller, 2012). These data and the research team’s existing networks and contacts were used to identify a smaller selection of science community engagement initiatives to be explored as case studies for the second phase of the research (July to November 2012). The second phase also included a more detailed synthesis of the literature to help frame the final data analysis, and a small number of focus-group interviews.

Structure

This report draws together the findings from the case studies and literature synthesis undertaken in phase two. Chapter 2 draws on the literature to examine various arguments for why schools should engage with the science community. Chapter 3 outlines emerging themes across the case studies, and Chapter 4 presents brief overviews and some specific insights from each case study.³ Chapter 5 provides conclusions and recommendations.

³ Full descriptions of case studies are presented in the appendix to this report.

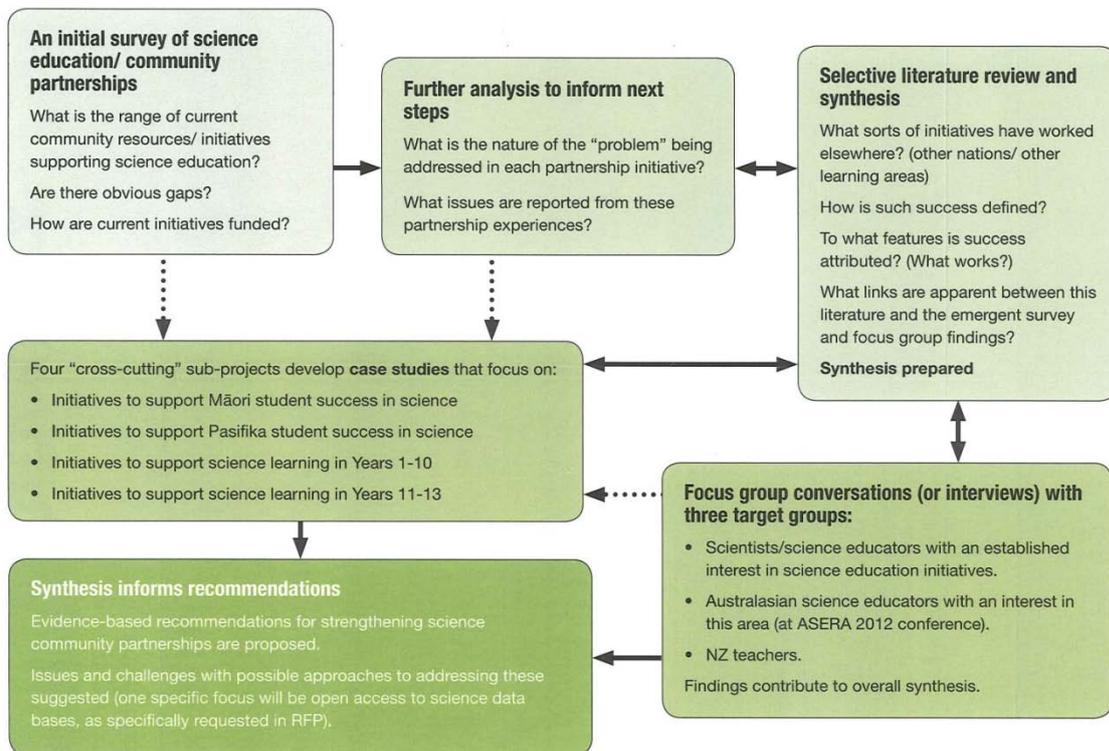


Figure 1 **Figure 1 Overview of the science community engagement project**

Data sources are summarised in Table 1, and key findings from phase one are summarised in Table 2.

Table 1 Summary of data sources

Teacher survey	179 secondary and 122 primary teachers
Science provider survey	43 science providers
Literature review and synthesis	Selected key literature, primarily from New Zealand, Australia and the United Kingdom (see reference list)
Case studies	5–7 case studies ⁱ (see Chapter 3 and the Appendix)
Focus groups	3–4 focus groups with scientists, science educators and students ⁱⁱ

ⁱ The Otago University case study actually comprises three strands. Although it was initially conceived as one case study, it became clear in the research that it would be valuable to develop three interconnected case studies. Thus the original five case studies became seven.

ⁱⁱ One focus group included six female scientists (all had school-aged or pre-school children). A planned focus group with science educators at the Australasian Science Education Research Association (ASERA) conference did not proceed, although a general discussion with science educators was held following the presentation about the first phase of this research at that conference. A third focus group with a group of parents became The Clinic case study. A few student focus groups were also convened in an attempt to capture the voice of Māori and Pasifika students involved in science community engagement initiatives that were investigated as part of the research.

Table 2 Summary of key findings from phase oneⁱ

Range of initiatives in New Zealand	<p>A wide variety were found, including:</p> <ul style="list-style-type: none"> • one-off events (e.g., students visiting science workplaces or universities, career information days/presentations, open days, science fairs, road shows, short LEOTCⁱⁱ visits, scientists visiting schools to give talks) • ongoing work with schools (e.g., students mentored by scientists or tertiary science students, internships, scientists working alongside schools in local projects, 'hands-on' programmes or intensive residential courses at universities or other science institutions) • Web-based initiatives (e.g., virtual field trips, connecting with scientists online and the provision of science resources for schools, such as through online hubs or portals) • initiatives that support teachers (e.g., Royal Society Teacher Fellowships, access to expert information and support, such as through online hubs or portals).
Aims of the initiatives	<p>There were two broad categories:</p> <ul style="list-style-type: none"> • those that aim to encourage more students to go into science careers • those that aim to engage <i>all</i> students in science learning.
Target groups	<p>Some initiatives targeted primary or secondary students, others targeted all year levels. There are some specific target groups such as Māori or Pasifika students, or students in need of extension in science. Some initiatives are aimed at both students <i>and</i> teachers.</p>
Resourcing	<p>Initiatives are variously supported by the Ministry of Education, universities, Crown Research Institutes and other science research organisations, local or regional councils, business and philanthropic groups, and community trusts.</p> <p>Resourcing was the issue most commonly cited by science providers—working with schools was often seen as worthwhile but placed considerable demands on scientists' time and the funding available to them. Sourcing funding for <i>sustaining</i> initiatives after the initial stages was seen as a challenge.</p>
Benefits	<p>Teachers surveyed were likely to see science community engagement initiatives as benefiting student learning rather than their own. Teachers saw science community resources as good for connecting school learning to real-world contexts, extending gifted and talented students, and providing students with insights into science careers.</p> <p>Science providers often reported that their initiatives supported both teacher <i>and</i> student learning. Almost all of those surveyed said their initiative "puts science learning in a more hands-on, fun, or engaging context" and "supports students to undertake science inquiry/research in a real context or for a real purpose". The majority of initiatives were portrayed by the science providers as being mainly beneficial to schools (learners and teachers). Very few mentioned reciprocal benefits to the science community.ⁱⁱⁱ</p>
Access and uptake by teachers	<p>According to the teacher survey, museums, science and technology centres, aquariums, zoos and planetariums, and their staff, were the most frequently used science community resources.</p> <p>Further analysis provided evidence that non-users of science curriculum resources were also likely to be non-users of specific community resources. Conversely, innovative users of curriculum resources were also more likely than all other respondents to be active users of science community resources</p>

ⁱ See Bull et al., 2012; Hipkins & Hodgen, 2012.

ⁱⁱ LEOTC = Learning experiences outside the classroom

ⁱⁱⁱ However, this question was not directly asked in the survey, and many of the science community partners in the case studies *did* identify significant benefits flowing from their engagements with schools.

2. Why should schools engage with the science community?

Learners' and teachers' engagement with the science or STEM (science, technology, engineering and mathematics) community is widely perceived to be a good thing, with multiple benefits.⁴ However, it is important to examine *why* it is perceived to be good, and how it relates to the purpose of learning science at school.

Science education academics identify a range of purposes for school science education, including:

- preparing students for a career in science (pre-professional training purpose)
- equipping students with practical knowledge of how things work (utilitarian purpose)
- developing students' ability to make informed decisions about socio-scientific issues (citizenship purpose)
- developing students' ability to think scientifically, and building their knowledge of science as part of their intellectual enculturation (cultural/intellectual purpose) (see Bull, Gilbert, Barwick, Hipkins, & Baker, 2010).

The New Zealand Curriculum, like most other curricula, attempts to serve all these purposes. However, this mixture of purposes means that time should be spent clarifying exactly what it is that we are trying to achieve in school science and then how this should be supported by engagements with the science/STEM community. The report from the first phase of this research noted a broad range of initiatives in New Zealand (see Table 2). The international literature shows that equally varied initiatives occur in other countries, where many approaches have been used to examine and describe their impacts and outcomes. This

⁴ This sentiment was also reflected in the survey phase of this study, with 89 percent of primary and 71 percent of secondary teachers agreeing that "engagement with people from the science community is essential for 21st century science education programmes" (Hipkins & Hodgen, 2012, p. 54).

chapter draws on the literature to critically examine the overall purpose of such engagements, and their impacts and outcomes.

Although there is an extensive body of New Zealand and international literature on school engagements with the science community, most studies focus on the processes, impacts and outcomes of particular initiatives. Given the vast range of engagements between schools and the science community, the challenge is to look beyond individual studies to identify overall themes that can inform a system-level view of what may be needed to strengthen and support connections between the education and science communities.

For this reason we focused on science education literature that sought to draw together findings across multiple studies and contexts.⁵ We also looked *beyond* the science education literature to the wider literature on engagements between schools and community partners,⁶ and to future-oriented ideas about learning and education.⁷ Distilling this literature we identified at least six arguments for why schools should engage with the science community. The first three we have labelled ‘business as usual’ arguments. They are:

1. the science community can provide access to up-to-date scientific knowledge and expertise, and can access resources or environments that are out of the reach of most schools
2. the science/STEM community can provide learners with experiences that are engaging, motivating, interesting or expand their horizons
3. role models from the science community can inspire learners or help them to see themselves and their identities reflected in science.

These three arguments provide a sound case for the value of school–science community engagements. However, they do not *on their own* provide an impetus for significant changes in current approaches to school science curriculum planning, teaching and learning. By contrast, the fourth, fifth and sixth arguments *do* provide an impetus for deeper shifts in thinking about the way in which school science teaching and learning are designed and

⁵ The most relevant literature tended to be from New Zealand, Australia and the United Kingdom. There have been strong parallels in the development of STEM education research and practice, with significant cross-pollination of thinking among the research communities in these countries. As a result, there is now a reasonable degree of coherence across this literature, pointing to a consistent set of issues and questions for educators, policy makers, the science/STEM communities and the wider public to consider in the development of school science education. Key pieces of science education literature that informed this synthesis are France & Compton, 2012; Tytler, 2007; and Tytler, Symington, Smith, & Rodrigues, 2008.

⁶ This included literature on schools’ relationships with community in terms of family/whānau, as well as parts of the wider community (e.g., the creative community, enterprise community).

⁷ Key literature includes Arts Council England, 2007; Bolstad & Gilbert, 2012; Bolstad, Roberts, & McDowall, 2010; Bull, 2011a; Eames, Benton, Sharp, & Kendall, 2006; Kress, 2008; Leadbeater, 2005, 2011.

planned, including the potential role and scope for engagements with the science community in this process. These are:

4. science community engagements enable learners to experience authentic and relevant science
5. applying scientific knowledge to address real-world challenges requires complex interaction with other knowledge domains, and learning this is as important as learning the scientific knowledge itself
6. schools, on their own, do not have the resources or expertise to supply all the kinds of learning support needed by 21st-century learners; the resources of the wider community need to be available to learners.

Each of the six arguments is discussed in more detail below.

Six arguments for school–science community engagements

Three business-as-usual arguments

1. The science community can provide access to up-to-date scientific knowledge and expertise, and can access resources or environments that are out of the reach of most schools

This argument suggests that the science community can give teachers and learners direct access to up-to-date knowledge, resources and guidance that would otherwise be difficult for schools to provide on their own. In doing this, science community engagement initiatives can be viewed as supplementing schools' knowledge and resourcing limitations. These initiatives have the potential to change learners' access to, or experiences of, learning science, including providing a more motivating, challenging, engaging and real experience of science. These initiatives could have flow-on effects that lead to deeper changes in everyday school science teaching and learning practices.⁸

However, these outcomes may not be achieved if not explicitly planned for in the engagement. As a result, science community engagements may provide a valuable

⁸ For example, learners and teachers could gain new knowledge, skills or ways of questioning or investigating the world around them, and this in turn could have a lasting impact on the way they approach scientific thinking and practice in the classroom as well as in other facets of their lives. The initiatives could change participants' views of the nature of science, and science's relationship to society and to their own lives and communities.

supplement that extends and enriches the experiences of learners and teachers, but school science learning and teaching may remain largely business as usual.

2. The science/STEM community can provide learners with experiences that are engaging, motivating, interesting or expand their horizons

There are myriad ways in which school/STEM community engagements could provide more motivating, engaging, challenging or interesting experiences for learners. These include opportunities to:

- experience interesting environments, phenomena or resources that are unavailable in schools (see argument 1)
- meet and learn about people and their jobs and how they came to be doing what they are doing
- understand how scientific concepts and processes are relevant in real contexts
- learn in different ways (e.g., experiential, practical, whole-body learning) that are not as often encountered in conventional classroom teaching and learning practice
- form positive relationships with people in the science community whom students would otherwise be unlikely to encounter in this context.

There is ample evidence in the research literature to support claims that engagement with the science community can support these outcomes. However, this research also shows that what is motivating and engaging for some learners may fail to connect with others. This suggests the importance of thinking about how school–science community engagements can be personalised and tailored to learners’ needs, interests and contexts,⁹ rather than assuming that one size fits all.

The engagement and motivation argument also leaves unanswered the question of *why* it matters for students to be engaged with or motivated about learning science. For example, is it to prepare them for further learning or careers in science, or is it to prepare them for their roles as citizens? And can the same kinds of approaches serve both ends? As long as these questions go unexplored, school science teaching and learning are likely to remain business as usual. (Note that, as with the previous argument, this does not diminish the role of science community engagement in supporting outcomes for learners that teachers and schools might not be able to achieve on their own.)

3. Role models from the science community can inspire learners or help them to see themselves and their identities reflected in science

⁹ For example, some students with an existing interest in science may be engaged by opportunities to be challenged and extended, while other students with limited prior connections with science may be engaged by encountering people who challenge and reshape their ideas about science and the people who work with science, and so on.

New Zealand and international research provide evidence that students who remain interested in science and pursue STEM pathways later in life have often developed scientific interests and can imagine themselves in particular kinds of STEM careers before the age of 14 (see Bolstad & Hipkins, 2008; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008). Researchers argue that we need to better understand how and why these interests and aspirations develop or decline, and what might be done differently to support wider engagement in STEM.

One area of focus has been to support learners from communities or demographic groupings that are under-represented in the sciences (or particular branches of science). It is thought that these learners need to see people like them involved with science to realise that this can be a possibility for them too. This goal of raising learners' interests and aspirations regarding science has been paralleled by efforts to understand deeper structural, economic, social and cultural barriers that inhibit their involvement and participation in the sciences. This research has demonstrated that connecting learners with potential role models from their own cultural groups is only one part of a larger set of strategies that are necessary to support greater diversity among the population of science learners and future scientists. As some of the case studies in this research show, giving learners opportunities to engage with science that is *embedded in their own community's contexts and environments* is a powerful way for learners not only to encounter science mentors and role models they can relate to, but also to engage with particular science-related knowledge and practices that are important and relevant to themselves and their communities.¹⁰

Developments such as these begin to point towards the more transformative edge of this argument for engagement with the science community. First, shaping students' learning around locally and personally relevant contexts as a way of enriching their (and their communities') engagement with science opens up the possibility for quite different ways of thinking about science curriculum planning and who from the wider community might be involved in that process. Second, embedding science engagement in personally and community-relevant contexts may offer substantial benefits for science education for citizenship purposes, providing benefits for even those learners who do not pursue further study or a career in science-related areas. These ideas are picked up and expanded in the next three arguments for school–science community engagements.

¹⁰ Becoming enculturated into the community of science requires the learner to be both able and willing to participate in a community whose values, beliefs, ways of working and interacting, and languages may be quite different from what they are used to. This has opened up debate about the need for science teaching—and science practice itself—to accommodate, or at least support more substantive dialogue across, different ways of knowing and seeing the world. There is an extensive New Zealand-based literature on these issues, with a particular focus on the success, engagement and achievement of Māori and Pasifika learners in science as well as other areas of the curriculum.

Three arguments that point towards deeper changes

4. Science community engagement enables learners to experience real, authentic and relevant science

Themes of *authenticity* and *relevance* recur across much of the literature as a rationale for schools connecting with the science community. Engaging with ‘real’ science or scientists, it is argued, provides a pathway for learners to see how and why scientific knowledge is relevant in real situations. However, there are at least three ways to think about what ‘authentic’ means.

- Authentic/relevant science in the eyes of the science community: i.e., opportunities for learners to see or engage with science *as it is practised and understood by the science community*.
- Authentic in terms of personal relevance to the learner: i.e., learners experience a connection with scientific contexts that *matter to them*, are connected to their lives/interest/knowledge, are personally meaningful and engaging, motivating, etc.
- Authentic in terms of relevance for the community and society: i.e., learners, teachers and scientists engage together in science-related learning and activities that are of *immediate relevance and important to the local community or wider society*—for example, addressing issues related to community health, local environments, local or nationally relevant sustainability issues, or other 21st century ‘wicked problems’ (see below).

These three views of authenticity are not mutually exclusive, but it is useful to discuss each separately because they can lead to different emphases in school–science community engagement.

The first interpretation focuses on how science is understood and practised within the science community. It is argued that the traditional focus on the acquisition of content knowledge *in* science education needs to shift towards a greater focus on learning *about* science and how it is practised in the contemporary world—the Nature of Science strand (or NoS) of the *Curriculum*. Here, connections with the science community can support students to develop a more accurate insight into the realities of contemporary science, particularly by learning *with* scientists and undertaking real scientific research which, unlike much school science, can be more open-ended, complex, messy and does not have predetermined answers. This reflects a sociocultural apprenticeship model of learning whereby learners are seen as novices who are working at the peripheries of, and developing towards a deeper knowledge and understanding of, what it takes to be a fully fledged member of that community (see France & Compton, 2012).

The second interpretation considers what is relevant or authentic from the *learner’s* perspective. This leads to questions about how learners can experience science learning that

is relevant, engaging, accessible and connected to their lives, interests and identities (see argument 3). Research highlights the need to think about the changing nature of youth identity in “late modern” society (Kress, 2008; Tytler, Osborne, et al., 2008). Theorists argue that young people in the 21st century are increasingly driven by an intrinsic search for personal meaning. At the same time, they are expected to make appropriate choices and actively participate in constructing their own lives and careers.

However, there is a growing mismatch between these aspects of late-modern youth identity and the traditional systems and structures of schooling. In the past, society has tended to value attributes such as obedience, conscientiousness and humility. In late-modern society, by contrast, youth are more likely to be motivated by an appeal to the contribution of the individual, and to value such things as care for the environment, democracy, care for others, creativity and self-realisation. Research suggests that young people may not associate school science with activities that offer the potential for self-realisation or other values they believe will give meaning to their working lives: “In this context, education is continuously evaluated against how it contributes to students’ self-development asking ‘what does it mean for me?’” (Tytler, Osborne et al., 2008, p. 84). Theorists argue that school science needs to change in order to better reflect the identities that young people are building—or wish to build for their future selves—against a backdrop of local, national and global issues and concerns. This idea is further developed in argument 5.

The third, related, view positions science within broader contexts that are relevant to the lives of individuals, communities or the wider public. It asks, What is an authentic science-related context from the point of view of the wider community or 21st-century society at large? This line of questioning leads to fruitful discussions about the purposes of science education from a 21st-century citizenship perspective. Although many STEM initiatives have an explicit goal of attracting and engaging students who may pursue further studies and careers in this area, there is also the question of science education for those who, for whatever reason, will not follow these pathways. In other words, aside from laying the groundwork for learners to potentially pursue further learning and careers connected with science, why is it important for all students to learn science, and what kinds of science learning do they need? This idea is further developed in argument 5.

