# REPORT INFORMATION SHEET

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<th>Report Title</th>
<th>Science-for-Life: Programme Description Document</th>
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Universal Declaration of Human Rights

Article 27: Everyone has the right to freely participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits.

“Science ... provides the most important explanations we have of the material world. In addition, some understanding of the practises and processes of science is essential to engage with many of the issues confronting contemporary society”

(Osborne & Dillon, 2008)
Executive Summary

Science-for-Life is an intervention programme for schools and teachers to develop partnerships between schools and Crown Research Institutes (CRIs) to enhance science education and literacy.

The programme provides guidance for CRIs, research organisations and scientists on effective ways of interacting with schools to help meet their science education needs. It also identifies a range of methods that can be used to support science learning in schools.

Underlying the programme is an effective pedagogy on science learning, based on the constructivist model of how students learn. Constructivist learning theory posits that knowledge is constructed through the active engagement of the learner with others, experiences, and the environment, rather than simply acquired through a process of transmission from knowledgeable ‘expert’ to ‘apprentice’. Increased knowledge results from learners using these experiences and linking them with previously acquired understandings in the development of new knowledge or modification of existing knowledge. A commonly-used teaching and learning framework based on constructivist theory is known as Inquiry learning (Inquiry), which utilises student questions as the basis of authentic science inquiries, typically involving high levels of ‘hands on’ investigation, hypothesising, experimentation, recording and reporting to a range of audiences.

In partnership with teachers, different types of interactions with schools and with teachers were trialled. The beneficial interaction models developed require different levels of partnerships with schools and teachers to ensure they benefit the school and students. Critical elements of the intervention models are:

- The development of individualised partnerships between scientists and classrooms;
- Developing both teacher and student knowledge and capability;
- Balancing of technological support with face-to-face support;
- Development a diverse set of partnerships;
- Making CRI resources available to schools.

The three major interactions developed are:

- **Within School Personalised Partnerships**
  Personalised partnerships developed between teachers, CRI facilitator(s) and scientists, in order to tailor any interaction to the students learning requirements.

- **Structured partnerships**
  Structured partnerships based on a partnership developing between teachers, CRI facilitator(s) and scientists, were based on material prepared by the science organisation. The teacher would use this material as a basis for their unit plans.

- **CRI to Teacher Interactions**
  The provision of informal or formal professional development to teachers in aspects of science, using science technology, and understanding authentic science from the science organisation, for use in the classroom.
This report identifies the costs and benefits to schools of different intervention models based on a number of case studies.

**Key learnings from the pilot**

CRI interactions in schools should consider:

- How to raise overall achievement and engagement in science by students. Intervention strategies should be developed and structured which address the reasons for the lack of engagement, static level of academic achievement, and long ‘achievement tail’ in science, as identified in the PISA, TIMSS and Science-for-Life research reports;
- Supporting high achievers, who will use and engage with science into the future in further study or business;
- Including professional development for teachers and providing opportunities for teachers to develop scientific understanding to increase their competency and self-efficacy in science.

The case studies and interventions to date provide evidence that the schools and students benefited from personal interactions with scientists. The benefits tend to be higher when scientists are in person, rather than remotely. Targeted video conferencing to senior high schools and the use of blogs and wikis also was highly beneficial for students.

Teachers benefited since scientists encouraged the ‘deepening’ of the science being investigated at secondary level, and up skilled teachers in the case of primary schools by providing professional expertise, knowledge and support, which boosted confidence to try new science in the classroom.

There is no single programme or approach that can meet all the challenges facing science education. School interventions framed around constructivist pedagogies are shown to be an effective mechanism for delivering significant benefits to students and teachers alike.

Overall other CRIs reported that they did not have required funding to be involved in schools in a sustained and effective manner.