5. Applying scientific knowledge to address real-world challenges requires interaction with other knowledge domains, and learning this is as important as learning the science knowledge itself

This argument foregrounds the complex new realities of the 21st century. The term ‘wicked problems’ has been used to characterise the major challenges of the 21st-century world. Wicked problems span multiple domains: social, economic, political, environmental, legal and moral. They are “highly complex, uncertain, and value-laden” (Frame & Brown, 2008, p. 226) and cannot be solved using straightforward puzzle-solving or mathematical solutions. Science and technology are deeply implicated in wicked problems, but are not, *on their own*, able to provide the complete solutions to these challenges.

It has been suggested that wicked problems can only be addressed with ‘clumsy’ solutions, and this involves bringing together disparate perspectives on the problem. These forms of engagement demand new kinds of capabilities from lay people and people with well-developed scientific knowledge. This has implications for thinking about how science education can support budding scientists and budding citizens to actively develop the capabilities they need to productively engage in 21st-century wicked-problem solving. This is not something that our current structures and systems were designed to achieve.

This argument suggests that students’ science learning ought to be situated in real contexts of genuine relevance to the community or society, and which bring them into contact with community partners and support them to achieve and share real outcomes as a result of their learning work. This approach is likely to have consequences for many deeper structural elements of science education in schools. It has implications for the way the curriculum is planned and organised, for the interconnection of science learning and other learning, and for the kinds of relationships, timeframes and resources needed to support this interconnection, including resources from the wider community.

6. Schools, on their own, do not have the resources or expertise to supply all the kinds of learning support needed by 21st-century learners

This argument links to the previous five. Future-oriented thinking suggests that the problem of resourcing learners’ (and teachers’) needs—which has always been an issue in education—is more important than ever. This argument parallels argument 1—“the science community can provide access to up-to-date scientific knowledge and expertise, and access resources or environments that are out of the reach of most schools”—but on a much broader scale. It goes beyond thinking about how to connect learners to expertise within individual fields of knowledge, such as science. It is an argument that all of schooling needs to be thought of as a much more community-connected and community-supported endeavour, drawing much more on the expertise, knowledge and resources of the wider community to support learning contexts that meet increasingly complex 21st-century learning needs.

The literature suggests that members of the wider community may have a significant effect in determining what kinds of science learning are needed for a ‘lifelong learner’. One small Australian study found that community leaders “promoted a vision of school science that is relatively coherent yet at odds with mainstream formulations of the nature and purposes of school science” (Symington & Tytler, 2004). In discussing what students ought to learn, the participants who had not been teachers “did not talk about the constraining influences of curriculum design and school/classroom management, nor did they define a core set of knowledge that students need, or even the need for this”. Rather, they offered the view “that emphasised school science as a beginning not an end, contributing to, and encouraging life-long learning in science” and “the school curriculum as a launching pad into a complex and highly contextualized future, rather than the creation of a certified knowledge bank”.

The authors concluded that community stakeholders should be involved in the early stages of school science curriculum development because they bring relevant contributions with different emphases to those in the school system, yet relevant to students' life paths. Traditionally, communities' needs and views (not to mention those of the students and parents) have not been central to professional discourses about curriculum and teaching. There is substantial evidence to suggest that seeking greater community input into shaping school learning is genuinely challenging (Bolstad, 2004; Bull, 2010). Nevertheless, there are strong theoretical arguments for why community and public engagement in shaping education is increasingly important, even in an area such as science, which has traditionally been seen as the domain of disciplinary subject experts.

Drawing the arguments together

Drawing together the six arguments suggests that future-oriented science education should be shaped with attention to at least three perspectives on what is important and relevant science learning: that of the science community, that of the learner(s) and that of the wider community or society. As a thought experiment, the scenarios below speculate what might happen if science learning experiences are shaped without attention being paid to any one of these three perspectives.

Scenario 1: Science learning that does not draw on what the science community views as relevant and authentic science knowledge

Hypothetical example: Learners discover and engage with a real problem in their community (e.g., an environmental problem). They seek to take action to solve the issue but apply inappropriate scientific methods in the course of their research, or misunderstand or misuse data, or do not draw on scientific knowledge at all.

Potential result: What students learn and do may be important or interesting to them, but it may not be considered to be 'good science', or to be science at all, by those within the science community. Opportunities for schools to build positive connections with the science community could be missed, as could opportunities to develop and extend students' scientific knowledge and understanding.

Scenario 2: Science learning that does not take account of what learners will find interesting, relevant, motivating and engaging

Hypothetical example: Teachers and scientists collaborate to develop a programme for learners based around a relevant science area, with clear applicability to contemporary issues for the community, society or the environment, or a combination of all three. However, this is done in a way that fails to connect with learners.

Potential result: What students learn and do may be important to the science community and relevant to 21st-century challenges, but it may fail to engage or enthuse learners and may not even be understood by learners. At worst, learners could become more alienated or disconnected from science as a result.

Scenario 3: Science learning that does not include opportunities to understand how scientific issues connect with community/society

Hypothetical example: Teachers, scientists and learners collaborate in projects and experiences that engage and enthuse learners, supporting them to develop their knowledge and understanding of accepted scientific concepts and practices. However, this learning is bracketed off from opportunities to engage with other relevant disciplinary knowledge and broader social issues that come into play in real-world social, community and national issues.

Potential result: What students learn and do might bring them closer to understanding science as it is practised today, or engage them with a desire and interest to pursue science. But does it support them and others in their community to develop the knowledge and experiences needed to become ‘wicked problem’ solvers?

Scenario 4: The ideal?

Hypothetical example: Schools, the science community and members of the wider community collaborate to shape and support science learning opportunities that are perceived as meaningful by all parties. These learning opportunities can be personalised to learners’ different needs, interests, aspirations and contexts.

Potential result: Schools, the science community, learners and the wider community experience short- and long-term benefits from their collaborative engagements. Reciprocal benefits of the collaborations are evident to all parties: learners, science community partners and people from the wider community. Science education supports students on pathways to further study and careers. It also provides learning benefits for students who will not pursue these pathways.

Learning from what is already known

It is clear there is already a great deal of research and development that could inform the future of school–science community engagement initiatives. The literature shows that different initiatives are premised on different underlying goals and purposes. These range from supporting students on pathways towards further science study and careers, to helping students learn and understand very specific pieces of knowledge or skills related to a particular piece of scientific practice, to ‘science for citizenship’ approaches that seek to engage and connect students to complex real-world issues involving science within their

communities. France and Compton (2012) point out the need to match approaches to purposes very carefully. They argue that, for any initiative:

- there needs to be alignment between an engagement initiative's purpose, theoretical perspectives and implementation decisions¹¹
- the importance of all participants understanding the purpose of the connection and their role within it cannot be overstated
- it is equally important to design a monitoring component to provide feedback at key stages of the initiative.

For the last point above, France and Compton's edited book (and other New Zealand studies) shows that there is already a great deal of knowledge within some of the many school–STEM community engagement initiatives that exist in New Zealand.¹² The major challenge is how to integrate what is already known so that we can advance both our collective thinking and our ability to see the next step for the future of engagements between the education and science communities.

The Australian literature provides relevant insights into school–STEM community engagements. For example, Tytler, Symington, et al. (2008) undertook a major piece of work researching 16 projects funded by the Australian School Innovation in Science, Technology and Mathematics Project (ASISTM), which, at the time of the research, had funded over 300 projects across Australia worth \$33.7 million. Some of the key findings from the research are summarised in Table 3.

¹¹ For example, France and Compton discuss the argument that developing an understanding of NoS requires learners to encounter the messiness of real practice so they can get a real sense of the discipline. Initiatives do this in various ways, including opportunities for learners to work alongside scientists and technologists. However, if the goal is the development of conceptual and procedural knowledge, these authors argue that the messiness of NoS and NoT can actually mask the concepts and practices learners are trying to understand because they have fewer hooks to make sense of detail (as novices).

¹² France and Compton's (2012) book looked at more than a dozen different initiatives with the aim of distilling guiding principles for future developments. New Zealand initiatives discussed in the book include the Royal Society of New Zealand's CREST and Teacher Fellowship schemes (Meylan & Leaman, 2012), the New Zealand Biotechnology Learning Hub (Bunting & Jones, 2012), Futureintech (Christie, 2012), Bright Sparks (Peterson, 2012), LENSscience (Bay, Sloboda, Vickers, & Mora, 2012), and Café Scientifique (Otrell-Cass, Campbell, & Wilson, 2012).

Table 3 Key findings from an evaluation of ASISTM

<p>Issues and visions underpinning these projects: All the projects shared a focus on student interest and engagement. This was generally linked in the projects to students being exposed to contemporary real world practice, and to expert practitioners of science, technology and mathematics. Thus, while knowledge was a very important aim, it was usually very contextual, exhibited a variety of types and served this broad focus on engagement.</p> <p>Ideas pursued in the innovation: The knowledge that students were exposed to in these projects was incredibly varied and represented a broad range of purposes for education in science, technology, and mathematics (STM), including understanding investigative and design processes, awareness of careers, and problem solving. Engagement with science was largely achieved through involving students in authentic practices in local settings. Knowledge was often generated to pursue particular purposes, often related to community interests.</p> <p>Practices represented in the innovations: Students were often exposed to cutting-edge contemporary practices in science, technology and mathematics that formed the content focus for activities in these fields. The same was true of pedagogical practices and wider school and cluster practices associated with the innovation. Taken as a set, these projects involved a number of pedagogical practices that differ from traditional science or mathematics classroom practice, including:</p> <ul style="list-style-type: none"> • project-based or problem-based learning • a strong skills focus involving scientific and related processes • more open pedagogies, where students are given increased agency • the creation rather than absorption of knowledge by students • a wider range of knowledge, including knowledge of processes and interdisciplinary links, knowledge about the contemporary and local use of STM, and knowledge of people using STM in employment • school programmes providing significant <i>in situ</i> learning experiences for teachers • a real audience for students' work • field trips and projects in the local environment • working with scientists and with local community members, as well as involvement of parents and the wider school community. <p>The practices were in almost all cases as significant for teachers as they were for students. For many teachers in these projects, the interaction with scientists and technologists and other community personnel led to a steep but satisfying learning curve. This was also true of their experience of new pedagogies.</p> <p>Outcomes of the projects: The projects had significant outcomes for:</p> <ul style="list-style-type: none"> • <i>students</i>—in addition to engendering enthusiasm there was significant knowledge generation and the development of expertise • <i>teachers</i>—there was considerable evidence of professional growth and in some cases professional renewal in their stories (the ASISTM initiative offers a significant model of teacher professional learning) • <i>teacher associates</i>—there has been increased understanding of education and the value of support from outside the school system, and some have chosen to enter the teaching profession • <i>the community</i>—there has been increased understanding of science in society, science, mathematics and technology education, student interest in science-based careers, and contributions to community facilities.
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Source: Tytler, Symington et al., 2008

Tytler et al.'s analysis provides an additional and useful perspective regarding the many 'actors' involved in supporting these projects. They define actors as those human or material entities that have an impact on the shaping and conduct of the project. These can be human (scientists, organisations, industries or the local community) or non-human (local environmental conditions, resources or organisational circumstances that shape possibilities). Tytler et al. note that the actors recruited to the project performed dual roles: they supported the project and its implementation, but they were also part of the local circumstances that gave rise to the project and shaped its direction.

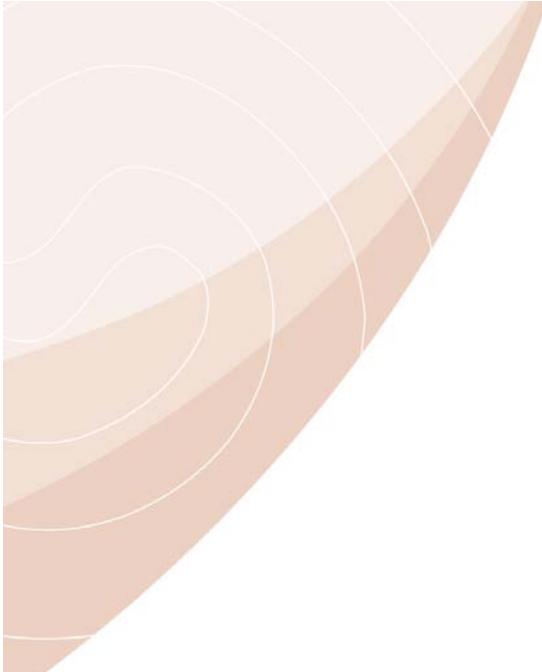
The innovation implicit in ASISTM is the alignment of teachers and outside experts in a partnership in a project that represents contemporary practice. Thus in many projects the actors provided insight for students into contemporary science and professional learning in the discipline for teachers. Teachers themselves were often powerful actors in the initiative. In some cases, particularly those involving large organisations, the management role was taken over by the non-school partner and this released teachers and associates to focus on the intellectual framing and direction of the project. Community interests were important actors in some projects, particularly in rural areas. (Tytler, Symington et al., 2008, p.12)

Tytler et al. comment that it is important for the success and likely sustainability of individual projects that these elements—ideas, actors and practices—be aligned and mutually supportive. As a generalisation, access to scientists working on local issues (actors) encouraged the pursuit of wider purposes of school science, technology and mathematics (ideas), and involved contemporary scientific and technological practices, and pedagogies that were varied and generally student centred (practices).

Summary of key messages from the literature synthesis

Our analysis of the literature highlights opportunities for schools' engagement with the science community to extend *beyond* supplementing business-as-usual school science education with additional knowledge, resources, role models and the like. The arguments presented in this chapter imply that engagements with the science community could be a mechanism for supporting much wider shifts in the thinking, planning, design, resourcing and support of science learning. From this point of view, closer engagement between the education and science communities (as well as the wider community) could become the central pillar for shaping science education in schools—in effect, changing business-as-usual school science education to better reflect learning needs in the 21st century.

As the case studies in the next chapters illustrate, this approach has the potential to be effective in terms of both supporting students who will go on to science-related education and career pathways *and* engaging learners in science learning for citizenship purposes. The case studies illustrate some of the ways this can occur in practice.



3. Themes emerging from the case studies

The contexts for the case studies

As phase one of this research showed, there is a vast range of school–science community engagement in New Zealand. We used data from phase one of this research as well as our team’s existing contacts and networks to identify different initiatives that illustrated a range of approaches. The case studies selected for phase two are not intended to represent every different kind of initiative, although they do provide a spread of types across several different regions in New Zealand. Table 4 provides a brief summary of key details of the case studies, including their age groups, location, scope and reach, and any particular focus or defining features.¹³

¹³ The Ministry of Education requested that the case studies include initiatives that focused on success for Māori learners, success for Pasifika learners, as well as initiatives at both the Year 1–10 and Year 11–13 levels of schooling.

Table 4 Summary of the case studies

Case study	Location	Primary	Intermediate	Secondary	Scope/reach	Particular focus
1. Otago University Science Outreach:						
• Chemistry Outreach programme	Otago	✓	✓	✓	Dozens of schools in Otago / South Canterbury	Emphasis on multiple-engagement programmes in schools
• Science Wānanga	Multiple regions			✓	Hundreds of Māori students from dozens of schools in several different regions	Partnering with iwi to support Māori learners' engagement with science in contexts selected by the local community (iwi* partners)
• New Zealand Marine Studies Centre	Otago/Southland and Nelson/Marlborough	✓	✓	✓	Hundreds of schools, thousands of students	The public face for the Dept of Marine Science, offering a range of programmes largely supported by LEOTC funding. The case study focuses on multi-day field and lab programmes for senior students.
2. The Liggins Education Network for Science (LENScience)	Auckland		✓	✓	Hundreds of schools, thousands of students	Māori students, Pasifika students, students in low-decile schools
3. The Clinic	Wellington	✓			One school	A parent-led initiative that aims to provide a place for the wider school community to connect and share their interests. Science was the focus for the pilot.
4. Dinosaurs and Disasters Geocamp	Hawke's Bay		✓		Four schools	Providing intermediate-age students with an insight into how scientists work
5. Health Science Academies	South Auckland			✓	Three pilot schools	Supporting Māori and Pasifika students in pathways into health positions in their communities

Iwi = tribe or extended kinship group.

This chapter highlights some of the emerging themes across the case studies.

Origins and drivers

The case studies show that schools' engagement with the science community can stem from different origins and drivers. For example, some initiatives are driven by the science community's general commitments to provide educational outreach for schools, or the public, or both. The LENSscience initiative and two of the University of Otago initiatives (the New Zealand Marine Studies Centre and Chemistry Outreach) illustrate these kinds of drivers.¹⁴ Schools' requests to the science community for assistance can also spark productive engagement.

Other initiatives are driven by a very specific *community* need linked with science. A good example is the Health Science Academies in South Auckland, which aim to grow and support learners' pathways into the health workforce as a long-term strategy for addressing health issues within those communities. This initiative, driven in significant part by the health sector (through the district health board), provides a clearly structured route into health sciences. It includes defined programmes of study for senior secondary students, and opportunities to engage with health science practices and people in tertiary and workplace settings.

Community-based drivers may include even broader long-term goals. Science Wānanga, which is part of the University of Otago's Science Outreach programme, is a good example. This initiative began with the university picking up on a request from the late Dr Paratene Ngata in 2007 to co-ordinate a programme that advanced Ngāti Porou's strategic imperative to increase the number of rangatahi (young people) achieving in science and the health sciences. The initiative has subsequently grown to include multiple partnership programmes between the university, iwi groups and schools (as well as other science community partners) in several different parts of the country. Through the partnership approach Science Wānanga aims to support iwi aspirations by building the capacity of young Māori—and their communities—to engage with scientific knowledge. Rangatahi Māori will be helped on their own individual pathways and, in the long term, wānanga will support them to contribute to decision making in their own communities in areas such as health and environmental or resource management.

On a much smaller scale, one of the primary school case studies (The Clinic) is an initiative driven by a small group of parents who see value in connecting learners with science

¹⁴ In the case of Chemistry Outreach, the programme as it operates today developed from the university's Scientists in Schools initiative (where schools request that a scientist come into their school), but grew and developed to become more of a multiple-engagement approach to support schools' needs in a more in-depth way.

expertise in the wider school community, even if this occurs outside the regular school curriculum programme.

The case studies suggest that, whatever the origins and drivers of schools' engagement with the science community, an essential dimension of programme effectiveness is the ability to form strong working partnerships and co-develop the *details* of the engagement initiatives in ways that effectively identify and support learners', teachers' and communities' science learning needs. Initiatives may evolve over time as the partners recognise new opportunities, or next steps, that need to be addressed to achieve their goals.

The initiatives also illustrate the importance of sustained and embedded partnerships as a means of resourcing the larger, longer-term engagement initiatives (see 'Sustainability, scalability, and long-term relationships', below).

Matching means and ends (purposes and contexts)

The case studies show that it is important for all partners to have a clear sense of the desired purpose(s), or ends, of science community engagements in order to design contexts, or means, that align. Those ends can range from the goal of giving younger students engaging, interesting, enjoyable experiences with science to 'awaken their inner investigator', to constructing and supporting pathways for students into particular science-related areas (such as health sciences), to meeting a big-picture community need for science-literate current and future decision makers. Partners in the initiative should have a shared view of these purposes, particularly so that the decisions about the contexts and structures for students' learning can be made together.

Clearly articulated purposes can also enable initiatives to grow, change and evolve organically as the partners see new opportunities to expand their means in order to provide even greater support for learners (and teachers, and other partners) to achieve the desired ends. Good processes for research and evaluation are also implicated here, to understand and track progress against big-picture goals and provide mechanisms for initiatives to grow and evolve on the basis of feedback from participants and stakeholders. This point will be addressed further below (see 'Research and evaluation').

Time, relationships and environments

The case studies illustrate the importance of *immersive* time and repeated engagements *over time*. Immersive time can occur in the form of multi-day in-depth programmes that give learners more complete, connected, in-depth opportunities to experience multiple interconnected parts of a science investigation process or context. Repeated engagements over time can involve learners in multiple learning experiences with people from the science community over the course of a term, a school year or even several years.