The following key learnings have been generated to date during this pilot:

**Key learning 1:**

Interventions should be tailored to meet the specific context of partner schools, there is no single approach. However, interventions using an Inquiry or constructivist framework have been found to be an effective mechanism in delivering positive outcomes in science education;

**Key learning 2:**

Explicit acknowledgment is required of CRI’s unique contribution to science education. Access to authentic scientific research, expertise and experience is critical to improving science literacy in students;
Key learning 3:
CRI recognises that benefits may come simply from students engaging with scientists, and not solely with educationalists or communication groups within their organisation;

Key learning 4:
CRI implements intervention programmes that fit with their capabilities and capacity, but that are focused and founded on the constructivist learning models that actively engage students;

Key learning 5:
CRI works in partnership with schools and educators to jointly improve science learning, recognising the responsibilities teachers have with the curriculum and school teaching plans;

Key learning 6:
CRI are mandated to engage in science education to whatever level is appropriate to their circumstance and that appropriate funding mechanisms are developed to support this activity.

Scion’s developmental work to date is preliminary, and further research is required on programme-type interventions including setting up and hosting individual or small groups of students within CRI; the development of educational services including teacher professional development, and utilising the NEN and the ultra-fast broadband roll out for virtual interactions and support, when this comes on stream.
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1 Science-for-Life

1.1 Introduction

Science-for-Life is a Ministry of Research, Science and Technology (MoRST) funded research programme. Its purpose is to develop school partnerships to enhance science education and science literacy. The desired outcome is to create an environment where teachers, students and scientists may collaborate on developing approaches to more effective learning in science. Science-for-Life drew on the previous work undertaken by Scion with the Forests-of-Life programme. An extended summary is given in Appendix A.

The overall goals of the Science-for-Life project are:

- To create positive experiences for students in science;
- To engage students in authentic and contextual research projects;
- To energise science teaching and develop best practice models.

This project is underpinned by research to:

- Report on the efficacy of a range of CRI/school collaborative interventions or models for supporting science teaching and learning;
- Explore how CRI/school collaborations can be successfully integrated with elements of Inquiry learning in some science units taught in participating schools.

The following research questions were used to guide data collection:

- What is the present ‘state of play’ with regards to the teaching of science in participating schools?
- What was the motivation for schools’ engagement with the project, and what was the nature of the CRI collaboration which was developed for each school?
- What processes were involved in negotiating the collaboration, and how did the collaboration contribute overall to the attainment of teaching and learning goals?
- Did the collaboration act as a catalyst for changes to teaching and learning practices in science, and if so, what were these changes?
- Did the interventions contribute to improved learning or understanding in students?
- How critical were scientists to the learning and teaching practices?
- What influenced the effectiveness of the collaboration, and how might this be mitigated in any future initiatives?

The intended focus of the programme was high schools, but was expanded to include all schools as published research indicated that science engagement needs to be in place well before high school level.

Science-for-Life interacts with schools, teachers and students in school time. The programmes or intervention models developed use Inquiry-based learning as an effective pedagogy for teaching and
learning science. Inquiry models reflect the real life experience of many scientists – capturing the essence of self-driven research questioning and implementation.

1.2  The importance of science education

1.2.1  Science literacy for supporting economic, social and environmental goals

Science literacy may be defined as:

*Developing the ability to creatively utilise sound science knowledge ... to solve problems, make decisions and hence improve the quality of life (Holbrook and Rannikmae, 1997, p. 15).*

In further defining science literacy, clear distinction needs to be drawn between *doing* science - which is viewed as the realm of scientists and *using and knowing* science, which is, everyone’s concern (Hazen, 2009).