Both forms (immersive and repeated engagement) seem to be important in developing *relationships*. Most case studies commented on learners developing positive, productive, warm and rewarding relationships with the science community partners and, in many cases, their teachers as well. The benefits of these relationships were reported to flow both ways, being rewarding not just for learners but for scientists, university science student mentors, teachers and other partners.

Many of the case studies occurred in *environments* outside the normal school or classroom context. These ranged from the expected scientific research institutional environments or natural environments, to more culturally located environments (e.g., the marae¹⁵-based Science Wānanga). These different environments are seen by participants as providing a different or more enriching experience than students could have within their normal school environments and are viewed as playing a role in fostering the productive relationships discussed above.¹⁶ However, other case studies show that valuable engagements can occur within the school environment as well, particularly if they are different from the standard teaching and learning experience of regular school routine.

Whether the engagement occurs within the school or in some other environment, what seems to be important is that learners' needs, interests and motivations are attended to, supported and planned for at the heart of the engagements. These needs, as we have seen in the preceding section, must be viewed in the context of the wider purposes of the engagements.

Key people

Across all the case studies there is evidence of the importance of a key person or people whose knowledge, passion, commitment and motivation carry the work forward and makes things happen. In some cases it is a person who has made a transition from the science community into the teaching profession, or vice versa. In other cases it is someone who has a specific role as a co-ordinator or intermediary between schools and the science community. Often a successful initiative depends on a handful of people who are connected together.

Across the case studies, certain recurring roles seem to be important:

- co-ordinators/science educators within the science community who can mediate and liaise between the worlds of science and education

¹⁵ For international readers: Marae are Māori community facilities that usually consist of a carved meeting house, a dining hall and cooking area and the marae ātea (sacred space in front of the meeting house).

¹⁶ For example, several case studies showed that learners and teachers experienced positive relationship shifts and saw each other in a new light through the time spent together in environments outside the normal school/classroom setting.

- teachers who have a special understanding of, or commitment to, science education— commonly they had experienced science-related teacher fellowships or some other form of engagement with the science community
- working scientists, tertiary science educators and tertiary science students who are committed to the intentions of the engagement initiative and open to the flow-back benefits of their own engagement
- people with strong mana and leadership roles in the community or particular sectors (philanthropic, health, business) who have the power to inspire support for an initiative, or mobilise resources around it, or both
- other people within the wider community who support the big-picture intentions of the initiative and can provide additional resources or other kinds of input.

However, dependence on key people threatens the sustainability of initiatives in three ways: key people may move on, insufficient resources may be allocated to enable them to spend the time doing the work that is needed, and there may be a lack of structural support to sustain the initiatives beyond energy inputs from key people (see ‘Sustainability, scalability and long-term relationships’, below).

Many case studies point to an essential niche in the science education ecosystem for community engagement intermediaries—people who can liaise between schools, science communities, tertiary institutions and the wider community. The people who effectively performed these roles demonstrated a particular blend of knowledge, experience and disposition. This mix of skills and attitude included a sophisticated understanding of the multiple purposes for science learning, and familiarity with the operational characteristics of school science teaching and learning, including curriculum and assessment frameworks. Intermediaries often build and maintain relationships, seek and manage funding and resourcing, and identify areas where research or evaluation is needed to contribute to the development or refinement of programmes. The insecurity of the funding of many science community–school engagement initiatives often makes it difficult to build the capacity of people who are new to these positions.

Community connections, school collaborations

Some of the case studies provide insight into the wider community connectedness that could stem from science community engagement. A clear theme across the case studies is the idea that schools and wider communities need to have a shared and collective sense of responsibility for supporting learners across the community, rather than schools competing with one another for students, or for access to resourcing and support for the exclusive benefit of their own students.

The Clinic parents, for example, believed that deeper thought and investigation are required into how schools can best engage with their communities and use their knowledge, expertise

and participation in the delivery and development of education. One of these ways could be for a community link worker to help schools develop strategies relevant to their own communities. The Clinic parents felt that schools could benefit from expertise within the wider community, and they could see a role for a community link person who could support groups of schools to do this.

Another case study illustrates how a teacher is leveraging one school's relationship with the Chemistry Outreach programme at the University of Otago to support other schools in the region. Although the association with the university chemistry department was originally viewed as a competitive advantage over other schools in the region, the school is now working hard to make sure that all neighbouring schools benefit and is using it to help break down barriers between schools.

Participants in the Health Science Academies case study believed that the programme works because the South Auckland schools involved in the programme share a common goal: to increase the number of Māori and Pasifika high school graduates entering tertiary health science degree programmes and subsequent employment as health professionals. A high level of trust has helped the teachers in these schools to successfully co-construct the Health Science Academies programme and to understand and agree on its ongoing development.

Finally, the Science Wānanga case study illustrates an approach that explicitly seeks to engage whole communities, *including* schools. These initiatives collectively point towards the need for a community-connected view of science community engagement as part of a wider view of schools' need to engage with the wider community to provide the support needed by 21st-century learners.¹⁷

Sustainability, scalability and long-term relationships

Some of the case study initiatives are relatively new, small scale, localised and driven by a few committed individuals (e.g., The Clinic), while others are on a larger scale, involving multiple partners and activities (e.g., LENSscience involves partnerships between the Liggins Institute, partner tertiary organisations and teachers). Funding is derived from public good research and teaching grants, government contracts and philanthropic donations. The Health Science Academies are supported by partnerships between organisations including the Tindall Foundation, Counties Manukau District Health Board, Pasifika Medical Association, and several universities and schools. The Science Wānanga involves partnerships between the University of Otago and iwi, schools and other members of the wider New Zealand science community.

¹⁷ This aligns with argument 6 in the previous chapter. See also Bolstad & Gilbert, 2012,

These initiatives illustrate the importance of bedding in deep relationships and partnerships at the organisational or system level. Formal instruments may be used to do this, such as memorandums of understanding or committed working partnerships, either between organisations or within and across different parts of a large organisation. These longer-term organisational or system-level relationships and processes can enable the work of a science community engagement initiative to carry on and be insulated, to some extent, from the limitations of short-term contract funding. This continuity is more certain if each partner organisation is able to find and access resourcing to contribute to the initiative's needs.

This raises the question of what else may be needed at the system level to enable more schools to access and engage with the science community in these deep, integrated and sustained initiatives. In one case study (Geocamp), scientists made two suggestions. First, there could be a contestable fund for scientific research organisations to support these kinds of engagement initiatives. Second, scientific organisations could commit to undertaking at least one initiative per year to move towards fruitful school–science community engagement throughout Aotearoa New Zealand.

Synergies and connections across the science education ecosystem

Teacher survey data gathered in the first phase of this study suggested that teachers' use of the science community as a resource may be strongly connected with a range of other factors, including the teachers' years of experience and their degree of connectedness with the wider science education ecosystem. For example, 26 percent of the teachers surveyed were deemed active users of community resources, having used a combination of the following (either in the past 12 months or previously) to support their students' learning:

- a tertiary education science faculty
- tertiary science students
- other working scientists
- museums, zoos and the like
- environmentally focused EOTC¹⁸ programmes
- Futureintech ambassadors
- Royal Society scholarships/funds
- the Fonterra Science Roadshow.

¹⁸ Education outside the classroom

They were also likely to have accessed the Futureintech ambassadors for their own learning. In the past—but not more recently—they had also used virtual field trips (e.g., LEARNZ) and parents/whānau with relevant expertise. Several of the case studies in this research also highlighted the importance of teachers' science connectedness (see above under 'Key people').

The Otago University case studies (Chemistry Outreach, Science Wānanga and the New Zealand Marine Studies Centre) illustrate the opportunity for interconnections and synergies *across* initiatives, both at an organic level (key people collaborating and networking to share resources and knowledge) and at a strategic level (looking across science education outreach initiatives to identify opportunities for a more connected and collaborative approach across the system). This approach includes connectivity across science education outreach initiatives, as well as forming partnerships that are of mutual benefit across other areas of the institution (e.g., engaging faculty or students from education or sociology to carry out research on the impacts and outcomes for participants).

This linked approach raises the question of the extent to which the present interconnections and synergies across the science education ecosystem are largely fortuitous—the result of a fairly small, highly networked community of people in the science education community—as opposed to being planned and integrated as part of an overall strategy for the science education ecosystem; after all, as a small country New Zealand arguably has a small number of 'degrees of separation'. In addition, one case study participant suggested that another factor that is conducive to supporting networking across the science community to support school engagements is an environment where tertiary science institutions do not have to compete for students.

Flow-on effects for school science teaching and learning

Across the case studies there was mixed evidence for whether the engagements had significant and long-term impacts on business-as-usual science teaching and learning. In some cases teachers believed that their engagement experiences *would* have a lasting impact on the ways in which they planned and supported science learning for their students. Reasons for this included:

- teachers perceiving that they now knew how to connect with people in the science community, or could more easily gain access to knowledge, expertise and gear they needed to support their students' learning, or both
- teachers changing their assumptions or expectations about their learners' capability (e.g., seeing what motivates students, seeing new capabilities or aspirations in students they had not previously seen, holding higher expectations that students can succeed in the sciences)
- teachers perceiving that the engagement had increased their own scientific understanding in ways that would translate into their future teaching practice (e.g.,

developing teachers' understanding of the nature of science, or thinking differently about particular scientific issues in relation to learners or the local community).

However, the extent to which science community engagement can affect business-as-usual school science may be limited by factors that include teachers' own knowledge and confidence, or current structural features of school science teaching and learning (such as approaches to curriculum planning and assessment), or both. It is important to note that most of the initiatives in this case study focused on supporting science learning for *students*. Teacher professional learning was often a supplementary focus or by-product of these engagements. Some initiatives have identified a need for more focused teacher support and professional learning to help teachers to address and work around some of the wider structures that may constrain learners and teachers from experiencing authentic, relevant, engaging and community-connected learning as a routine and regular part of school science education.

Benefits to the science community

Many of the case studies identified benefits to the science community partners. For example, scientists, lecturers and tertiary science students became better at communicating science and developed their own teaching abilities. They found it personally rewarding and motivating to contribute to better science learning opportunities for school learners. At least one initiative (Science Wānanga) has shown the potential for much deeper reciprocal benefits, which include supporting the science community to learn from the communities they work with and creating the potential to cultivate long-term science research partnerships. A final benefit is the opportunity to contribute to growing the next generation of scientists and other people who will work in, with and alongside the science community.

Science community partners surveyed during phase one of this research noted that working with schools was often seen as worthwhile but placed considerable demands on scientists' time and the funding available to them. Many science community partners wondered how to resource their outreach and engagement activities in sustainable ways, or how these engagements might become a more permanent feature of their institution's or organisation's core business.

The University of Otago case study (incorporating Chemistry Outreach, the New Zealand Marine Studies Centre and Science Wānanga) provides an interesting argument: community engagement (including engagement with schools) ought to be seen as a key strategic imperative for the institution, and as such, outcomes for the university's core activities of research and teaching need to be clear. Within the Division of Sciences, work is being undertaken to research the value of outreach engagements for the *tertiary* students and link this with the University of Otago graduate attributes.¹⁹ The Division has also developed a

¹⁹ See the University of Otago case study for further details of these attributes.

Science Outreach Certificate that recognises and values the contributions that tertiary students make, as well as the contribution that those engagements make to the students' own learning.

Research and evaluation

Several of the case studies highlight the need for research and evaluation strategies to sit alongside the development and growth of engagement initiatives. In some initiatives, such as the Health Science Academies, there is still a lack of clarity about how to evaluate the impacts of the programme. An example of this ambiguity is the question of whether students who leave school will be monitored and tracked through their tertiary education, or into jobs, or both.

On the other hand, the LENSscience, Chemistry Outreach, Science Wānanga and the New Zealand Marine Studies Centre initiatives already self-evaluate through a range of strategies. They also continue to identify areas where more research or evaluation could support 'next steps' developments, including:

- identifying the need for more long-term research on the impacts of these initiatives for learners
- gaining a deeper understanding of the flow-back benefits of these engagements for the science community and wider community
- knowing how the work of the outreach initiatives connects with the core activities of the university, including its big-picture aims as a tertiary education institution (e.g., linking outreach initiatives to the Otago University graduate attributes).

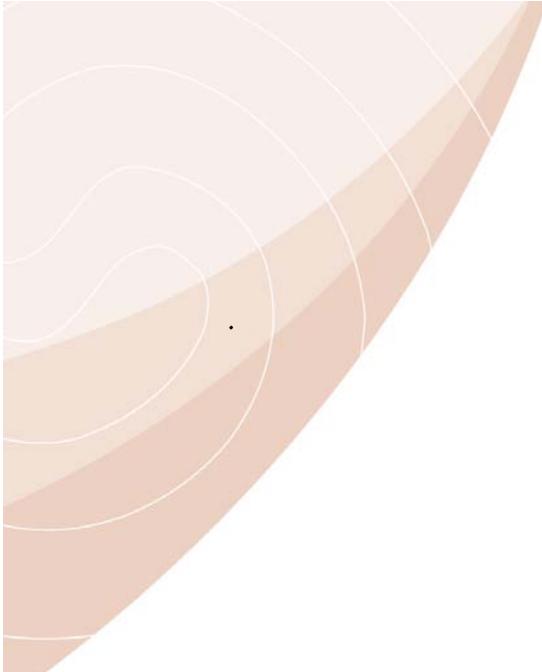
Using research and evaluation strategically to provide value to science community engagement initiatives has resourcing implications. Some initiatives in the case studies had accumulated large amounts of evaluation data (e.g., in the form of teacher and student feedback about their involvement in these initiatives) but had limited resources to process and use these data. Even with resourcing (time, or expertise, or both), evaluating the long-term impact of some of these initiatives will be complex. It will require well-thought-out systems and processes that provide relevant and useful information about the short-, medium- and longer-term impacts of the initiatives, as well as bringing attention to areas in need of further development or additional support. This suggests value in science community engagement initiatives partnering with people and groups who have an appropriate mix of resources, research and evaluation capability and can support and guide new knowledge development over time.

There is also the question of whether a long-term strategy for supporting, monitoring and evaluating the effectiveness of engagements between schools and the science community *across the system* is needed. For example, opportunities may arise for greater pooling of

existing knowledge and data held by different parties in these engagements. First, however, a clear view of the aim of gathering or evaluating information like this is needed.

Looking at the case studies in more detail

This chapter has raised some of the themes that are evident when looking across the case studies, particularly in view of the ideas outlined in the previous chapters. However, there is also much to be learnt from the specifics of each individual case study. The next chapter very briefly describes each case study and highlights some of the insights that each initiative provides for science community engagement with schools. (For full descriptions of each case study, see the Appendix.)



4. Case study insights

Science Outreach at the University of Otago

Although it was initially conceived as one case study, it became clear during the research that it would be valuable to develop the University of Otago Science Outreach case study into three interconnected case studies:

- Chemistry Outreach
- The New Zealand Marine Studies Centre (NZMSC)
- Science Wānanga.

Chemistry Outreach

Over the last 4 years the Chemistry Outreach programme has included multiple engagement programmes for Year 7 and 8 students in their own schools. The programme plays out differently in different schools but basically involves university chemistry students providing three to four sessions for school students over the period of a month or a term.

Insights from Chemistry Outreach

- An important feature of this initiative is the multiple visits, which allow the chemists to develop relationships with both the teachers and the students and provide an opportunity to scaffold the learning of both students and teachers.
- The use of chemistry students as leaders allows for multiple engagements because they volunteer their time. However, it is also clear that an experienced teacher with a passion for and knowledge of the subject area is also required for the programme to be

a success. (The three teachers interviewed in this case study all held responsibility for science in their schools and had all been recipients of teacher fellowships.)

The New Zealand Marine Studies Centre

The NZMSC provides a range of opportunities for students to experience real science in an authentic setting. One of these opportunities is the Year 13 Small Animal Study, which involves a 3-day course where students come to the NZMSC and design and carry out individual investigations for NCEA credits.

Insights from the NZMSC

- An important feature of this initiative is the opportunity for students to *work as scientists*. The programme is embedded in a tertiary science and research setting, and this gives students access to equipment and the support to carry out high-quality experiments. It also provides students with opportunities to deal with live animals and carry out procedures that are not readily replicated in classrooms.
- The extended period without the interruptions and distractions of other classes and activities allows students to become deeply engaged with their investigations.
- The guidance of a specialist science educator (with curriculum and marine sciences knowledge) and the active involvement of the classroom teacher in the full programme are also key to the success of this initiative.

Science Wānanga

The primary objective of the University of Otago Science Wānanga is to enhance the achievement and engagement of Māori in science and health sciences. Science Wānanga programmes offer 2- or 3-day interactive science experiences for Māori secondary students, based on marae and in communities, and facilitated by tertiary students, scientists and the local community. Science is presented alongside mātauranga Māori (Māori knowledge) provided by kaumātua (Māori elders), which encourages students to understand connections and actions through science that are relevant to their lives.

Insights from Science Wānanga

- Although contract funding has played an important role in initiating and developing Science Wānanga, the University of Otago has also taken steps to ensure that Science Wānanga is not limited by the terms and time frames of fixed-term contracts. For

example, the role of the kaituitui wānanga (the Science Wānanga co-ordinator) has become a permanent position situated at a divisional level of the university's administration, enabling wānanga co-ordination to draw on and work with āMfi support services across various divisions within the university (Science, Health Sciences, Humanities and Commerce) as well as the academics and students within the departments. This commitment to establishing deep and long-term relationships with Science Wānanga has also meant that in some cases different partners have contributed funds to enable wānanga to go ahead when other funding has not been available. As the kaituitui wānanga explains:

The key thing is that if you go into partnership with iwi, there is no 'end point' [compared with fixed-term contract funding]. [Endpoints] are not how permanent institutions work, and they are not how iwi groups work, because they are looking at sustainable development into the far, far future, and they want long-term relationships that are going to be maintained.

- Science Wānanga is notable for the extent to which it locates science learning experiences within authentic, community-selected contexts. According to the kaituitui wānanga, when students are asked what makes them disengage from science at school, invariably they give three main responses: science is "too hard", "[involves] too much bookwork", and "is not about me". Topics are chosen *by* communities and often link to the inter-relatedness between human health and environmental health. Science Wānanga brings together science and mātauranga Māori in ways that acknowledge the knowledge, understanding and skills of all the individuals involved.

The Liggins Education Network for Science (LENScience)

LENScience is based in the Liggins Institute (a centre for research on fetal and child health, nutrition, breast cancer, epigenetics and evolutionary medicine) at the University of Auckland. Its vision is "bringing schools and scientists together to promote scientific literacy". For LENSscience, the purposes of connecting schools and the science community are to *support science education* and to *enable science communication and translation in the community*. Partnerships between schools and the science community are clearly seen as mutually beneficial, and the specialist science educators based at LENSscience are key to the success of the initiative.

LENSscience uses a variety of ways to connect students (Years 7–13) with science. These include:

- face-to-face sessions at the specialist classroom at the Liggins Institute
- the provision of classroom resources that present cutting-edge research and are

accessible to students

- e-learning interactions.

LENScience has a strong focus on working with Māori and Pasifika communities. The Māori and Pasifika initiative includes priority access to LENSscience face-to-face programmes for schools within the initiative, a student–scientist mentor programme for gifted and talented students, opportunities for students and scientists to co-host community events, and a school-to-university transition programme. LENSscience also provides a range of professional learning and development opportunities for teachers.

Insights from LENSscience

- The role of the specialist science educators at LENSscience is crucial to the success of this initiative because they bridge the gap between the science community and schools. One way this bridging occurs is through the development of classroom resources. The science educators work in collaboration with scientists to create research stories about health-related issues of concern to the wider community. These stories are accessible to adolescent learners, and they also maintain the authenticity of the research itself. This is an example of a science community engagement that enables learners to experience science that meets three standards of authenticity or relevance: it is authentic and relevant in the eyes of the science community; it is authentic in terms of personal relevance to the learners; and finally it is authentic in terms of relevance for the local community and wider society. This focus on contexts that are important to all programme partners is certainly one of the strengths of LENSscience.
- Another important feature of LENSscience is the emphasis placed on research. This emphasis is relatively unusual in science community–school engagement initiatives in New Zealand and overseas. The considerable energy LENSscience has put into collecting pre- and post-intervention data not only enables it to evaluate and adapt its programmes but also lays the foundation for longitudinal studies investigating whether changes in attitude and behaviour are being sustained.