In summary, science literacy:

- Develops knowledge of the nature of science and technology, the relationship between science and technology, and how both of these impact society and the environment;
- Develops the basic level of skill required for carrying out science investigations including problem solving, working collaboratively, and communicating outcomes;
- Constructs knowledge of concepts related to the main disciplines of science (earth, life, physical, chemistry) and applying these to extend their understandings;
- Develops responsible attitudes to the acquisition and application of science knowledge to personal and societal benefit.  
  (Myers, 2009)

There are clear links between economic goals and levels of general science literacy (American Association for the Advancement of Science, 1989; 1993; Bybee, 1997; Hurd, 1958; McCurdy, 1958; Organisation for Economic Cooperation and Development, 2003; 2007; Rychen & Salganik, 2003; United Nations Education, Scientific and Cultural Organisation, 1993). These studies argue that general science literacy is linked to notions of empowerment, facilitated through the acquisition of knowledge, skills and attitudes. This enables citizens to make informed decisions and responses to a variety of situations which have a science or technological dimension.

Hodson (2005) describes the benefits of greater science literacy as citizens who...

*...better cope with the demands of everyday life in an increasingly technologically-dominated society, better positioned to evaluate and respond appropriately to scientific and pseudoscientific arguments used by advertisers, commercial organisations and politicians, and better equipped to make important decisions that affect their health, security, and economic well-being (p. 3).*
1.3 Challenges facing science education in New Zealand

1.3.1 Achievement in science

The latest available data from the 2007 Trends in International Mathematics and Science Study (TIMSS) study of student achievement in science at year 5&6 level positioned New Zealand at an average of just over 21st out of 36 nations in its levels of school science achievement. This ranking comprised scores in both science discipline knowledge (Life science – 22nd; Physical science – 23rd; and Earth science – 21st) and science skills (Knowing – 23rd; Applying – 22nd; and Reasoning – 22nd). These scores are well below Australia (average 13th) and England (average 8th).

The most recently available data for Science achievement from the Programme for International Student Assessment (OCED, 2006) at 15 year old level, indicated a considerable improvement in science proficiency by the time students reached year 11 at secondary school. Data indicated that 80% of the students surveyed had reached what was considered to be a minimal level of science knowledge and skill proficiency (level 2) at the end of year 11, while a comparatively high 4% of students were working at the highest level of proficiency (level 6). However, when the PISA index for levels of interest in learning science is examined, the mean score for all New Zealand students at this age is 461 as compared with the OECD average of 500. Additionally, when data from the index of self-efficacy in science is analysed, the average for the OECD is +.03, while for New Zealand it is -.02. This data indicates that while at middle and upper secondary level students are achieving reasonably well in science (and our very top students are achieving particularly well), there is limited genuine interest in science as a subject, and a weak sense of self-efficacy in their belief of being able to ‘do’ science well.

This data is further supported by outcomes from the two scoping studies carried out by Spence, Barnard, Crawford and Dunningham (2009a, 2009b) as part of the initial planning stage for Science-for-Life. Qualitative data from these studies indicates that by the time significant numbers of students reach tertiary level their reasons for opting for science relates not to satisfaction from engaging in and learning science, but because science subjects are prerequisites for career opportunities or courses in other areas. Although naturally this does not apply to all students undertaking science at tertiary levels, these reports indicated for many this was a driving consideration.

What is of concern in relation to levels of interest in science and self-efficacy is the potential impact this could have on the general level of science literacy of the adult population, as it indicates a level of ‘disengagement’ with science outside of exposure in the compulsory education system.

Therefore, results of the analysis of New Zealand’s TIMMS and PISA data may be summarised as follows:

- New Zealand students generally have a low interest in science careers or advanced science study, perceiving learning science as a means to achieving non or only peripherally-related future goals;
- Students have a below (OECD) average perception of self-efficacy in science i.e. their belief in their ability to ‘do’ science;
- A significantly lower than (OECD) average number of students have an interest in learning science;
- Over the duration of both surveys, trends indicate at best a stable position in science achievement in relative terms;
• Data indicates a significant issue facing science learning to be the long ‘tail’ of underachievement;
• Underachievement in science may be linked with socio-economic inequities.