The Clinic

The Clinic is a small initiative driven by a group of parents at a primary school. These parents organise scientists with links to the school to provide engaging science activities for students at lunchtime. The Clinic is independent of the school programme and focuses on student engagement and on building networks within the wider school community.

Insights from The Clinic

- Although this initiative was started by a group of parents and operates independently of the school programme, it is already having some flow-on effects for the school. For instance, some of the parents have been invited by teachers to come into their classrooms to run science activities. The principal reports that this initiative has highlighted people resources that are available in the wider community and has been instrumental in her rethinking what community engagement involves.
- The Clinic parents believe that deeper thought and investigation are required into how schools can best engage with their communities and use their knowledge, expertise and participation in the delivery and development of education. One of these ways could be for a community link worker to help schools to develop strategies relevant to their own communities.

Dinosaurs and Disasters Geocamp

This initiative was run by GNS Science in Hawke's Bay. It involved a small number of Year 7 and 8 students and seven teachers (including three primary teacher fellows) participating in a 2-week programme that consisted of geology-based field trips with scientists, and ended with students presenting their work in a show-and-tell expo that was open to the public.

Insights from the Dinosaurs and Disasters Geocamp

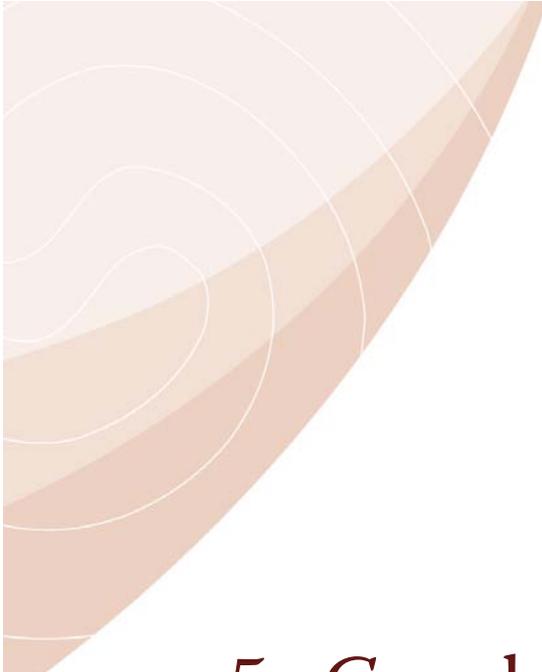
- An important feature of this initiative was the extended immersion experience in science for students. The students were provided with an initial motivating experience and then had an extended period during which they were free to develop their own interests and learning. The requirement for producing something tangible for the public presentation at the end of the fortnight provided a focus for their explorations. This immersion experience appeared particularly powerful for those students who remained together as a group throughout the camp rather than returning home in the evenings.
- This initiative also provided valuable learning for teachers. Despite several of the teachers not being ideally positioned to build on these experiences in their schools, some nevertheless managed to do this. One teacher was able to work not only with her own small school but with two neighbouring schools as well.
- As with several other case studies, the role of the specialist science educator was key to the success of the initiative.

Health Science Academies

This initiative is designed to provide pathways for senior secondary Māori and Pasifika students into the health workforce in Counties Manukau and South Auckland. The programme is currently operating in three secondary schools. Students are invited to apply for entry to the Health Science Academies during Year 10. The aim is to support students to gain entry to tertiary-level sciences. Those selected participate in a specifically designed science-based academic programme that is supported by after-school tutorials and free resources. There is also a focus on providing students with career information and opportunities to visit a range of health providers. A high level of family support for students who are selected for the Health Science Academies is also expected.

Insights from the Health Science Academies

- The Health Science academies have the explicit goal of increasing the number of Māori and Pasifika secondary students entering the health professions. Teachers interviewed from the three schools currently involved believed this common goal allowed staff to work successfully together to co-construct the Health Science Academies programme.
- This initiative also facilitated the development of more productive relationships between students and teachers, and between teachers and families. Students reported that they got to know their teachers better as they spent more time with them, during and after the normal school day. Teachers also reported that they had increased contact with families through different reporting procedures.
- Sustained engagement (at least a year) changed teachers' practice in ways that supported Māori and Pasifika students to achieve. The teachers' new pedagogical approaches also transferred to their other classes.



5. Conclusion

From this study we conclude that it is time to take a whole-system perspective on the future of school engagements with the science community as a way to support 21st-century science learning. This will require all the relevant stakeholders in school–science community engagements to contribute to decisions about how to shape a system that enables multiple types of engagements at different levels of the schooling system. Within this system, the different needs of learners, teachers, schools and communities will need to be met, and wider national needs for a science-engaged and knowledgeable population will need to be addressed. This must happen in a coherent and connected-up way.

We conclude by highlighting factors that appear to be important for enabling schools and science communities to work together in support of student learning and engagement, and we discuss possibilities for further strengthening these connections.

What enables schools to collaborate with the science community?

This research suggests that the following factors are important:

- opportunities to develop connections between schools and willing, able and supportive partners in the science community—these science community partners can assist learners and teachers to make further connections into and across the science community to draw on expertise, knowledge and resources to support new and emerging needs for learners, teachers and communities as they arise
- strategies to minimise potential barriers to access—these barriers include time, cost, distance and accommodation

- people within (or closely connected to) the school who can provide co-ordination support, liaising between the science partners and teachers and learners, both *within* their school and *across* schools (where appropriate)
- partnerships in the wider community that support, extend and enrich the value of schools' engagements with science community partners
- shared community-level goals for supporting science education across the community, enabling schools to collaborate in a high-trust, non-competitive environment
- teacher professional learning that develops teachers' understanding of the nature of science and the purposes of learning science in the 21st century
- a curriculum that is enabling, and assessment structures that can be used flexibly to enable future-oriented science learning.

What enables the science community to collaborate with schools?

This research suggests that the following factors are important:

- high-level commitments from the science community to support science learning and engagement for young New Zealanders, accompanied by resources and structures that enable these commitments to be realised in practical ways
- a collaborative environment for organisations and institutions in the science community, so that partners can work together towards the greater goals of supporting science learning and engaging all learners
- 'intermediaries'—people with the knowledge, experience and dispositions that enable them to effectively liaise between the education and science communities—who need, among other things, a sophisticated level of understanding of the multiple purposes of science learning, and familiarity with the operational characteristics of school science teaching and learning, including curriculum and assessment frameworks, and whose work often involves building and maintaining relationships, seeking and managing funding and resourcing, and identifying areas where research or evaluation is needed to contribute to the development or refinement of programmes
- deeply embedded relationships, including formal agreements, which insulate science community engagement from the start/stop limitations of fixed-term contract funding and enable the work of science community engagement to continue even when key people move on
- clear lines of sight to show how engagements with the education sector also contribute to the core business of the science community partners

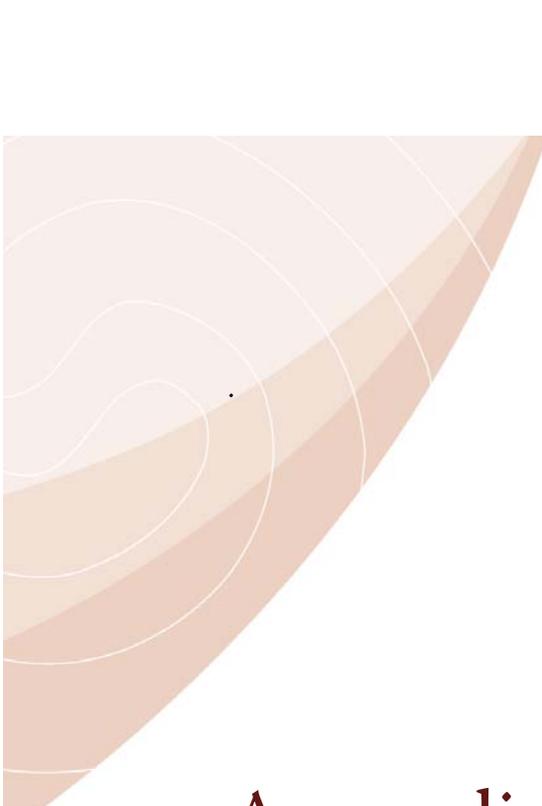
- practical structures that recognise and support the return benefits of engaging with the education community (e.g., methods for formally acknowledging the contributions of, and learning benefits accrued by, science community partners).

How could the capacity of schools and the science community to engage with each other be strengthened?

From this study we have concluded that there are many key ingredients that could support a whole-system approach to future engagements between the science community, schools and the wider community. These include:

- providing strategic leadership to support knowledge development, sharing and co-ordination of school–science community engagement initiatives
- strengthening networks of science-connected teachers
- strengthening networks of people working in intermediary roles across existing school–science community engagement initiatives
- ensuring equity of opportunity for all learners across all New Zealand schools
- identifying a number of key socio-scientific issues that have relevance to whole communities across New Zealand—with adequate and secure funding, specialist science educators and scientists could work together to develop high-quality resources that could be adapted to suit specific communities
- committing to, and resourcing, well-designed longitudinal research to evaluate the effectiveness of initiatives.

This research project takes a future-oriented perspective. It draws together what is already known about science community engagements with schools to provide a basis for informed discussion by all stakeholders about what next steps might be needed to strengthen science learning for young New Zealanders in the 21st century.



Appendix: Case studies

Case study 1: Science Outreach at the University of Otago

Strengthening external engagement is one of the University of Otago's six strategic imperatives.²⁰ Engagement with the community occurs on a variety of levels and has a range of benefits for both the university and the community—including schools. The Division of Sciences has been leading the way in developing links and opportunities for schools, with most departments and disciplines providing support and inspiration for teachers and students at some level.²¹ This case study focuses on activities in three specific areas.

- **Chemistry Outreach:** the Chemistry Department offers programmes at a variety of levels. This case study focuses on how they engage primary and intermediate-level students and their teachers.

²⁰ *University of Otago Strategic Direction to 2012* identifies six strategic imperatives for the university: achieving research excellence, achieving excellence in research-informed teaching, ensuring outstanding campus environments and student experience, contributing to the national good and to international progress, strengthening external engagement, and building and sustaining capability. Each imperative addresses a critical issue or area from a particular perspective that is regarded as vital to the future of the university.

²¹ Some departments have assigned specific staff to support engagement with schools. A list of the science opportunities for schools at the University of Otago can be found at <http://www.sciences.otago.ac.nz/schools/schoolresources.html>

- **The New Zealand Marine Studies Centre (NZMSC):** the Department of Marine Science’s outreach programme uses the research environment of the Portobello Marine Laboratory and natural environment to run programmes for both primary and secondary school students. The case study looks specifically at a multi-day Year 13 programme.
- **Science Wānanga:** this programme is designed to support the needs and aspirations of Māori students and their teachers through multi-day, marae-based programmes within their communities.

Although these three examples do not encompass *all* the ways in which the university contributes to school–science community engagement, they do illustrate a variety of approaches. This case study also offers an opportunity to look at the current and potential interconnections for strengthening school–science community engagements within one institution. Each initiative is outlined individually, followed by some concluding comments that cover all three.

Chemistry Outreach

Overview of the initiative

The Chemistry Department began to work with schools in 2008, and the Chemistry Outreach programme began as part of a wider University of Otago initiative, Adopt a Scientist.²² Although visits to primary schools started with chemistry magic shows, over the last 4 years there has been a focus on delivering multiple engagement programmes to Year 7 and 8 students in their classrooms. Secondary schools’ requests for help with independent investigations at the senior chemistry level²³ have led to Year 13 classes being invited to the Chemistry Department to carry out this unit of work. Teachers are given guidance about suitable investigation topics, and visits are restricted to times of year when the Chemistry Department technicians are not busy with university courses. In an average year the outreach programme works with about 2,500 students at different year levels, from 15–18 different schools in the Otago and South Canterbury area.

The programme leader is an experienced secondary chemistry teacher who came to Otago to do a PhD and was subsequently hired as a teaching fellow in the chemistry department to help with the first-year laboratories. He was the logical person to develop the school programme, and now about 80 percent of his role is dealing with schools. The programme leader feels strongly that there is “a need to encourage science at intermediate level before

²² This University of Otago initiative links primary and intermediate schools with scientists who can come into the school, usually with special topics in mind. The objective was to provide support for primary teachers, who are often wary of delivering science.

²³ AS90694 (3.1)—Carry out an extended practical investigation involving quantitative analysis.

the students get turned off science” and also that “there is a need for a science support role with teachers”.

Support for the programme has been department-wide. Both undergraduate and postgraduate students volunteer their time to help with programme delivery. This has been very successful, and according to the programme leader it has:

provided team building opportunities and given the students a means to give something back to the department and the community. The programme has provided excellent public relations for the department.

A key element of the Chemistry Outreach programme at the primary and intermediate level is that multiple visits allow the chemists to develop relationships with both the teachers and the students. The visits are usually 1.5 hours long and each student is involved in three or four sessions over the period of a month or a term. There is no cost to the students or the schools. Written resources are supplied on request, and professional development for the teachers is offered in addition to the student sessions.

Participants' views of the initiatives

Teachers' views

Teachers from two intermediate and one primary school were interviewed in September 2012. These three schools were chosen because they have had an extended involvement with the Chemistry Outreach programme (3 or more years) and have integrated the programme into the school plan in slightly different ways. The teachers interviewed were the co-ordinators of the programme within the schools. They all hold responsibility for science in their schools and coincidentally had been awarded Royal Society Endeavour or Primary Teacher Fellowships in the past. They were very grateful to the Chemistry Department for supporting this initiative. When asked if they thought their school would be involved with the programme if they had to pay, they all said yes, but felt they would be unlikely to be able to justify multiple sessions.

Teacher A (intermediate school) incorporated the Chemistry Outreach as part of the school's modules programme, which uses specialist spaces and teaching methods with groups as low as 13 in number. All Year 8 students were involved in each module, but they were in mixed groups (not classroom groups) and the modules were led by specialist teachers, not their classroom teacher. With the chemistry module, the chemistry team led four sessions and the specialist science teacher led the remaining six sessions. The advantage of this model was that it allowed for smaller class sizes (e.g., 15 students rather than 28 students per class), and it ensured the chemistry sessions were supported with pre-and post-trip work by the specialist science teacher. However, only the specialist teacher received the benefit of observing and learning from the chemistry team in action.

The school has a remodelled science lab so is well placed to deliver such a programme. However, the teacher acknowledged the value of bringing in outside people:

having the chemistry taught by the specialists is much better. Resources like nitrogen, hydrogen and pellets of carbon dioxide cannot be housed by the school.

The teacher thought the hands-on component was very important, and loved seeing students who struggled in the classroom become focused and engaged with this programme:

I have to tell them to leave the lab at the end of the session. They don't want it to end.

Teacher A commented that the Chemistry Outreach programme had provided considerable professional development for her, which she also shares with the other classroom teachers:

It has boosted my confidence and understanding and allows me to introduce new ideas and extend the more able students further.

The multiple visits allowed for a continuity that she had not experienced with other science programmes:

One-off visits have high interest, but the students are not getting the same value. This programme builds basic skills and expands knowledge.

Teacher B (intermediate school) had adopted a slightly different approach to the delivery of the chemistry programme within the school. Each Year 8 student participates in three chemistry sessions with their classroom teachers and the teachers deliver six other lessons with experiments to complete the term unit. The chemistry team delivered professional development for the teachers and has helped with the development of the support lessons. Teacher B had clear views about what he wanted the students to gain from the programme, and he had talked to secondary chemistry teachers about the knowledge and skills they expected students to have coming into high school. This information, along with the curriculum objectives, was used in designing the chemistry programme for the school.

The programme helps set the stage for the development of science-fair projects, which every student is expected to do. Students who really enjoy the chemistry programme are encouraged to join a science extension group, which carries out environmental monitoring of the local lagoon. The university chemistry team further supports the school by providing guidance for chemistry-focused science fair projects, analysis of water samples for the school's science extension group, and resources for 'wow' chemistry experiments to be run by the teachers during their school's open night.

Teacher C (primary school) has involved the Chemistry Outreach team with students from all year levels as they are a small school located about an hour's drive from Dunedin. This year the chemistry team visited the school three times per term and worked with two classes per visit. Classroom teachers attend the chemistry programme and, according to Teacher C:

The teachers are now starting to play. They initially just sat back and observed.

The programme delivered varies from year to year, and it links with the school theme for the year or term.²⁴ The students not only benefit from multiple visits during the year, but over the years the students are exposed to a comprehensive science programme that extends from Year 1 to Year 8. It is not just the science that gets a lift, though. Teacher C claimed that:

the programme provides authentic experiences for maths, oral and written language and reading.

Teacher C organised professional development for teachers in her school and others in the region. Through her teacher fellowship she developed classroom resources, which she has shared with other teachers, and is working with Chemistry Outreach to set up a science hub at her school. This hub will be a store of glassware, chemicals and experimental protocols that other schools will be able to access and borrow—not unlike the offices of the past science advisors.

Although the association with the university Chemistry Department was originally viewed as a competitive advantage over other schools in the region, the school is now working hard to ensure that all neighbouring schools benefit and is using it to help break down barriers between schools. According to Teacher C, this has been a trade-off for the school because “the number and duration of Chemistry Outreach visits to our school has decreased as other schools in the region are now involved”.

Students' views

Five Year 8 students from School A were involved in a focus group. They were able to recall lots of information about the programme they participated in, especially things they had not seen before or were not normally allowed to do. For example, they recounted the experiments with liquid nitrogen and hydrogen gas and activities where they were allowed to throw frozen onions against the wall. Science at Year 8 was described as “more complicated” than science at Year 7, but they liked the challenge of balancing chemical equations. One student summarised the programme strengths as follows:

[I]t makes you realise that science is more than a lab. It is fun not boring. There is writing but when you are doing it you are having fun and don't notice the writing. It is good to write down for revision and so you don't forget it.

These comments may be a reflection of the review the teacher did in the classroom to reinforce the experience of the chemistry programme.

²⁴ Examples of themes are ‘fizz and splutter’ and ‘the colour blue’.

Another student said she liked that “you got to do the experiment for yourself and see for yourself” and that the leaders were “experienced people from the university, who knew what they were doing”. The students commented that there were lots of these people to help you with the experiment, and that they were easy to talk to and didn’t yell. The students emphasised that they liked the fact that it was not just a one-off experience. They were “excited about going back” and they “knew they were going to learn something new”. They also described feelings of anticipation as they “did not know what was going to happen”.

When asked why they thought the chemistry programme was important, they highlighted the following reasons:

Later in life it is good to know about all the sciences, it is how you get a job.
(Student)

Some of us might want to study chemistry at university. (Student)

It is good to be able to read chemical formulas. It helps in tests and to find out what is poisonous. (Student)

One student said that he had since downloaded a number of chemistry apps for his phone.

When asked if they had done science at primary school, three students said they had not done science at all and two said they had done some measuring of pH. It is unclear if they made the distinction between science and chemistry, but their responses did suggest their understanding of what the term ‘science’ means may be limited.

School C has been involved in a whole-schools initiative, and 22 students in the Year 2 and 3 class were asked by their teacher for their opinions of Chemistry Outreach. All wanted more visits from the chemists, and all but one wanted to do more science. The leaders all received favourable comments about their ability to help, explain things well and incorporate humour into their teaching. The connections made with other subject areas did not go unnoticed. One student commented on a leader: “he gives us maths and knows the science maths”. All students made a distinction in role from their regular teachers, with one student commenting that “He is a proper scientist and won’t hurt us with stuff like fire on our hands.”

What this case study tells us about science community engagement

Multiple engagements with the students over time emerged as one of the key elements of the success of this programme. This kind of engagement allows relationships to develop between the chemists, the students and the teachers, and provides an opportunity to scaffold the learning of both the students and teachers. An added bonus is that the programme extends the children’s learning without leaving the classroom. Expert knowledge and chemical resources are not available within the school environment, but most intermediate schools do have a suitable science lab, and the chemicals and glassware required for the programme are relatively easy to transport. Teacher A outlined the value of the chemists coming to the

school rather than the students going to the university as “immeasurable, it avoids the organisational nightmare for the teacher”.