1.3.2 Issues impacting upon student engagement and achievement in science

As a precursor to any active engagement in the classroom, Scion sought to understand the context and scope of the issues facing schools in science education. This was largely undertaken through a series of national workshops (Spence et al., 2009) and a meeting of a panel of experts in 2009. Some of these findings are discussed below:

1.3.2.1 Teachers’ views of the nature of science knowledge

There is a link between the way in which teachers viewed science knowledge and how this was developed (their epistemological stance), and how they taught their subject (pedagogy). There was a tendency to view science knowledge as being able to be delivered as opposed to constructed. This influenced teachers’ approaches and strategy selection towards a more transmissive pedagogy. Teaching style was also influenced by the demands of the assessment system and the need to reproduce science knowledge rather than show capability in constructing it through, for example, investigative techniques. Such interpretations almost exclusively applied at senior secondary level, where external assessments as part of NCEA had a significant impact.

1.3.2.2 Teachers’ attitude towards teaching and their science discipline

Significant findings from the two workshop reports (Spence et al., 2009) was the influence teachers had in students’ decisions to engage in science studies, and eventually pursue science careers. A recurring theme was the enthusiasm teachers conveyed for their subject and their ability to relate this to their students. This aspect referred not so much to the level of expertise held by the teacher within their discipline (although this was a factor), but more to their sense of passion for science and genuine enthusiasm and interest in their students’ progress in it. This factor was also associated with the teacher’s pedagogical content knowledge, and how this supported them in finding ways of making the learning of complex science concepts easier and more accessible for their students.

1.3.2.3 A tendency towards efficiency over effectiveness

Much of the literature reviewed, and in particular the New Zealand science teacher studies (Spence et al., 2009), pointed to a tension existing between what teachers believed to be the best way to teach science, and what they saw as being the most efficient – given their priority towards helping their students prepare for assessments. While the teachers surveyed by Spence et al. (2009) understood the benefits of more investigation-based and student-centred pedagogies such as problem-based learning and Inquiry models, they felt they were unable to employ these at senior levels because they were viewed as inefficient and time consuming in delivering the sort of understandings needed to pass external assessments. The use of student-centred pedagogies was more apparent at lower levels of the school - in
particularly at primary and lower secondary, where there was a perception that the 'stakes were lower' and there was more flexibility in managing time in a way that supported such approaches.

Teachers commented that adopting more investigation-based approaches at senior level required a lot of 'prerequisite' teaching to build students' capabilities to design and carry out independent investigations, and that time taken to do this would be time taken from content provision. Such arguments tended to reinforce teachers' perceptions of the inefficiency of more student-centred pedagogies.

1.3.2.4 Constructivism for effective science teaching

The literature clearly laid out arguments supporting the use of pedagogies aligned with constructivist learning theories as being superior in developing enduring understandings of key science knowledge, science investigative processes and nature of science objectives. This was despite the greater managerial difficulty in implementing these within a typical secondary curriculum. Approaches such as modularisation or 'blocking' of programmes made the use of constructivist-referred pedagogies such as project-based learning possible, and contributed to enhanced student engagement and learning outcomes.

Issues related to the difficulties of achieving widespread adoption of such structures were raised, but addressing these were considered fundamental to improving student engagement and learning by doing science, as opposed to current methods which emphasised learning about science.

1.3.2.5 The relevance of context to effective science teaching

The final major theme summarised in the literature related to the importance of utilising relevant and meaningful contexts when teaching science. Contexts and topics which allow students to link in a concrete manner the often abstract concepts being explored in the classroom with 'real life' happenings of significance in their lives, were viewed as being particularly powerful for both motivating engagement and helping students better understand science knowledge. Associated with this, using local examples, or information and communication technology (ICT) to bring examples to the classroom 'virtually', was seen as preferable and more effective than the prevailing textbook approaches. Current science is seen by students as isolated, 'stepping stones', or random facts that are not integrated with societal concerns that illustrate the application of science.