The programme provides an opportunity for students and teachers to do science with experts. The chemists model good practice in an environment where the teachers are comfortable. Many of the experiments they carry out use equipment and chemicals you would find in your kitchen cupboard. The chemists are often students themselves and are able to provide the students with an image of a scientists that may be easier for them to relate to than the scientific ‘heroes’ that are often portrayed in the media.

The use of chemistry students (undergraduate and postgraduate) as leaders allows for multiple engagements and a high staff-to-student ratio for programme delivery because they volunteer their time, thus keeping costs low. However, it is also clear that an experienced teacher with the passion and knowledge of the subject area is required for the programme to be a success. This person acts as a central contact for the schools, develops the programme structure and models good teaching practice for the chemistry students.

To ensure the future sustainability of this initiative, outcomes for the university’s core activities (e.g., research and teaching) need to be clear. The Chemistry Department is already addressing this need and has been doing research on the value of the experience to the chemistry students and linking this to the University of Otago graduate attributes.²⁵ A survey of graduate students involved in the programmes highlighted the value of the programme in developing graduate attributes (Warren, 2010, 2011). According to the programme leader:

The Chemistry Outreach students have clearly developed a set of skills and attitudes that are not those usually seen from a science PhD and act as a role model within the department for undergraduate students. Further, undergraduates who have had an extensive involvement in the outreach program also appear to be developing similar skills, with possible implications around the development of graduate attributes as part of a degree program.

However, the key contributions to the development of such attributes remain unclear. Further study on the development of these attributes by graduates and undergraduates involved in the programme may help in this understanding and allow further programme development.

²⁵ The Otago Graduate Profile can be found in the *University of Otago Teaching and Learning Action Plan (Interim Plan 2011–2012)*. The graduate attributes are future focused and highlight: a global perspective, an interdisciplinary perspective, lifelong learning, and scholarship. The attributes also include those most often sought after by employers; communication, critical thinking, cultural understanding, ethics, environmental literacy, information literacy, research, self-motivation and team work.

The Chemistry Department has also looked at how the Outreach Programme can be incorporated into the undergraduate teaching programme. A special topics third-year course in chemistry is using the Outreach Programme as a research topic for some students. They are required to develop ideas for the school classroom, and instead of keeping a traditional lab book they are required to keep a reflective diary. This course is for students who are not going to do honours and it gives them a practical application of the chemical techniques they have learnt.

Career development is clearly an outcome for some of the school students as many of them are unaware of what a scientist does or even what it means to study at university level. The university chemistry students act as role models and mentors, as well as teachers. The programme opens the eyes of the school students as well as the university students in terms of career options. As Teacher A noted, “it is good for the chemistry students to see that not all students learn in the same way as many of them show an interest in going into teaching”.

The leader of this programme has been very flexible in the organisation of the Chemistry Outreach programme. He has shaped the programme to meet the teachers’ needs and the school’s structure. The time commitment involved with multiple engagements with the students and schools is significant. The Chemistry Outreach team made 16 separate 2-hour visits to School A and 10 full-day visits to School B. At present the programme is limited by the number of experienced students leading the programme who have the time available. For the programme to grow, the teaching staff must also grow.

Like other initiatives, the success of the chemistry programme relies on the energy and hard work of a few people. Although outreach is high on the chemistry department’s agenda, further financial support is required for growth and development. In the current climate of reduced university spending, this extra funding may be hard to find.

The New Zealand Marine Studies Centre

Overview of the initiative

At the New Zealand Marine Studies Centre (NZMSC), scientists and educators engage with the community and provide opportunities for students to experience real science in an authentic setting. The NZMSC, adjacent to the Portobello Marine Laboratory, is the public face of marine science at Otago. The NZMSC contributes significantly to the University of Otago’s community service goal, with over 31,000 people involved in this outreach programme in 2011. Of this number, more than a third were students and teachers from 155 schools in southern New Zealand. The NZMSC also runs school programmes in the Nelson–Tasman–Marlborough area.

The NZMSC interprets the local marine environment, conservation issues and current research through live display and interactive exhibits, hands-on experiences and knowledgeable staff. According to the head of the Marine Science Department:

We are able to use the excitement of the sea to culture the interest of students in a range of sciences that are fundamental to the knowledge economy of New Zealand and critical in our future decision-making.

The NZMSC uses a variety of ways to connect students with science.²⁶ Many of these programmes are currently supported by a Ministry of Education contract to deliver Learning Experiences Outside the Classroom (LEOTC) and by the University of Otago. LEOTC funding is contestable, limited and currently under review. Schools contribute to the cost of the programmes (\$4–6 an hour per student) and cover the cost of travel and accommodation when required. Although the total cost can be significant, especially for rural schools, few complaints have been received from secondary schools. A 2011 survey of secondary teachers who have used the facility indicated that teachers especially value the programme for its provision of scientific expertise, as well as providing students with hands-on experiences and access to live animals.

Year 13 Small Animal Study

This case study focuses on just one of the NZMSC's secondary science programmes. The Year 13 Small Animal Study (NCEA Bio 3.1 AS 90713) requires the students to study one animal species and investigate aspects of its survival in its ecological niche. Over the 3-day course students design and carry out individual investigations (under guidance) that look at the response of an animal to abiotic or biotic factors. In 2012, 25 schools came to Portobello to participate in this initiative. This included 46 percent of secondary schools from Otago,

²⁶ These include: (a) Hands-on programmes for primary schools: these programmes are usually a few hours long and often include a shore study, laboratory investigation and interaction with live marine species. Although the main focus is science, the programmes are interdisciplinary and link to a variety of topics and curriculum areas. (b) Science investigations for secondary students: these programmes range from a half-day to 3 days and involve dissections and seashore surveys, as well as laboratory and field investigations. The programmes all support curriculum objectives and achievement standards in science and biology. (c) Gifted and talented programmes for both primary and secondary students: these longer programmes extend from 4 to 8 days and at secondary level include a residential component. The programmes provide an opportunity for students to work in a research team with other students of similar abilities, engage with postgraduate students as mentors, and carry out a research investigation, which includes developing a hypothesis, collecting and analysing data and communicating their findings to an audience. (d) Science resources: the NZMSC has developed resources (e.g., identification guides, species databases, activity books, protocols for seashore surveys, etc.) to support science teaching at both the primary and secondary level nationwide.

14 percent from Southland and 50 percent from South Canterbury.²⁷ Four schools from Christchurch/Mid-Canterbury and one school from Westland were also involved in 2012.

The NZMSC programme leader, supporting staff and four secondary teachers were interviewed specifically about this programme. One teacher was from a local school and the students returned home each night, two teachers were from rural schools, and one teacher was from a city school and had travelled more than 5 hours to attend the programme. Most of the students who participated in the programme in 2012 completed a written survey at the end of the programme.

Participants' views of the programme

Leader's view

The secondary educator at the NZMSC has been in the role since 2005. Before that, as a biology teacher he brought his Year 13 students to the NZMSC to do this programme many times. The Year 13 3-day study at NZMSC aims to meet curriculum objectives and is valued by teachers and students because it enhances their ability to meet achievement standards targets. However, the secondary educator described its real value as

its ability to challenge, support and inspire interest for all students. Whether they are in the top few percent who are comfortable with the increasing reading and writing demands of senior curriculum or whether they are part of the majority who will take part in their communities as active citizens and parents, this programme provides, probably, the deepest and most sustained engagement with the nature of science they are likely to have in all their schooling.

'Guidance' is the key word in the achievement standard,²⁸ which allows for and underpins all the values the programme gives teachers and students. The secondary educator commented that it is key to the success of the programme:

Because the guidance is informed by reflective practice, housed in a university setting, sensitive to students' own ideas and starting points, rigorous about the science and served by the handling of seawater and live animals, it is the backbone that makes this programme an exploration of curriculum, an excellent assessment opportunity and an education.

²⁷ In total, 81 percent of Otago secondary schools and 43 percent of Southland secondary schools do some form of Year 13 LEOTC programme with NZMSC, including single-day LEOTC visits.

²⁸ AS 90713 Carry out a practical investigation into an aspect of an organism's ecological niche with guidance. 'With guidance' means the teacher is supporting the student throughout the investigation but the whole process is student driven. The teacher sets the parameters (such as organisms suitable for study, equipment available) and provides general information (such as resource suggestions or possible new directions).

Postgraduate students in marine science help the programme leader to deliver the programmes. They are involved in their own MSc or PhD project and frequently share their research, their own career path and their experiences with the students:

It is great also to work within a marine context, one, because some students probably would not have the opportunity to do so otherwise, and two, because I think there is quite often a terrestrial bias in high school biology. As a mentor I enjoy sharing this knowledge and interacting with the students. It is fantastic to see students overcoming fears, enjoying what they are doing, questioning why, and finding a real passion for biology.

These postgraduates are typically not much older than the Year 13 students and they provide these students with role models as both a university student and a scientist.

Teachers' views

The number of schools doing this achievement standard has grown from year to year, and to the teachers involved the benefits are clear. In the classroom, teachers 'teach about science' but at the NZMSC students are given the opportunity to 'do science'. Teachers described it as follows.

The first time the students have been exposed to experimental science. (Teacher)

The students are given the opportunity to develop real science skills as opposed to just following a recipe in the classroom. (Teacher)

They have never been exposed to so many variables. (Teacher)

They are testing their preconceived ideas and are confounded and challenged with the notion that these ideas may be wrong. (Teacher)

Although secondary teachers often complain that it is impossible to take secondary students out of the classroom for more than a 50-minute period, the teachers involved in this programme seem to be able to justify the absence from school as they come back year after year.²⁹ According to one teacher, "the amount of work completed in three days is equivalent to a full term's work at school". This is partly due to the loss in time and momentum of having to set up and clean up for each period. There is also the issue of keeping the animals alive for extended periods in the classroom.

In addition to the intensive time period, the out-of-town teachers commented on the value of the residential component, because the students discussed the assignment and supported each other during the evenings. "The environment helps them overcome their lack of

²⁹ It is becoming common for groups to request that the first or last day include part of the weekend to lessen the impact on the school schedule.

confidence and limited skill.” The teachers felt that students were more likely to complete the achievement standard when it was carried out as one piece of work and they didn’t have time to lose interest or focus. The environment helped the less engaged students to focus, and students supported each other. In addition to scientific skills, the teachers felt that the students develop strong time management skills.

All the teachers referred to their own personal growth resulting from attending the programme. Observing someone else explain how to develop a hypothesis and control variables was useful. For early career teachers it gives them a framework on which to base their classroom teaching and develops their confidence to see the unit taught by someone else. Having access to the university facilities was only part of the equation for the teachers. They valued the expertise of the NZMSC educator in terms of his curriculum and marine science knowledge and they appreciated the set-up time and organisation that went into preparing for the visit:

It is a one-stop shop for teachers. It provides the animals, the guidance and the opportunity to interact with a tertiary institution.

Two teachers clearly stated that if they had access to the facilities but not the educator, then they would not do the programme because they did not have time to collect animals and organise equipment, and they also felt they did not have enough knowledge of the animals to provide guidance on suitable experiments.

All teachers commented that the programme provides a good context for talking about bioethics, as they do not deal with live animals in the classroom:

They start the course by poking the crabs, squealing, and show fear in the requirement to handle the animals. By the end of the third day they handle the animals in a very professional way and have a clear purpose in their handling.

Running the programme within a research facility models the Nature of Science achievement objectives of ‘Understanding about science’ and ‘Investigating in science’.³⁰

Having students working on the same species provides opportunity to talk with and observe the work of other students. What did other students find out and how does that apply to their own study? This illustrates the Nature of Science—real scientists talk to each other, share ideas and work together to improve methods, understand data etc.

³⁰ Level 8 Nature of Science achievement objectives: ‘Understanding about science’: understand that scientists have an obligation to connect their new ideas to current and historical scientific knowledge and to present their findings for peer review and debate; ‘Investigating in science’: develop and carry out investigations that extend their scientific knowledge, including developing their understanding of the relationship between investigations and scientific theories and models.

This is often the first time the students have had the opportunity to do science within a context. “The growth in the students as scientists over the 3 days is equivalent to 6 months in the classroom,” as one teacher said. Teachers also believed that the programme was valuable for exposing the students to a different learning environment and possible career pathways, as well as having an impact on the students’ understanding and interpretation of science:

Students come away realising that science is a lot of work. They have to work through the difficulties of carrying out an investigation ... and come away with a better sense of purpose. It raises the mana of science in their eyes.

Students’ views

Teachers described the course as being

physically and mentally exhausting for [students]. They have to maintain a high level of concentration and are continually problem solving. On the first day they are overwhelmed by the huge amount of stuff they have to do; by the third day they are confident in their ability to be able to do it.

Most of the students surveyed (n = 248) felt they gained new factual knowledge, specifically about the biology of crabs, during the 3-day programme (81 percent of students). They highlighted information they had gained through their experiments about the relationship between the behaviour of crabs and the environment they live in (28 percent) and ethical considerations when doing experiments with live animals (13 percent). When asked specifically if the programme raised their awareness of ethical issues for working with animals, 96 percent said yes and 100 percent said that the first day of the course prepared them well to work with animals in an ethical manner. Most said they learned a large amount through the use of animals in the course (72 percent). One student—who had gained an Excellence for the achievement standard report on the research completed during the programme—was asked to describe the experience 2 months later. She said:

the most interesting, valuable and exciting aspect was being able to handle and use live animals in the experimental work. The hardest part was being patient and consistent with doing replicates on the third day.

For new skills, students referred to their improved skill in handling the crabs (64 percent of students), their ability to use various scientific tools and equipment (38 percent), and increased skill with respect to science and the experimental process (24 percent).

Only 60 percent of the students made comments about how they felt the programme changed their attitudes. This attitudinal shift included a change in their respect for and appreciation of animals in their environment (31 percent), changes in their confidence about their own learning (9 percent), and positive shifts in their stance towards learning (8 percent). “I learnt I can work well under pressure”, commented one student. Some students also acknowledged that they were much more aware of the scientific process

(9 percent), with one stating that “I have a greater appreciation of the effort that goes into testing and research.” Less than 1 percent reported a negative shift in interest.

Many students commented on how the programme changed their thinking and understanding about science. Some referred to the qualities needed to be a scientist:

Science requires patience and understanding. (Student)

It taught me to be more aware of confounding variables and be more careful in order to avoid messing with the results. (Student)

Other students reflected on the application of their study to the wider world:

There are many things that affect an organism’s functioning. (Student)

I believe I now understand why some animals are different depending on the place that they live. (Student)

Adapting the programme to a new location

This programme was recently adapted to another scientific institution. The NZMSC Nelson educator approached the Cawthron Institute and Nelson Marlborough Institute of Technology (NMIT) about hosting Year 13 students to carry out their Small Animal Study. Because the NZMSC already had an educator working in Nelson, the programme could be adapted from one research facility to another and from shore crabs to mussels. Cawthron and SpatNZ Ltd provided equipment, technical and scientific expertise and the animals (mussel spat, or larvae). NMIT provided a teaching laboratory.

The programme leader was identified as being key to the success of transferring the programme from one facility to another. NZMSC’s Portobello educator helped the Nelson educator modify and adapt the programme and liaise with schools. Cawthron acknowledged the need for a specialist science educator and the scientists were more supportive of the initiative knowing that NZMSC staff were to front the programme and that their role was advisory. The success of the initiative was recently brought to light when the top three prizes for the 2012 Nelson Science Fair went to students who had done experiments on mussel spat through this programme.

What this case study tells us about science community engagement

The programmes offered at the NZMSC are not easily replicated in the classroom. The key strengths identified for the Year 13 programme were:

- access to live animals and their habitat³¹
- a research laboratory and equipment to allow students to carry out high-quality experiments
- an extended period without the interruptions and distractions of other classes/activities
- the guidance of a specialist science educator
- the involvement of the classroom teacher in the full programme
- an embedding of the programme in a tertiary science and research setting.

These elements are relevant for enthusing, engaging and educating students about science at any level. Although the difficulties in taking the students out of the classroom for extended periods and the cost were highlighted, they were not identified as major barriers. The facilities and equipment and environment available at the NZMSC provide an opportunity for students to extend their learning. They are challenged to lift their game and think for themselves. It provides a taste of what tertiary study and a science career might involve, and there is some evidence that these experiences have an impact on students' choice to take science at the tertiary level or follow a career in science or a science-related field.³²

Teacher involvement in this programme is essential. Not only do teachers have time to stand back and observe their students learning, but they are able to extend the experience to the classroom. Teachers also benefit from being immersed in a research environment. They have the opportunity to talk to scientists, see research in action and ask questions. Many of the teachers involved in the NZMSC programme have been inspired to apply for the Royal Society Endeavour Teacher Fellowships, and a handful have carried out those fellowships within the Department of Marine Science. Some smaller rural schools join and do the programme at the same time. Teachers enjoy the opportunity to talk with and work alongside other senior biology teachers.

Research has shown that the graduate students also benefit from their involvement with the NZMSC programmes. The graduate students have reported improved communication,

³¹ According to teachers, the NZMSC programmes are one of the few opportunities that students are given to work with live animals. Film and computer technology, although valuable as teaching tools, do not provide a multi-sensory experience nor the relevance that comes with studying the real thing. Dealing with live animals also provides the unique opportunity to teach about animal ethics, which teachers say is not covered in the classroom.

³² Marine science, traditionally a postgraduate department, offered a 100-level undergraduate paper for the first time in 2012, and these students were surveyed about their past involvement with the NZMSC. Of the students enrolled from Otago, Southland and Canterbury, one-third had been involved in the Year 13 programme, and their comments showed a direct link between the NZMSC programme and their course choice at university. A further 27 percent had been involved in the NZMSC primary programme, but their comments related to their love of the marine environment, not specifically their experience with the primary programme. Twenty-seven percent of the New Zealand students taking the course had previously visited the NZMSC aquarium with their family.

planning and questioning skills, including metacognitive thinking (Cutler, Riley, MacIntyre, & Bicknell, 2010). One student involved in teaching the Year 13 programme recently won the best poster award at the NZ Marine Sciences Society conference, and another has just been awarded a Fulbright Scholarship. Both achievements reflect on their communication skills.

The opportunities the NZMSC offers schools throughout the year are unique in New Zealand. Schools are linked with this world-class marine science programme in a range of ways: from sharing facilities with a research laboratory, to developing programmes in association with cutting-edge researchers across the biological, chemical, geological and physical sciences. By using the excitement of current research to cultivate the interest of students and teachers in a range of scientific disciplines, the transformative value of the programmes comes to the fore:

The students start thinking of themselves as science students, not just students who take science!

Science Wānanga

Overview of the initiative

The primary objective of the University of Otago Science Wānanga is to enhance the achievement and engagement of Māori in science and health sciences.³³ Science Wānanga programmes offer 2- or 3-day interactive science experiences for Māori secondary students. They are based at marae and in communities, and facilitated by tertiary students, scientists and the local community. Science is presented alongside mātauranga Māori (Māori knowledge) provided by kaumātua, which encourages students to understand connections and actions through science that are relevant to their lives.

Science Wānanga grew out of a request from the late Dr Paratene Ngata in 2007 to coordinate a programme that advanced Ngāti Porou's strategic imperative to increase the number of rangatahi (youth) achieving in science and health sciences. In 2007/08 the university's Office of Māori Development funded two initial wānanga for the East Coast. From 2009 to 2011 funding was received from the Tertiary Education Commission to continue this programme and expand to Northland and Hawke's Bay. The Ministry of Health provided funding to extend the programme to Southland and Marlborough from 2010 to 2013.

In 2012 the university recognised an increased demand for wānanga in new regions, alongside the need to sustain existing relationships. The Office of Māori Development again funded wānanga on the East Coast (which was matched by Te Rūnanga o Ngāti Porou), initiated two wānanga in Otago and began relationship development in Nelson and the West Coast. Requests from communities for Science Wānanga are increasing. University and iwi are highly committed to the programme, but external operational funding is insecure and therefore an immediate priority.

³³ A wānanga is characterised by teaching and research that maintains, advances, and disseminates knowledge and develops intellectual independence, and assists the application of knowledge regarding āhuatanga Māori (Māori tradition) according to tikanga Māori (Māori custom). (Definition from Education Act 1989). Some traditional pedagogies actively encouraged at wānanga are:

- students and teachers are at the centre of the educative process
- life-long intergenerational learning is normalised
- students undertake gradual learning from a familiar starting point
- mixed and complementary curricula are used
- learning and teaching are conducted out of students' strengths
- small student numbers and one-on-one interaction are important.

(Adapted from Hemara, 2000)

Although contract funding has played an important role in initiating and developing Science Wānanga, the University of Otago has also taken steps to ensure the Science Wānanga programme is not limited by the terms and time frames of fixed-term contracts. As the kaituitui wānanga (Science Wānanga co-ordinator) explained:

The key thing is that if you go into partnership with iwi, there is no ‘end point’ [compared with fixed-term contract funding]. [Endpoints] are not how permanent institutions work, and they are not how iwi groups work, because they are looking at sustainable development into the far far future, and they want long-term relationships that are going to be maintained.

The role of kaituitui wānanga has become a permanent position, situated at a divisional level of the university’s administration, enabling wānanga co-ordination to draw on and work with Māori support services across various divisions within the university (Science, Health Science, Humanities and Commerce), as well as the academics and students within departments. A role was also created for a kaiwhakahaere wānanga (administrator) to support the kaituitui wānanga. A reference group for Science Wānanga within the University of Otago meets quarterly.³⁴

Two other key players include the Māori Student Support Centre and the Office of Māori Development, the latter of which enables various agreements (e.g., memorandums of understanding) with iwi in various areas to provide an umbrella for the university to work within as it engages with iwi through Science Wānanga. Conversely, new engagements with iwi through Science Wānanga can lead to the development of new memorandums of understanding, or agreement, or both. This work to establish deep and long-term relationships around Science Wānanga has meant that in some cases different partners have contributed funds to enable Science Wānanga to go ahead when other funding has not been available.

Participants in the 18 wānanga delivered between 2008 and 2012 include 703 Māori students studying science in Years 9–13, and 114 of their teachers from 40 schools. There have been 171 university staff and postgraduates and 25 community members involved in delivering science projects, plus many kaumātua and kuia (male and female elders), whānau (extended family) and ringawera (kitchen helpers) engaging through manaakitanga and mātauranga on marae.

During September/October we interviewed the kaituitui wānanga and visited one school (Tolaga Bay Area School), which had been involved in Science Wānanga since 2007. The

³⁴ In addition to the kaituitui wānanga and kaiwhakahaere wānanga, the reference group includes the Associate Dean Māori of Division of Health Sciences, the Associate Dean Māori of Division of Sciences, the Pro-Vice Chancellor of Division of Sciences, the Director of Te Irika o Te Wharawhara Te Raki (Office of Māori Development), the Tumuaki (Director) of Te Huka Mātauraka (Māori Student Support Centre) and a lecturer in Māori pedagogy at Te Tumu (School of Māori Pacific and Indigenous Studies).

kaituitui wānanga also supplied background material, including research and evaluation findings already undertaken by the University of Otago.

Science in relevant community contexts

Science Wānanga is notable for the extent to which it locates science learning experiences within authentic community-selected contexts. According to the kaituitui wānanga, when students are asked what makes them disengage from science at school they invariably give three main responses: science is “too hard”, “[involves] too much bookwork”, and “is not about me”:

So that’s what we’re focusing on. We’re changing it to be ‘about me’ [the learners]. The relevance is coming from the fact that students get to suggest topics, the schools and iwi groups that are involved in whatever region have input into the focus [as well]. We have all the resources of the university, [as well as] other institutions and networks at our disposal, so we are very flexible to make sure that we take what’s relevant to the community [into Science Wānanga].

Topics are chosen by communities and often make the link between human health and environmental health. A couple of examples from different communities illustrate how this operates in practice.

Example 1

A South Island rūnanga identified diabetes as an issue for the community. This led to discussions about the importance of understanding the interrelationships between human health and the environment, and this in turn led to the development of a Science Wānanga programme on the sustainability of the tītī (muttonbird) harvest. This was an area in which the university had significant scientific capacity through more than a decade of involvement in research with iwi.³⁵ The context also had personal relevance for students, many of whom had participated in muttonbirding. Students’ prior knowledge and expertise provided an opportunity to “springboard into the nitty-gritty of the science” (kaituitui wānanga).

The focus was on examining the technologies and techniques that scientists working with Māori communities used to address questions on what affected the birds and the sustainability of the harvest. Since many students already had familiarity with the context,

suddenly they realised they actually understood and knew a lot of science too, because they had that local knowledge and the long-term observational understanding ... They knew that birds were in burrows, and could relate to

³⁵ The research is conducted by the University of Otago, but the overall research direction is directed by the Rakiura Māori community. See <http://www.otago.ac.nz/titi/bicultural.html>

the fact that to work out breeding success, [scientists] had to know (a) how many eggs were in the burrow, (b) how many hatched, and (c) whether those chicks fledged. So how do you actually crunch that into numbers scientifically to work out a rate of breeding success? To make a model to see how sustainable your take is over time, you need to know some of these basic biological parameters.

Example 2

On the East Coast of the North Island, community concerns about oil companies exploring off the coast led to a Science Wānanga programme with two focuses. The first was oil: What are the oil companies looking for, what are they going to do, and what might the impacts be? The second focus was earthquakes. With schools located near the beach, how would the community respond to an earthquake on the scale of the Christchurch earthquake? The Science Wānanga drew on the resources and expertise of the university's chemistry and geology departments. A chemistry team took the students through activities to measure the energy values of various synthetic oils and to explore products made from oil alternatives (e.g., making plastics from corn starch). The geology dimension involved looking at the rock structures in the areas and seismic maps, which addressed questions about earthquake and tsunami risks and scenarios, as well as understanding what and how petrochemical companies are looking at rock structures under the sea as part of their processes of surveying for oil.

The kaituitui wānanga described the intention of these explorations:

To give them the scientific background so that they understand what's happening, and what the consequences good and bad might be, so that they can make an informed opinion and decisions themselves.

A subsequent wānanga in the same region carried some of the energy-related themes and content forward into a new theme, alternative energy. This involved bringing in physicists and graduate students, and engaging learners in activities such as generating electricity from rivers using a micro-hydro generator, calculating the energy efficiencies of systems in their schools, marae or homes, such as the energy required to heat water for showers, and calculating what the energy requirements might be if the community was (for example) seeking to supply its own energy needs.

The Science Wānanga process

The pedagogy of the Science Wānanga incorporates:

- a commitment to hands-on and relevant experiential learning (located in contexts selected by, and of relevance to, learners and their community)

- Bishop and Berryman's principles of effective teaching for Māori learners³⁶
- a partnership focus, and a philosophy of bringing together science and mātauranga Māori in ways that acknowledge the knowledge, understanding and skills of all the individuals involved
- a whole-community approach, adapted from the Enviroschools whole-school approach, which incorporates four key areas of school life that have an effect on sustainability and student learning;³⁷ the Science Wānanga focuses on consistency and quality of engagement in science and mātauranga Māori in these key areas: place (wāhi), practices (tikanga), programme (kaupapa ako), people and participation (tangata).

Each wānanga involves about 40 Māori secondary students (from several schools), their teachers, and a team of scientists and postgraduate science students in the selected focus areas for that wānanga. In some wānanga there is a focus on NCEA-level students (Years 11–13), whereas in other regions communities identify a need to focus on students in Years 9 and 10 to keep them from becoming disengaged with science before they reach the senior school. In areas where there have been many repeated wānanga, students may return to Science Wānanga over a period of terms or several years.

The first iterations of Science Wānanga were run over a day and a half, with a pōwhiri (welcome ceremony) in the morning, followed by the science-learning activities, with groups staying overnight and leaving the next day. Around 2009 it became clear that more time was needed to allow for the pōwhiri process and the science activities. Subsequently, the Science Wānanga model was extended to 2–3 days with the pōwhiri held on the first afternoon, giving time for proper tikanga processes and whanaungatanga (the development of relationships), and for the students, teachers, scientists and other manuhiri (visitors) to be welcomed and meet one another, with science-learning activities commencing the following morning.

Although the wānanga are marae-based, the science learning is undertaken in English. Assembling the scientific teams (scientists and graduate/postgraduate students) is a careful process that takes into account the expertise that is needed to address the topics identified by the communities, as well as personal characteristics and dispositions. Where possible,

³⁶ Bishop and Berryman's (2009) work indicates that relationships and interactions between teachers and students are key to the effective teaching of Māori students. Effective teachers take a positive, non-deficit view of Māori students, and see themselves as capable of making a difference for them. Effective interactions rely on:

- manaakitanga (caring for students as Māori and acknowledging their mana)
- mana motuhake (having high expectations)
- ngā whakapiringatanga (managing the classroom to promote learning)
- wānanga and ako (using a range of dynamic, interactive teaching styles)
- kotahitanga (teachers and students reflecting together on student achievement in order to move forward collaboratively).

³⁷ See http://www.enviroschools.org.nz/our_programmes/how-it-works

Māori scientists and students from the iwi are engaged. The marae partners provide access to local people with mātauranga Māori related to the topics of interest. Non-Māori scientists and postgraduate students are also involved because of their expertise, but it is important that these people are willing, interested and able to operate comfortably within the tikanga processes of the wānanga. Science Wānanga co-ordination includes the provision of tikanga support for manuhiri.

The kaituitui wānanga stated that it is “essential” that the teachers come along with the students as part of their professional development, in terms of both the science and (if the teachers are non-Māori) understanding things Māori. Often the wānanga has a host school, which helps with the organisation and makes its labs and resources available for the learners, teachers and science teams to use. The kaituitui wānanga also noted that Science Wānanga provides opportunities for teachers and students to see one another in “a new light”. For example, teachers could see their students demonstrating knowledge or showing enthusiasm for learning in ways the teachers had not seen previously. Students could get to know their teachers (as well as the scientists and science students) as people, through sharing time together on the marae.

Participants' views

Principal's view

The principal of Tolaga Bay Area School has been involved in Science Wānanga since the beginning. When Paratene Ngata offered support for the community to pick up the challenge he had identified, the principal was aware that much work would be needed:

We knew that the biggest shift that we had to make was an attitudinal shift towards [students] seeing themselves as scientists, trying to restore and regain our cultural identity as good scientists, and we knew that was a long haul.

The establishment of a marae-based approach was seen as not only beneficial for students, but also a way of providing a reciprocal benefit for the University of Otago science partners, through the community's willingness “to provide our cultural knowledge, mātauranga Ngāti Porou” as the principal said, alongside the scientific knowledge and expertise the University of Otago could provide.

The initial focus was on raising student achievement in NCEA and developing teachers' capability to support this:

Since then we have shifted from there, and it has been a mutually agreed shift, and that is less emphasis on ‘we have to get these kids credits...’ and more about opening their eyes and exposing them to the possibilities that exist in science, and how so much of your life is directed by science, and [aiming for] that attitudinal shift.

Since Science Wānanga began there has been a shift in students' interests, attitudes and engagement in science, as well as incremental improvements in NCEA, which the principal felt was consistent with the long-term approach:

The wānanga has really helped us to grow in our understanding of science and its place, not just in a science curriculum, but in a community and in an iwi.

In the principal's view, the relationship with Otago University has supported the school and community leaders' confidence and capability to engage with other scientific organisations, including the Royal Society of New Zealand, the Alan Wilson Centre, and international institutions such as Kew Gardens in London.³⁸ The relationships with the science community are thus embedded through the Tolaga Bay *community*, with the school firmly connected at the centre of these community engagements. The principal believed that the collaborative, co-operative nature of the relationships between the community and these organisations was a key to the success of "our journey".

An important aspect of that journey has been the willingness of the science partners to take on board the ideas and aspirations of the community, and the forging of open and honest relationships in which partners can ask for help or collaborate to develop projects together. An example described by the principal was the community's restoration of the Uawanui river mouth to reflect what it might have looked like when Captain Cook arrived in Aotearoa New Zealand in 1769:

So [the community said] well we want to do that, but how do we do that—we need help ... So in steps the Alan Wilson Centre, they looked at the project and, without being patronising, said, yes that's a great idea and a great project, but there's so much more we can work with you on. And that's what they did, and so the sustainability project became the whole Uawa catchment.

The community's co-construction of the Uawanui sustainability project with all their science partners led to engagements with the forestry industry, land owners and people who live near the waterways, with students visiting all these places during Science Wānanga and having the opportunity to see the interconnections (and complexities of inter-relationships) within the social and natural ecosystems of their community.³⁹

³⁸ As discussed in a recent article in the *NZ Education Gazette* ('Acknowledging history for future planning', 2012), some of these engagements are connected with Tolaga Bay community's involvement in hosting a major event associated with the 2012 transit of Venus.

³⁹ The Uawanui Sustainability Project is also discussed in the 7 June 2012 episode of *Our Changing World*. See <http://www.radionz.co.nz/national/programmes/ourchangingworld/20120607>

Teachers' views

Two teachers at Tolaga Bay Area School⁴⁰ who have been involved in multiple wānanga expressed very positive views of their engagements, particularly emphasising the benefits they saw for students. For the teachers, benefits included gaining fresh ideas, and being inspired (alongside students) by scientific contexts, concepts and topics they were less familiar with. Another key benefit for the teachers was the sense that they could access *specific* advice, help and connections to support those among their students who wanted to follow pathways to university.

The issue of supporting teacher capacity is an ongoing concern for the kaituitui wānanga, particularly in schools in which there is often only one science teacher, with responsibility for teaching across all the branches of science. Over time, Science Wānanga is contributing to teacher capacity in other ways, including providing support for teachers to come to Otago for professional learning opportunities. Both teachers felt that the relationship with Otago University needs to be sustained, and that the benefits of the engagement for teachers and students will “fizzle out” after a few years if it were to cease.

Students' views

We interviewed four Year 11–13 students who had participated in multiple Science Wānanga programmes. Two students were in the Māori immersion stream of the school. It was very clear that participation in wānanga had, for these students, provided a new and deep level of insight into the nature of science and its relationship to themselves, their culture and their community:

Compared [with] when I first used to do science, and then when we started doing Science Wānanga, it was a completely different view. It wasn't just looking at books and playing with Bunsen burners. It's going out and doing stuff that happens in everyday life that we just used to take for granted. Now you don't just go out into a paddock and see grass and birds. You think of how things grow, you think of what things live in the grass to make it grow. It's a more in-depth view of the world as we know it. (Student)

To have so much thought put into it ... to see how [science] surrounds us, I'd never really considered it. I've lived here all my life and I still learnt things—some complete strangers that have never been here before have taught me something about where I've lived for 18 years. It's just different ways of perceiving what's around you. (Student)

It was really eye-opening. They told us all these stories about our ancestors ... you can see how our heritage is based on science almost ... I've always

⁴⁰ Interviews with teachers and students from another school in the Science Wānanga cluster were planned, but owing to a teacher illness on the day of the case study visit this did not occur.

been interested in science, but after [Science Wānanga] I was just so much more passionate about it. (Student)

Students were able to easily and enthusiastically articulate precisely how Science Wānanga achieved this and why it worked for them:

[Science Wānanga] takes away the false illusion that everything is based on books, and the periodic table, [the] things that deter people from science. I don't really care about all the books, all I care about [are] things that are to do with me, my way of life, and the people in my community. I think that's why we are able to get our idea across [to you] that we've got a new perspective of life, because we're not constrained by the old view that science is about textbooks. It's more than that, it's life, it's how we are: it's everything we are.

Students commented on the two-way relationships between learners and science community partners:

Their method of teaching us is just so effective. It's not like, I'm the teacher you're the student. It's like, we're all equal, you teach me this and I'll teach you that. (Student)

All the people that come on the wānanga, not only do they give their knowledge freely, but they absorb the way that we think, they consider it. (Student)

The students also talked about the value of engaging with established scientists or lecturers and younger tertiary science students:

You can also see how thoughts evolve and are evolving, you can see how the lecturers at university thought really differently than the ones who were just in their second year of university. You can see how [people's] thoughts evolve over time, even though they are studying the same things.

Holding wānanga on the marae was seen as an essential element:

We're already bringing science into the community, but mixing it with our culture. The way we do things on the marae, the way we do things and the way we live, it's just really cool to mix those up [with science learning]. (Student)

Even the aunties on the marae, they learn, they're really interested. (Student)

When all the coast schools come together again it's reconnecting and renewing our ties and bonds—not through a tangi [funeral mourning gathering], or a birthday, or a reunion—it's through science, it's something different. (Student)

It seems like they are making science fit the community, not the community has to fit into science ... It's not just science, but for me going onto the marae all the time, it's given me new insight into everything as a person. Talking to random people, it's how some people just have one view of things, [whereas] now you have a whole different perspective of science, Māori, European, everything. (Student)

The students commented on some of the differences between their experiences of learning science at wānanga compared with ordinary school science teaching and learning. For example, all students wished that school science was less about reading and writing and was more “involved” and “hands on” (like Science Wānanga). One student commented on a recent engagement with other providers (not the Otago Science Wānanga) that was more focused on particular assessment standards and felt that the approach was more limiting and narrow:

I had questions they couldn't answer but that I really wanted to know, like what happens in the big eel breeding grounds when they go out in the ocean, why don't they float to the top when they die, stuff like that. But [the providers] just closed the book completely, this is what we are teaching [based on the unit standard], and I'm one of those people that just likes to think big. But then I was thinking questions like that, I wonder if there's anyone who can answer, and imagine if *I* was the person who could answer that question.

Another student commented on the benefits of undertaking school work in an area the teacher didn't know the answers to:

My practical assignment, my teacher didn't know much about [the topic], so I was learning *with* her. Which was really really cool because I didn't have anyone to tell me the answers. I was just so excited about that, everything was truly new to me.

As a final comment, students believed that Science Wānanga had provided them with a much more complex view of issues in their communities. They felt that they were carrying their new ways of thinking and seeing the world into all aspects of their lives and could see how this connected with greater educational goals—even at the national level:

I think the complexity thing makes it real. It shows New Zealand as a developing country ... science wānangas and other things that open you up to different things, we're growing people who can express ideas and getting away from that thing that 'everything is black and white'. We're getting to a new age where people can question everything ... there's no end to the path. That's where the real developing countries are going, they're questioning everything, they're not just stopping where their forefathers stopped.

What this case study tells us about science community engagement

In many ways, Science Wānanga provides the most obvious illustration of the kinds of community-connected, future-oriented, personalised forms of science community engagement argued for in the literature synthesis (Chapter 2). Science Wānanga has, at least for the community at the centre of this case study, provided a genuinely transformative experience of science and its relationships to students and their community.⁴¹ The role of relationships and partnerships in enabling and sustaining this transformation is clear, as is the long-view nature of the wider community's engagement with the science community.

Overall comment across the three University of Otago initiatives

The University of Otago Vice Chancellor's recent address to staff about the strategic direction to 2020 made it clear that outreach was one of the university's main imperatives. For the university's Pro-Vice-Chancellor, a university is not there just to educate people and do research:

We also have this role of critic and conscience of society, and we have this outreach role where we are expected to interact with communities. We may have paid lip service to that many years ago, but today it's become part of our normal business.

It's a co-ordinated effort with a lot of different facets, but the ultimate aim is to demystify science and humanise scientists in the eyes of young people and show them that it's perfectly all right, even cool, to aspire to do science at university.

One of the unexpected valuable outcomes of these engagements is to the teaching and learning of university students involved in the delivery of the programmes. In recognition of this, the University of Otago's Division of Science has recently developed the Science Outreach Certificate, an extension of a fledgeling system initiated by the Chemistry Department. Within the past 2 months more than 60 science students have registered.

All the case studies clearly show that the links between the University of Otago and schools have reciprocal benefits and that the value grows over the duration of the association. Each study clearly demonstrated the benefits—to teachers and students—of subject experts and role models, access to research facilities and environments, and the application of the science to careers and real-world issues. The value lies not only in providing educational experiences outside the classroom, but also in providing students with opportunities to go beyond the constraints of their teacher and the curriculum.

⁴¹ Research at the University of Otago is currently being undertaken to look at the experiences of and benefits for the university students involved in Science Wānanga.