Assessment systems encourage the learning of facts rather than deeper level understanding, especially when student assessment performance is used as a surrogate measure of school and teacher performance. Teaching can focus more on preparing students for examination, and assessments are structured to examine learning that can be easily and consistently assessed. This can result in a narrow focus and repetition, rather than depth and variety. New Zealand's new curriculum, with a focus on values and competencies, as well as the introduction of merit and excellence levels of achievement in NCEA; require students to be able to relate knowledge from one context to another.

1.3.2.6 Students values and identity

There is strong evidence that children's new freedom (over authority figures) in constructing their own identity rather than accepting either class-driven roles or roles from economic or social pressure...
encourages different decision-making in subject choice and potential careers. Students are ‘turned off’
science, as science is not perceived to match their values - it is perceived as a source of threat rather than
a source of solutions (Beck, 1992). This has lead to values-based decision making, as Osborne and Dillon
(2008) state,

Subject choice has changed from what do you want to be when you grow up to who do you want
to be when you grow up? Education in this context is one of self actualisation and creating
personal meaning ... personal interest become the dominate factor in subject choice, not the
possibility of a future career (p.17).

In this context, students see science as an advancement of technology, not something that aids people,
and hence not a means of self-realisation - a misconception that scientists and contextualised learning can
overcome.

1.4 Defining the possibilities for engagement between CRIs and Schools

The primary purpose of Science-for-Life was to identify ways in which CRIs in New Zealand may partner
schools to enhance teaching and learning in science, improve attitudes towards science, and increase
levels of science literacy. The field reports (Spence et al., 2009), the extensive review of literature
(Falloon, 2008), and the analysis of international achievement data, clearly indicated a set of parameters
and assumptions within which the programme was required to operate.

Science-for-Life should address in part:

- Improving the level of science achievement of a significant minority of students at middle and
  upper secondary level – ie: help to shorten the student underachievement ‘tail’ at this level;
- The low levels of self-efficacy held by students in their ability to ‘do’ science;
- The poor levels of conceptual understanding held by primary teachers in most areas of science;
- The low levels of self-efficacy of primary teachers in their ability to teach science with accuracy
  and relevance;
- The professional knowledge deficits of some secondary teachers in contemporary science
  knowledge, processes and techniques;
- The perception of a lack of local contexts for undertaking ‘authentic’ science investigations with
  relevance to New Zealand;
- Resource issues limiting teachers’ ability to undertake science inquiries;
- Pedagogical issues related to the use of Inquiry-science in secondary schools;
- Retention issues with secondary students in science studies, particularly at years 12 and 13;
- Extension of senior secondary students who excel in science;
- Through activities in schools explore of the purpose of science, its enduring and meaningful
  contributions to society and its alignment with student-held values, where science can been seen
  as helping and beneficial to humanity and a way to self-fulfilment.

It is unreasonable to expect any one programme to make a significant impact upon all of these. Science-
for-Life should be viewed as one strategy amongst others in helping to address these issues.
A set of operational parameters were generated for Science-for-Life which influenced the type of partnership interventions which were undertaken. These included:

- A range of partnerships delivered in different ways and tailored as much as possible to meet particular needs at different levels of the school system should be developed and evaluated, as the development of a single programme type which could meet the needs of all target groups would be impractical;
- Partnerships that could support Inquiries predominantly in primary schools, intermediates, and at junior secondary level, while working within prevailing pedagogies and existing constraints at senior secondary level;
- Developing teacher competence and confidence in science, as a means of raising their level of up-to-date science knowledge and capacity and confidence to build this with students;
- Having passionate, knowledgeable and articulate scientists working directly with students and teachers on science studies, but in a manner which portrays science as relevant, interesting and accessible;
- Exploring options for using Information and Communications Technologies (ICT) extensively in the partnerships, both as a resource for enhancing classroom inquiries, and as a means of engaging in partnerships with schools at a distance;
- To pursue partnerships in secondary schools with alternative curriculum and organisational structures;
- Documenting the impact and costs for Scion associated with undertaking each of the partnership types.