Case study 2: The Liggins Education Network for Science (LENScience)

Overview of the initiative

The vision of the Liggins Education Network for Science (LENScience) is “bringing schools and scientists together to promote scientific literacy”.⁴² LENSscience is based in the Liggins Institute, a research unit within the University of Auckland, and its programmes are designed to be implemented by schools, in partnership with the Liggins Institute and its partner tertiary organisations.⁴³ These partnerships rely on the joint expertise of scientists, specialist science educators (based at LENSscience) and classroom teachers. The purpose of these connections between schools and science organisations is to support science education and enable science communication and translation in the community. Since its establishment in 2006 more than 35,000 11- to 18-year-old students have participated in its programmes.

LENScience uses a variety of ways to connect students with science. These include:

- face-to-face sessions
- the provision of classroom resources that present cutting-edge research in ways that are accessible to students
- e-learning interactions.

The face-to-face sessions involve Year 7–13 classes visiting the specialist classroom at the Liggins for a range of programmes. These include:

- Me, Myself, My Environment – Nutrition (New Zealand Curriculum [NZC], Level 4)
- Me, Myself, My Environment – Growing up (NZC, Level 5)
- DNA Discovery Day (NZC, Level 5)
- Diabetes: An Issue for My Community (NZC, Level 6)
- The Role of Biotechnology in Scientific Research (NZC, Level 8).

During these visits, students are taught by the LENSscience specialist science educators, use specialised scientific equipment, have the opportunity to meet and talk with scientists, and experience being in a university research environment. These visits are one component of a module of work that is carried out at school but supported by resources produced by LENSscience. Students also have opportunities to interact in live online events with scientists.

⁴² *LENScience Strategic Plan 2010–2014*.

⁴³ LENSscience is a member of the National Research Centre for Growth and Development, a New Zealand Centre of Research Excellence.

As well as providing these experiences and resources for students, LENSscience offers professional learning and development for teachers—both online and face to face—and supports schools to communicate with their communities about science.⁴⁴

LENSscience also has a strong focus on working with Māori and Pacific communities. Recent LENSscience research has shown that “students from lower socioeconomic communities, and populations carrying a high burden of disease risk, value the (LENSscience) programmes more highly than others”⁴⁵. The Māori and Pacific initiative includes repeated exposure to context-embedded modules during the secondary school years, priority access to the LENSscience face-to-face programmes for schools within the initiative, a student–scientist mentor programme for gifted and talented students, opportunities for students and scientists to co-host community events, and a school-to-university transition programme.

Funding for the LENSscience programmes comes from public-good research and teaching grants, government contracts and philanthropic donations.⁴⁶ There is no charge for schools to participate in the programmes. LENSscience is seen by the research director of the Liggins Institute as a research entity. This means that it is treated as a research group with research goals and research targets.⁴⁷ This focus on research appears relatively unusual in science community school engagement initiatives, both in New Zealand and overseas. The considerable energy LENSscience has put into collecting pre- and post-intervention data not only enables them to evaluate and adapt their programmes, but also lays the foundation for longitudinal studies investigating whether changes in attitude and behaviour are sustained. Initial research into the Healthy Start to Life Adolescent Education Project, for example, has shown not only significant improvements in adolescents’ understanding of the association between a mother’s nutrition and the health of her children (even when they are adults), but has also shown that these adolescents are communicating their new knowledge to their families.

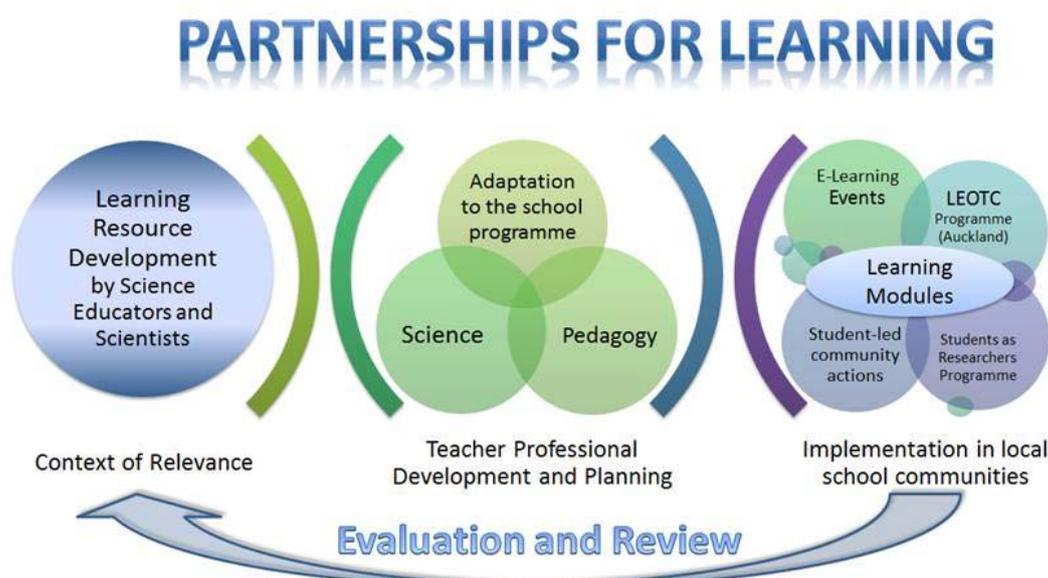
⁴⁴ The e-in science project includes LENSscience’s online professional development for teachers as a case study.

⁴⁵ LENS Report 2012/2

⁴⁶ See <http://www.lenscience.auckland.ac.nz/uoa/home/about/about-lenscience> for further details.

⁴⁷ One of LENSscience’s strategic goals for 2010–2014 is “To develop and deliver a high-quality research programme.”

Figure 2 Draft model for LENSscience’s partnerships for learning



Participants’ views of the initiatives

During July and August we interviewed the research director of the Liggins Institute, the director of LENSscience, and four teachers from different schools that have been closely involved with LENSscience. One teacher was from an intermediate school and the other three were secondary teachers. During September some Māori and Pasifika students who had been involved with various aspects of the LENSscience programme were also interviewed. All adults interviewed said an important goal of science education is for students to become more informed about scientific issues and develop the capacity to make “wise choices”. In addition to this science for citizenship focus, developing the future supply of scientists was seen as an important purpose of school science. At the intermediate level, the teacher focused on nurturing positive attitudes to science so that students would want to continue to study it at secondary school.

When asked about the benefits of the initiatives, the first thing the teachers from all four schools spoke about was the wonderful opportunities the initiatives provided for teachers to learn alongside the students. Two of the teachers whose schools had been involved in a wide range of initiatives with LENSscience felt that the biggest gains for students were in two main areas:

- in the student–scientist mentor programme, where students built up long-term relationships with scientists
- in the current Students as Researchers pilot.

Benefits to students included not only the acquisition of scientific knowledge and skills, but also generic skills such as time management, resourcefulness and resilience. Working alongside professional scientists was particularly useful for developing ideas about the nature of science. Interestingly, one secondary teacher commented that at his school the ideas about what science really is were flowing out to a wider group than just the “Liggins kids”—the school’s term for the students involved in the student–scientist mentor programme.⁴⁸ The teacher from one of the other secondary schools noted that, since becoming involved with LENSscience, “the number of students completing Science Fair projects has increased steadily each year, as well as the number of students receiving major category prizes and special awards at the Auckland NIWA Science and Technology Fair”. This teacher also commented on the usefulness of the Biology Senior Seminar Series and said, “We have had students passing the Biology Scholarship examination in 2009, 2010 and 2011 for the first time.”

The teacher from the third secondary school noted that meeting the scientists was often a highlight for students, and that the low ability classes they took to the Liggins Institute seemed even more excited about the experience than the top classes. At the intermediate level the teacher reported that the students were highly motivated by the opportunity to visit the university, but also that the topic on diabetes was “incredibly motivating” for these students, many of whom had family members with diabetes. For these students their involvement with LENSscience was through a special science extension programme for Māori and Pasifika students. According to the teacher, the main purpose of this programme is to “dissolve the myth that science is too hard” and to encourage these students to take science options at college. This teacher⁴⁹ had also hosted, with the support of staff from the Liggins, a highly successful science evening for the school community where Year 7 and 8 students presented their scientific investigations alongside professional scientists who were talking about their own research.

Despite their enthusiasm for the initiatives, both secondary teachers expressed concerns about the long-term sustainability of the programmes. They felt the success of the programmes was dependent on having interested teachers who were committed to them: maintaining this interest could be challenging with staff turnover, despite the significant amount of support the schools received from the LENSscience educators. Another issue mentioned was the increasing number of initiatives available to schools and the difficulty in deciding which initiatives to become involved with and how to manage competing demands on staff time. The secondary teachers also commented that they “picked and chose” which aspects of the resources to use because there was not time to do them all. One teacher, while very positive about the resources, said that they would not drive the programme but

⁴⁸ This teacher also noted a recent increase in the number of students enrolling in senior biology at the school. Whether or not this is related to the school’s extensive involvement in LENSscience is of course unknown, but it could be worth investigating.

⁴⁹ The teacher had previously been a teacher fellow hosted by the Liggins Institute.

complemented what the school traditionally did.⁵⁰ The director of LENSscience had a slightly different perspective on the resources. She said, “We see the modules as the most powerful offering that we have”.

Everyone interviewed spoke about the motivational aspects of the LENSscience initiatives. The Liggins Research Director also talked about the importance of LENSscience initiatives being “tethered to the curriculum” while also providing experiences that are sufficiently different from the usual classroom to be memorable for students. When asked about the benefits of their involvement in these initiatives for the scientists, the Research Director responded that the immediate benefits for scientists currently seem to be largely personal: they often find interacting with students and schools engaging, motivating and energising. In his opinion the professional benefits are currently only tangential, but this could change in the future as more emphasis is put on the importance of science translation. The Research Director acknowledged that scientists struggled to communicate the work of science within society and that developing partnerships between scientists and educators was a way of enabling effective communication with diverse communities. Another (long-term) benefit to scientists is that the initiatives contribute to the development of the next generation of scientists.⁵¹

The Year 7 and Year 8 students involved in the science extension programme for Māori and Pasifika were very positive about this special programme. They spoke about particularly enjoying the hands-on activities and being able to explore a relevant topic in depth. In their opinion this programme involved less writing than their usual class science units, and writing was perceived as “hard and boring”. According to one student, “Hands-on is much better because it helps you get more understanding”. Another student commented that after this programme he “didn’t feel stupid anymore”.

On the other hand, a small group of Year 9 students (at another school) who had visited the LENSscience classroom struggled to remember very much about what they had done. They indicated that both school science and the science they experienced at the LENSscience classroom did not live up to their expectations of what science at high school was going to involve. For them, real science involved “doing lots of experiments and blowing things up”. For these students, science was more interesting than maths and English but less interesting than social studies and PE. Even though they were not particularly positive about science, all these Year 9 students thought science was important for certain careers,⁵² and half of the group felt it was important to do well in science at school.

⁵⁰ Anecdotally we heard of another school where the involvement with LENSscience actually led to the development of a more integrated curriculum. This is an area that would be interesting to explore further.

⁵¹ According to Bay, Sloboda et al. (2012), PhD students who were involved as LENSscience mentors reported that this process of mentoring secondary students taught them how to more effectively use their own supervisors.

⁵² None of these students mentioned a science for citizenship goal for learning science.

What this case study tells us about science community engagement

Perhaps one of the most powerful aspects of the LENSscience initiative is the space it opens up for thinking differently about the relationship between schools and their communities. This initiative is based on the assumption that scientists and specialist science educators need to work together with schools and their communities to support the “functional scientific literacy development at a societal level” that is necessary if we are to address the significant environmental, economic, social and health challenges we are currently facing as a country (Bay, Sloboda et al., 2012). This challenge requires different sorts of expertise to be put together to do something that none of the players could do on their own. Just as it is unrealistic for school science teachers to keep up with advances in science, so is it unrealistic to expect scientists to have the pedagogical knowledge to work effectively with young people.

Critical to the success of the LENSscience initiative is the specialist science educator role—someone who bridges the gap between the science community and schools. As the Research Director at the Liggins pointed out, “Scientists and teachers speak different languages”. There is a need for someone who can understand the science but is also knowledgeable about the current curriculum and about pedagogy. At LENSscience, the science educator role is multi-faceted. The science educator not only works directly with students in the Liggins classroom, but also with teachers in schools, and with students and teachers online. The science educator role also involves working in collaboration with scientists to create research stories that are accessible to adolescent learners and at the same time maintain the authenticity of the research itself. The role also involves carrying out research into the effectiveness of programmes.

For the director of LENSscience, considerable time and energy are also put into fostering relationships and collaborations within the science and science education communities, both in New Zealand and internationally, promoting LENSscience and seeking ongoing resourcing. Secure, long-term funding is necessary for running and building on existing programmes and for longitudinal research, and also to enable the development of future specialist science educators. This role, as previously noted, is different from that of a classroom teacher and requires a particular skill set. There is a need to support new science educators as they learn the role, and this is difficult to provide under short-term funding models. The teachers interviewed in this research project also spoke about the importance of developing relationships with the LENSscience educators—and again this takes time.

Despite the concerns about long-term funding and the challenges for educators working within a science environment, there are ways that the success of this initiative could be built on and potentially scaled up. One secondary teacher commented that his experiences with LENSscience had shown him the benefits of partnerships with the science community and made him more confident approaching other organisations for support with school science, and in this way LENSscience had served a “seeding” function.

The director of LENSscience believes there is enormous potential for New Zealand, both socially and economically, through effective science education. She said, “We’re not there

yet—we are on the beginning of a journey but we are excited about what we are doing”. She believes one of the strengths of the LENSscience programmes is that they focus on contexts that are important to all the programme partners—scientists, educators, students and their families, and the wider community. LENSscience programmes focus on health-based socio-scientific issues, but there are other issues affecting whole communities, such as environmental issues, nanotechnology, energy and water, for which the LENSscience model could potentially serve as a guide for future developments. LENSscience appears to be unique in New Zealand, especially in relation to the strong research programme that surrounds it, and as such it provides interesting insights into what might be possible.

Case study 3: The Clinic

Overview of the initiative

At a Wellington primary school the disused dental clinic has become a place for the school community to “gather, share, explore and learn alongside our children”.⁵³ The Clinic, as the initiative is known, is driven by an enthusiastic group of parents who are passionate about science, or community engagement, or both. The community-led learning centre is independent of the school programme and focuses on student engagement and on building networks within the school community. The focus is currently on science, as this is an area the school community has identified as a priority for their children, but the group of parents who are driving this initiative imagine a future where a range of interests could be represented. For instance, this school community includes parents who are involved in design, architecture and the like, as well as the sciences.

The initiative was piloted over terms two and three in 2012.⁵⁴ It runs two lunchtimes a week (the actual day depends on volunteer availability), and so far activities have included dissecting sheep lungs and hearts, making ice-cream, identifying rocks and using microscopes.⁵⁵ The Clinic’s philosophy places a high value on experiences that are hands-on, fun and awaken curiosity. Parents value the freedom of children to learn at their own pace and in their own way—hence the emphasis on child-directed learning and the drop-in structure of sessions, where children can come and go as they please. The sessions are advertised through the school’s morning notices.

This Thursday (6 Sept) at The Clinic

Come and join zoologist Dr _____ who will be bringing a box full of cat bones and a complete cat skeleton! See if you can match a bone to the skeleton, and find out how cats ‘work’. You may never look at your pet cat the same way again! The Clinic is open from 12.40pm until 1.25pm. All students welcome.

⁵³ Quote on school website.

⁵⁴ It is currently about to be evaluated.

⁵⁵ In the scoping phase of this initiative, children were asked to make suggestions about things they would be interested in learning more about.

The Clinic was initially open to children in Years 5 and 6, but younger children are now included. Each session is staffed by a member of the core organising committee, a science expert from the school community and other parent helpers. (The focus of a session is largely determined by which science expert is available.) According to the organising committee, the number of children attending the sessions has varied. Some days there have been 40 to 50 children, on others about a dozen.⁵⁶

This initiative is about developing a learning community—it is not just about experts coming in. All the volunteers need to have some affiliation to the school, though; for example, parents, grandparents or the wider whānau of children attending the school. According to the parents driving this initiative, The Clinic allows children to get to know a range of different adults as well as being exposed to different aspects of science. Another important aspect of the initiative is the opportunity it provides for parent helpers to “wonder alongside their children”. Three of the four mothers who form the core organising committee have Playcentre backgrounds and the philosophy of parents and children learning together is obviously highly valued. These sessions at The Clinic allow the sort of adult learning that commonly happens in Playcentres as well as providing a way of ensuring that the considerable scientific expertise of this specific school community is effectively shared. It also provides opportunities to strengthen relationships between the adult members of the school community.

Participants’ views of the initiative

The four mothers in the core organising group who were interviewed spoke highly of the school’s teachers and the immense workload they were carrying: “we ask too much of teachers”. However, in their opinion many of the current school-initiated opportunities for parent involvement do not tap into the considerable expertise that exists within this school’s community. These parents want to be involved with the learning of the children in the school, and they also want to learn together with other parents. To these parents it is important for adults to model life-long learning. These parents “want to do more than fundraising, laminating, and shelving books”. They want to offer their specific areas of expertise to the school community.

They are also keen to organise professional development for parent helpers at The Clinic.⁵⁷ They acknowledge that many parents lack the confidence to get involved and suggest that

⁵⁶ There are other, more structured parent-led science initiatives that operate out of the same space after school. These after-school sessions charge a fee and follow a theme (e.g., chemistry), whereas the lunchtime sessions provide more of a taste of a range of experiences, and children are free to come and go as they please.

⁵⁷ Getting enough parent help for The Clinic has been challenging for the organising committee. They have found that many parents of junior children are unable to help because they have pre-schoolers, and that many parents of older children have rejoined the paid work force.

parents are more likely to get involved if they know exactly what is being asked of them and are given enough time to rearrange their busy lives.

According to the principal of the school and the teacher in charge of science, this initiative is really successful in engaging students. Both have been surprised by the depth and range of expertise within the community and acknowledge that this is a resource that had previously been under-used.

Nine Year 5 and 6 students and four Year 3 and 4 students were interviewed about their experience of The Clinic. Some of these students said they attended regularly and others popped in occasionally, but all were very positive about the experience:

I never really liked science before, but now that I go to The Clinic, I really do. (Student)

The Clinic makes you think deeper about things. (Student)

They particularly liked the range of exploratory, hands-on activities provided at The Clinic and the fact that they could come and go as they pleased. Students said that the science at The Clinic was different from the science they did in class—at The Clinic there is a very wide range of activities (Living World, Physical World and Material World). They also said science in class was more about “just observing and writing things down”.

What this case study tells us about school–science community engagement

The mothers in the core organising group feel that The Clinic could influence how the school science programme operates, although this is not an explicit aim. Already they have been asked by teachers to have some input into planning a science unit, and they think the way students talk about The Clinic will have a flow-on effect in the classroom. They have seen resources that were used in The Clinic being used later in classrooms. Some parents have been invited by teachers to run science activities in their children’s classes.

Looking ahead, this group sees a need for a dedicated community link person. The role of this person would be to liaise between the school and its community and ensure the effective use of community expertise. One person said she thought it was unrealistic for teachers to do everything and that their job should be focused on building relationships and getting to know all children as individual learners. In her opinion it is unrealistic to expect teachers to be subject experts as well, and this expertise could be sourced from the community. A link person could perhaps work with a whole cluster of schools. This could be particularly useful in allowing different school communities to share their strengths with nearby schools. For example, parents running The Clinic science sessions could help other schools whose communities might not have such strong science experience.

The group of mothers interviewed was keen to emphasise that:

every school community would be different, with diverse needs and diverse abilities within it. We wouldn't want people to think that our model would necessarily work everywhere. That's our point really—that whatever arises should come from the community itself to meet the needs of that community at that time.

The principal spoke very positively about how this parent-driven initiative had been instrumental in her rethinking what community engagement involves. She admits to in the past seeing community engagement largely as a consultation exercise driven by *The New Zealand Curriculum*, but now she sees how the community could really drive the creation of a locally relevant school-based curriculum. She says this initiative has allowed her to think differently about how curriculum could be organised, and she is excited by the possibilities.