From an analysis of interactions with schools the expected outputs were:

- That a range of partnership and interaction types will be described and their impact upon teachers and students assessed;
- Indicative costs will be developed;
- Operational and logistical considerations required to implement the partnerships/interactions will be identified;
- Implications for wider-scale implementation of partnership models such as this for CRIs will be drawn.

1.5 Current levels of CRI engagement in science education

A telephone survey of CRIs was carried out to outline the current levels of CRI engagement in schools. While CRIs have been involved in a range of formal activities with the education sector through initiatives such as the Royal Society Teacher Fellowships and through contracted programmes such as Forests of Life, in general interactions and activities have been spontaneous, time bound and largely uncoordinated.

Outcomes from the informal telephone survey of CRIs revealed:

- Positive responses from CRI’s in their engagements with Crest, hosting teacher fellows, assistance with science fairs and more recently with the science learning hub.
• There have been some highly effective and engaging CRI school programmes developed and web resources created.
• A lack of mandate for CRIs and scientists to undertake support of science education in schools;
• A lack of funding to undertake effective support for science education to enable it to be done well;
• The opportunity costs of scientists being involved in supporting science education would be significant;
• A lack of understanding beyond public relations or public good of the rationales and benefits of having scientists involved in schools;
• A lack of understanding of where any CRI activity supporting science in schools would ‘fit in’ with the core business of the CRI as a science research organisation;
• Significant concern relating to the logistics of operating a partnership programme such as Science-for-Life within the CRI.
2 Case studies and school interventions

2.1 Context

Science-for-Life undertook a series of school interactions at different levels of involvement, and using different methods for communicating with students. Qualitative research was undertaken to support all interactions with teachers and schools. The depth of the research was tailored to the depth on the intervention and the responsiveness of the teachers. The goals of interactions with students, schools and teachers were:

- To develop and operate in partnerships with each other;
- To provide benefit to schools, and in particular student science learning and achievement;
- To use pedagogy that is appropriate to the school and is effective in achieving learning and science literacy outcomes;
- To have interactions that are grounded in curriculum and NCEA;
- To use science and science expertise from within our organisation.

The mission statement developed was:

*To advance, in collaboration with schools, students and other educators, scientific literacy, and promote a diverse workforce in a range of science and applied sciences, encouraging academic excellence, science interest, innovation, enterprise and stewardship, and increase informed decision-making for the New Zealand public (adapted from NOAA).*

Science-for-Life does not promote a single engagement model but does seek to operate within the constructivist framework outlined earlier. The interaction is defined by the in-school environment for example, school academic requirements, school administrative frameworks and teacher workloads.

Science-for-Life defined a series of engagement methods with primary, intermediate and secondary schools, which have different pedagogical bases, different levels of interaction and costs, and resulted in different levels of perceived benefit to teachers and students. The methods involved scientists developing a working relationship with teachers and then students, to deliver specific learning collaborations and/or interventions. A collective case study framework was used in collecting data for the Science-for-Life research. The research methodology used is in the Appendix.