Case study 4: Dinosaurs and Disasters Geocamp

Overview of the initiative

This initiative took place in Hawke's Bay from 19 to 31 March 2012. It was developed, organised and run by three staff at GNS Science (Te P ū Ao), a New Zealand Crown Research Institute. One member was the GNS Science outreach educator, a trained secondary school teacher who had taught science for several years in the secondary school system. The other two were scientists working in the field of earth science. One had worked with the outreach educator on previous school–science community initiatives, while for the other member this was his first school–science community initiative.

The initiative was advertised as free to lower-decile full primary and intermediate schools for Year 7 and 8 students in Hawke's Bay. Schools had to apply to GNS Science to attend the programme, which ran from 9 am to 3 pm Monday to Friday for 2 weeks, as well as a full day on the final Saturday. In their application, schools agreed to send a teacher who would accompany the school's students every day. The programme operated out of a physical space (not charged) at the National Aquarium in Napier. It involved field trips with data collection to various geological locations in Hawke's Bay. Interactive sessions at the aquarium punctuated the field trips.⁵⁸ The students worked in small, collaborative groups and each group was given the task of producing one or more demonstrations, models or visualisations to communicate their new-found understanding to their families, schools and the public at a 2-day show-and-tell expo at the end of the fortnight.

The intentions of the initiative for the students can be summed up by two of the GNS Science staff:

⁵⁸ The GNS Science staff also offered an optional weekend trip to the site where Joan Wiffen discovered fossil evidence that dinosaurs once walked in New Zealand. This was attended by about half the participants.

We wanted the students to be awakened to the revelations of what you can discover when you use your senses and investigate the world around you ... we wanted to waken up something in the children—the ‘investigator’ within them, the ‘scientist’ in the broad sense. (GNS staff member A)

[W]e try to give an authentic science experience ... we are trying to change their perceptions of scientists and we are not trying to address a specific geo-science content ... really what we are trying to get these kids to learn is—what science is all about ... here is an experience that might be able to help you understand more about what scientists do and it is not sitting around reading textbooks but it is getting outside and experiencing things ... to produce a scientifically literate society ... (GNS staff member B)

The GNS Science team hoped that having the teachers involved in the programme would help them develop their own scientific understanding, by focusing on the process of science through the use of the five senses and the opportunities that science provides for students. The GNS Science team assumed that changes to the schools’ science curriculum might occur as a result of teachers’ involvement.

The participants in Geocamp 2012 involved the three GNS Science staff supported by three Royal Society Primary Science Teacher Fellows—one teacher fellow from the 2010 cohort who lived in Hawke’s Bay and two 2012 fellows who were being hosted by GNS Science. One intermediate and three full primary schools participated. Details of the teachers’ status, curriculum responsibility and student ratios are provided in Table 5.

Table 5. **Participating teachers’ and students’ details**

School (decile)	Status of teacher(s) attending Geocamp 2012	Responsible for science curriculum	Number of students (F:M)
Intermediate (2)	3 different teachers	No	4 (0:4)
Full primary 1 (3)	Principal’s release ⁵⁹	Yes	4 (4:0)
Full primary 2 (5)	Job share (3 days)	Yes	6 (2:4)
Full primary 3 (5)	Occasional reliever	No	5 (2:3)
			19 (8:11)

⁵⁹ This teacher moved to another school as principal’s release in Term 2 with no specific responsibility for science curriculum at the new school.

A Todd Foundation grant of \$40,000 supported the funding of the Geocamp initiative, along with well over \$60,000⁶⁰ from GNS Science. Schools were given a \$1,000 grant for teacher release and transportation cost from the school to Bay Aquarium and back each day.

Participants' views of the initiative

During August we interviewed the three GNS Science staff, two of the three Royal Society Primary Science Teacher Fellows, 14 of the 19 students and four of the seven teachers from the four schools.

Students' views

The Geocamp was clearly highly engaging for students. Students said, “Geocamp was the greatest time of my life”, “best-ever experience”, “best education trip” and “never to be repeated”. They also spoke highly of the ability of GNS Science staff to communicate their enthusiasm for science. They said the scientists were fun, committed, positive and friendly. The scientists taught in different ways from their teachers, and they made it clear there was “no such thing as a bad idea”. Students' perceptions of what a scientist is were changed by their interactions with the three GNS Science staff.

Students were asked, “Do you think differently about *science* after your experience with Geocamp?” The immediate response from students in three schools was to identify an aspect of the content knowledge about geoscience followed by statements that reflected a present interest in geoscience. The responses from full primary 2 were slightly different in that they contextualised their geoscience knowledge. Further probing with this interview question revealed that these students were now able to identify how scientists work (e.g., need more time to observe, collaborate but also work interdependently, and do a lot of interpreting).

The question “Do you think differently about *school science* after the Geocamp experience?” brought similar responses from students at three of the schools. The students did not seem to differentiate between science and school science, and they largely repeated their responses from the previous question. On the other hand, the full primary 3 students provided very specific suggestions for how teaching science at school could be different—such as more hands-on learning, “science that is meaningful to me”, “part of my everyday learning”. They recommended more time to get into it, making it exciting or having fun while learning, going outside to learn things in different places, freedom to choose science topics and making history a part of science.

⁶⁰ This estimate was provided based on the normal ‘charge out’ rate for the three staff and the cost of the transport, accommodation etc.

Teachers' views

The teachers indicated that they had learnt a lot about geoscience which they could use in the classroom. They also commented on how the hands-on activities had motivated and engaged the students. Three of the teachers said that Geocamp had taught them the importance of careful observations and the role of knowledge in generating useful questions. These three teachers saw that the GNS scientists were giving the students ownership of their learning by the way they questioned. This was a style of learning science the teachers had not previously experienced. Despite this, none of the teachers specifically identified Geocamp as modelling the process of science or the Nature of Science. Probing more deeply into thinking differently about school science, just two of the seven identified that the GNS scientists were demonstrating many elements of the Nature of Science that could be used in their own teaching of science.

GNS Science staff's views

For the GNS Science outreach educator the most powerful aspect of the Geocamp was the opportunity for students to have an extended immersion experience of hands-on science. He said students were provided with an initial motivating experience and then had the time and space to develop their own investigations, with the key outcome being that they produced creative demonstrations for the expo at the end. In his opinion, this open structure enabled powerful student-driven learning.

According to this outreach educator, schools reported that the Geocamp provided great opportunities for the children attending, and benefits for other pupils and teachers in the schools. One teacher who attended the Geocamp was so inspired that, although she is now working in another school, she has been able to develop an exciting geology project in her new school and is planning to involve other local schools.

What this case study tells us about science community engagement

The cost of initiatives such as this makes sustainability a challenge. The two GNS scientists made two suggestions for the sustainability of any such initiative. First, there could be a contestable fund (just for Crown Research Institutes) within the new Ministry of Business, Innovation and Employment to support these kinds of engagement initiatives. Secondly, Crown Research Institutes and tertiary institutes could undertake at least one initiative per year to move towards fruitful school–science community engagement throughout Aotearoa New Zealand if it will allow staff to continue their own research agendas with little impact on the Crown Research Institute.

Transitioning and sustaining the experiences and understanding from the initiative when the students are back at school is largely dependent on the teachers' position (e.g., in charge of the science curriculum) and employment status (e.g., permanent teaching positions). Because of the cost of releasing teachers, several schools sent teachers who seemed less likely to be able to influence ongoing change back in their schools (see Table 5). Informal

discussion with the teacher in charge of science at the intermediate school indicated that the school could not fund one teacher to be away for a full 2 weeks, even though \$1,000 was provided, hence the reason for the three different teachers⁶¹ from the school. This was the same reason given by the principal at full primary 3, who used a reliever to accompany the five students each day. The two other primary schools were able to meet the financial cost by creative manipulation of the principal release time; otherwise the cost would have been prohibitive for both. Full primary 2 decided to stay at a school member's house in Napier for the 2 weeks to reduce the cost and time involved in travelling to and from the camp each day. Despite these challenges, some schools were still able to build on this intensive experience. In turn, other students in their schools also benefited.

It is interesting to note here that three of the seven teachers indicated that the initiative was more important for the teachers than it was for the students (if you view Geocamp in terms of the impact on the number of students in Aotearoa New Zealand). They pointed out that only a small number of students were engaging with science during the 2 weeks, whereas teachers were in a position to have an impact on large numbers of students in their classes, year after year.

Another interesting feature of this case study was that the responses of the students and their teacher from full primary 3 were identifiably different from the other students and schools. If everyone was experiencing the same activities, engaging with the same field trips, interacting with the same GNS staff, what was the reason for the difference? The interview with the teacher of full primary 3 perhaps provided an answer to this question. She said that the time in residence⁶² with the six students was 24/7. She indicated that they had done things together during that time, playing games and recounting the things at night that had gone on that day. The 24/7 immersion seems to be an important part of successful science community engagement.

Case study 5: Health Science Academies

Overview of the initiative

Health Science Academies is an initiative designed specifically to provide pathways for M āori and Pasifika students at Years 11–13 into the health workforce in Counties Manukau and South Auckland. The aim of the initiative is to have 120 M āori and 120 Pasifika high school students ready for work and tertiary study for health positions in their communities by the end of 2015. The programme was established in 2009 in a partnership between the Tindall Foundation (which funds the programme) and Counties Manukau Health (CMH) to support

⁶¹ One was a non-teaching administrator, the second a classroom teacher and the third a relief teacher at the school.

⁶² This was the school that stayed in Napier during the 2-week Geocamp.

activities aimed at implementing the district health board's Grow Our Own Workforce initiative. Two schools, James Cook High School and Tangaroa College, began piloting this programme in 2011. Funding was provided for a 4-year period from 2010 to 2013.

A third Health Science Academy, initiated by the Pasifika Medical Association (PMA), also began in 2011 at Otahuhu College. This Health Science Academy targets only Pasifika students. It is funded by PMA through the Ministry of Health Pacific Provider Workforce Development Fund, with support from the ASB Community Trusts and the Todd Foundation. The structures of the programmes are similar in the three schools, and teachers meet frequently to share and develop best practice.

Health Science Academy programmes are designed around students gaining entry to tertiary-level sciences. They also have a focus on providing career information and encourage family support. This case study focuses on the Health Science Academy at James Cook High School.

Students are invited to apply for entry to the Health Science Academy in Year 10. Students make a written application to the Health Science Academy co-ordinator, and they and their parents are then invited to be interviewed. Although the Health Science Academy programme is highly academic at James Cook High School, selection is not based solely on academic ability. The school says they stipulated that the classes be mixed ability and that entry be open to every student interested in science regardless of their ethnicity. Counties Manukau Health report that

the academies are funded on the basis that they are targeted at Māori and Pacific students. However where schools cannot recruit sufficient numbers of suitable Māori and Pacific applicants a small number of non-Māori or non-Pacific students can be included instead.

On the whole, because of the ethnicity of students at the school the majority of the Health Science Academy students are Pasifika and Māori (other ethnicities include Indian, European and Afghani). Both the school and Counties Manukau Health agree that the ratio of Māori and Pasifika students and the small number of students of different ethnicities is a more realistic "mini reflection of their community". Table 6 shows how the Health Science Academy programme operates in Years 11–13 at James Cook High School.

Table 6 The Health Science Academy programme at James Cook High School

Year	Subjects	Notes
11	Academy science English Mathematics Science 2 option subjects	Students are taught together as one class for the first four subjects. Students to achieve UE numeracy in mathematics. Option subjects can be non-health related.
12	Academy biology Academy chemistry Academy physics English Mathematics 1 option subject	Students are taught together for the 3 Academy science disciplines. Students to achieve UE literacy in English. Option subject can be non-health related.
13	Academy biology Academy chemistry Academy physics English Statistics or calculus (if required) 1–2 option subjects	Students are taught together for the 3 Academy science disciplines. Option subject/s can be non-health related.

Source: www.jchs.school.nz

In the Year 11 class of the Health Science Academy at James Cook High School, one of the two science classes is biology and the other is physics and chemistry (half a year each). This gives students in the Health Science Academy 10 science lessons in a 6-day timetable. In contrast, students in the mainstream Year 11 programme have one science class which covers all three science subjects (i.e., biology, physics and chemistry) so that these students have just five lessons of science in a 6-day timetable.

Academy biology, chemistry and physics courses at Year 12 and for Year 13 in 2013 are also available for mainstream students. Where the Health Science Academies' science curricula differ from the mainstream science programme is in the design of the lessons: science is taught in the Health Science Academy with a sharp focus on health contexts.

A second feature of the Health Science Academies is the focus on career information. At James Cook High School additional health career information is provided by Counties Manukau Health. The students have opportunities to visit hospitals and universities, health professionals give talks at assemblies, and in their school holidays students shadow health practitioners. The student visits to hospitals and universities are not only an opportunity for students to find out more about health careers, but are often used to help set science lessons in a health context; for example, physics is looked at in a medical technology context (scanning equipment) and biology in a diabetes context.

A further important feature for selection to the Health Science Academy is family support. Teachers believe that having the family involved enables the students to carry out the extra

study demands, such as attending after-school tutorials (available for all students), which run until 5 pm, and completing homework.

Participants' views of the initiatives

During September 2012 we interviewed the principal of the Health Science Academies along with the science, mathematics and English teachers.⁶³ We also interviewed 32 students in the Year 11 and Year 12 Health Science Academy at James Cook High School.

There was an overwhelming belief among all the participants in the benefit of the Health Science Academies. All the participants said that success was evident in the students' increased academic achievement. James Cook High School reported a large increase in Pasifika student participation in NCEA (the National Certificate in Educational Achievement) Level 1 external science examinations in 2011, as well as a much higher pass rate, especially at merit and excellence level. As one teacher noted in an email, these students would normally have been unlikely to enrol in these external standards because of class streaming. She attributes the Health Science Academy with opening up opportunities for these students to participate in the sciences, and says the differentiated contextual learning has allowed them to achieve at merit and excellence grades.

Across all three schools the aim of the programme was for 80 percent of the students to achieve NCEA Level 1. This was exceeded, with 87 percent achieving NCEA Level 1, with high levels of merit and excellence. All teachers also saw that the benefits of the Health Science Academy had a flow-on effect for other students in the school.

- With a fuller science programme in the Health Science Academy at Year 11, the Academy science teachers report that overall they teach more achievement standards in their particular science discipline(s)⁶⁴ than they do in their mainstream Year 11 classes. This has allowed them as a whole team to evaluate a wide range of achievement standards and to be more constructive about those that would be suitable for mainstream classes.
- By providing the Health Science Academy students with new edition textbooks, the teachers are able to evaluate these new versions for use in mainstream classes. Funding text books for Health Science Academy students also allows more textbooks to be available for mainstream students in science, mathematics and English classes.
- With students from the Health Science Academy as well as mainstream students being scaffolded into the senior sciences, teachers report that the senior science classes are larger than in previous years and students are more highly motivated.

⁶³ The science teachers interviewed were also the head of science and the co-ordinator of the Health Academy.

⁶⁴ Teachers at Year 11 usually teach one or two achievement standards in the three disciplines of physics, chemistry and biology. Teachers in the Health Science Academy may teach five or more achievement standards in a full year of biology, and up to three achievement standards each in a half year of physics and chemistry.

Also noticeable is that senior students outside the academies are opting into science subjects at a higher rate than previously.

- There is increased opportunity to work on a cross-curricular basis (e.g., linking speech requirements in English to the students' science topic).
- Using Health Science Academy lessons based around health contexts with students in mainstream classes increases student engagement.
- To help the students at James Cook High School meet Health Science Academy selection criteria, teachers felt they needed to do more work in literacy with their students, so they have included a literacy plan in their Year 9 scheme.
- Teachers note that attendance at after-school tutorials has increased because Health Science Academy students are bringing their mainstream friends.

The principal and the teachers interviewed believed the Health Science Academies would not be successful without the input and resources funded by their community partners. The teachers and principal believed that because students now see themselves working towards specific career pathways, they are more motivated to learn: studying science now had “a purpose”. Teachers based lessons on contexts that were relevant to jobs in the health sector.

The students said they felt privileged to be in the Health Science Academies. They talked about receiving free books and laptops, going on trips, and having a travelling uniform. They were also aware that they have more access to their teachers than other students: they meet their teachers in tutorials, they can access them by text and on a blog site, and they spend time with them during trips. Teachers collect them from their homes when they go on trips, and they sometimes visit teachers at their home.

Teachers also report they have more contact with Health Science Academy parents because parent evenings are held each term (where students report back on their work), and parent–teacher interviews are held separately to the rest of the school so that teachers have more time to speak with the parents. Teachers also report that because parent–teacher interviews for Health Science Academy parents involve just the teachers for those classes, they are less stressful for parents as opposed to whole-school parent–teacher interviews, which are typically held in a hall with over a hundred people present.

Students and teachers agreed that having the same teachers each year and the same class for science subjects made the class and teachers feel like a “whānau”. One student said:

[we] are all striving for the same thing. It feels different. It makes you more focused.

Teachers also noticed more self-efficacy among Health Science Academy students. Students now believed they would achieve at tertiary level:

[We] will not struggle at university.

Being part of a small group has also strengthened their confidence when asking for help:

[Tutorials] let you catch up. You can ask and it is not public. (Student)

You are not ashamed if you don't know. (Student)

Students reported that having a better understanding of science and science career pathways has changed their view of the subject. Before joining the Health Science Academy, students said they “Didn't know what science was”, “It [science] was hard and complicated” and “We didn't really try our best”. Now they talk about how “[Science is] important in life”, “It [science] can be used to help others”, “Many jobs require science”, “Science can be fun” and “It [science] can be made easy to understand”.

One negative aspect teachers noted was the huge pressure and expectations the Health Science Academy students faced. However, the students said increased pressure just increased their motivation to succeed. Students talked about how they wanted to “make their parents proud” and “not let their teachers down”. Teachers reported that a second negative aspect of Health Academies is the huge time commitment they need to give these students outside school hours. Teachers also reported that the status and privileges of the Health Academy students have been noticed by other students and teachers, but so far there has not been any noticeable negative effects.

What this case study tells us about science community engagement

In this case study a need in the community provided opportunities for schools to think differently about science and science education. Counties Manukau Health aims to increase the number of Māori and Pasifika in the professional health workforce. They report that research shows “that if your workforce reflects the people you serve, you get better health outcomes” (Rotherham, 2012). The schools' response has been to change the way they teach science so that their Māori and Pasifika students achieve at the academic levels required to enter tertiary education in their chosen health-career pathways.

In the partnership Counties Manukau Health has taken an active part in motivating students in the Health Science Academies by showing them the many career opportunities in the health sector and the pathways needed to achieve their career choice. Science has been put into context. For science teachers, increased contact time with their Health Science Academy students in the classroom, in tutorials and on trips has changed their relationship with these students. Teachers report they view these students more as whānau. Science teachers are also becoming more adept at contextualising science around health topics.

Community partnerships work when there is a common goal. The principal of James Cook High School believes the programme works because the South Auckland schools in the programme do not compete for students. Not only do they share a common goal (e.g., increasing the number of Māori and Pasifika high-school graduates entering tertiary health science degree programmes, and subsequently employment as health professionals), but

their similar communities and issues allow them to trust one another. A high level of trust has helped the teachers in these schools to successfully co-construct the Health Science Academy programme, and to understand and agree on its ongoing development. Both the principal and the teachers report that the partnership meetings include open discussions:

Everyone feels confident about discussing what is working and what is not and solutions are co-constructed.

There is a limit to the number of Health Academy classes a school can accommodate. The principal and head of sciences agree that for the number of interested students and the staffing requirements there can be no more than one Health Academy class at each senior year level. However, they do see opportunities to use the framework of the programme for other subject areas and they can see it scaled up into other schools. Despite concerns about future funding, James Cook High School believes the programme is so successful it will be continued.

How the programme will be evaluated is still unclear. There is confusion among the partners about how the students who leave school will be monitored and tracked through their tertiary education, or into jobs, or both. Neither Counties Manukau Health nor the Health Science Academy schools report any development in this aspect. As a new initiative there are obviously still some areas of work to be addressed if the programme is to become sustainable and the success of the programme measured effectively.

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