2.2 Description of interventions and outcomes

This section describes the nature of the interventions undertaken, the outcomes and presents the costs, benefits and raises issues around the pedagogical alignment of the interventions detailed in Table 1. A series of conceptual models described later, plots each of the ‘modes of interaction’ on conceptual models, providing a visual representation of the impact of each mode on participant perception of the partnership’s value.
<table>
<thead>
<tr>
<th>Science area</th>
<th>School/level/ duration</th>
<th>Goals/focus</th>
<th>Description of interaction/s</th>
<th>Mode of interaction (nature of contact)</th>
<th>Significant outcomes</th>
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<tr>
<td>Biotechnology – Achievement standard 90718: Application of Biotechnological Techniques.</td>
<td>College NCEA level 3 – scholarship (3 credits) Approx 5 weeks</td>
<td>Transgenesis Gene cloning Biotechnological techniques and their practical application</td>
<td>Two Scion scientists (a Plant Tissue Specialist and a Molecular Biologist) researched, prepared and presented two multimedia sessions with a group of approximately 20 scholarship students exploring applications of techniques in cryogenics, organism tanginess, and biolistics. Via videoconferencing using the KAREN network. Before each student session a practise session was held with the teacher in which draft content was presented and feedback given before actual presentation to the students. These sessions were attended by both scientists so they could learn from each others’ experience. Content was modified in response to feedback.</td>
<td>Via videoconferencing using the KAREN network. Before each student session a practise session was held with the teacher in which draft content was presented and feedback given before actual presentation to the students. These sessions were attended by both scientists so they could learn from each others’ experience. Content was modified in response to feedback.</td>
<td>• Enhanced teacher knowledge. Most previous teacher knowledge in these areas was theoretical and sourced from Internet or books • Practical techniques learned during presentation were applied to a classroom investigation of plant tissue culturing • Protocols for somatic embryo development applied to classroom study • Authenticity benefit from linking with local contexts and talking to ‘real’ scientists • Positive role models of women in science • Contact and relationships with scientists and opened communication for future interactions</td>
</tr>
<tr>
<td>Biology – Achievement standard 90769: The Impact of anthropogenic climate change on an ecosystem</td>
<td>College NCEA level 2 (3 credits) Approx 5 weeks</td>
<td>Climate change understanding. Research topic with limited class time. Assessment as a report.</td>
<td>Scientist provides feedback to questions posed by students on a forum host within the school intranet. Scientists are given access to the class website. Asynchronous interaction - providing resources so that students can find answers to specific questions.</td>
<td>Scientist provides feedback to questions posed by students on a forum host within the school intranet. Scientists are given access to the class website. Asynchronous interaction - providing resources so that students can find answers to specific questions.</td>
<td></td>
</tr>
<tr>
<td>Year 10 Science Sustainable Earth</td>
<td>College Approx 5 weeks</td>
<td>Properties and Changes in Matter. Interdependence of Living Things. Investigating the hydrosphere, atmosphere and biosphere.</td>
<td>In progress</td>
<td>Videoconferencing</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
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</tbody>
</table>
| Teacher professional development | College (3 teachers); Newstead Model Country School (1 teacher); Lynmore Primary School (1 teacher) 1 day workshops | For teachers to gain an understanding of the work of Scion and identify possible opportunities for collaboration. Start the joint planning process for partnerships. | Teachers are funded to travel to Scion and spend time talking to scientists and learning of the work of the CRI. Opportunities for collaboration are identified compatible with teacher planning and Scion resources. | Face-to-face on site contact, CRI tour and meetings in Rotorua. ‘Round table’ planning session held to develop initial framework for partnership. | • Coordination of teachers’ learning plans with what Scion has to offer  
• Built teacher understanding of the broader work of Scion  
• Relationship formation between teachers and coordinator  
• Establish greater understanding of the goals of Science-for-Life |
| **Primary Science** | Newstead Model Country School Year 5&6. Curriculum level 3. Approx 10 weeks | Living World: Ecology and Life Processes Planet Earth: Interacting systems Earth Systems Environmental and Sustainability education | A range of interactions spanning over a term:  
- Scaffolded teacher support from scientists (science knowledge and techniques);  
- Scientists at school working directly with students on field study (several visits);  
- Scientists responding to students’ questions via audio conference;  
- Scientists interacting with student questions via online wiki;  
- Scion provision of equipment (laptops, digital microscopes etc) to support school study;  
- Phone support from scientists advising on possible investigations etc. | A combination of virtual and face-to-face interactions (see interaction descriptors) | • Significant gains in teacher confidence to teach science with accuracy and interest  
• Substantial change in teaching approach towards Inquiry-oriented pedagogy  
• High levels of student, parent and community interest in the class’s science Inquiry  
• Substantial student science knowledge development  
• Feed in to the Regional Council’s care and maintenance plan for the school gully – environmental action  
• Greater integration of ICT in classroom curriculum |
**Primary Science**

**Primary School Rotorua Year 5 & 6 Curriculum level 3. Approx 4 weeks.**

Environmental and sustainability education. Interdependence of living organisms within an ecosystem. Context – Stream and bush health investigation of as plot adjacent to the school. Development of science investigative skills based on an Inquiry Learning model.

A range of face-to-face and one Skype interaction spanning the 4 weeks:

- A Skype interview with two Scion scientists about what they do and also to gain some ideas for possible stream investigations that could be carried out
- Scion involvement in preliminary planning with teachers. Specialist knowledge of possible stream investigations, and starter questions for inquiries
- Scion supported field testing with students in groups exploring stream pH, conductivity, clarity and temperature etc
- Provision of a range of ‘everyday’ test equipment and instruction of how to use it
- Scion supported species mapping of bush and stream areas (4 scientists)
- Scion debrief in class with students, summarising findings of field studies and working out implications for stream and bush health.

A Skype conference and onsite, face-to-face work. Scientists working with teachers in the school, and the teachers visiting Scion for familiarization and joint planning work.

- Development of a care and maintenance plan for the adjacent stream and bush area (‘gifted’ to the school by year 6 students)
- Significant increase in teacher knowledge of environmental science monitoring procedures and how to carry these out with students
- Improved student perception of science as an everyday and human endeavour through direct contact with scientists both in field studies, and via the Skype conference
- A range of field investigations where students used science monitoring techniques and equipment for authentic investigations
The following interactions will occur in terms 3 and 4, 2010

<table>
<thead>
<tr>
<th>Structured partnership - NCEA</th>
<th>High School</th>
<th>Develop a re-useable resource in Biotechnology</th>
<th>Personal interaction with a local high school.</th>
</tr>
</thead>
</table>
| Material World Primary Science. | Primary School (in progress) | Using the material world as a context and working with Scion’s research in non-renewable energy. | • Personal interaction over a term.  
• Design of experiments  
• Demonstration of experiments  
• Wanting time-series experimental data – tele operation  
• Support for 4 week student Inquiry using SOLO taxonomy. |
| Biology | High School – GATE Students (at planning stage) | Changes and impacts to ecosystem where effective pest control has occurred. | Week long impact project in local bush reserve. Probably use night vision camera, bird song recorders, insect monitoring. |
| Albany Senior high (module support for integrated study) | Student-developed Impact project support (in progress) | Provide science mentoring support for students as they undertake an EFS unit in habitat restoration and monitoring | Using night vision equipment to monitor the presence of mammalian pests. |
| Primary Science | Primary schools (2) (at planning stage) | Support the development of Inquiry. Pedagogy support. |  |
| Technology and Biology | High School (Christchurch) (in progress) | Provide science support for students developing a plant identification application on an iPod. | Provide personnel and ideas on how keys are constructed. Provide New Zealand context data. |
2.2.1 Benefits to schools

Different interventions have different levels of benefit to schools, and they are different across schools. Primary schools gained the greatest benefit from face-to-face interactions with Scion scientists and staff, and the least benefit from virtual (technology facilitated) interactions. The focus of the pilot in providing primary teachers, who may not be confident in science with contact with Scion scientists to support their field studies with students, was very beneficial. As detailed in the case studies, such contact not only provided the teachers with specific knowledge to fill (sometimes) ‘gaping holes’ in their science understanding, but also helped them to learn new investigative science skills and processes (e.g. laying out and recording data from a transect), and helped build their confidence in being able to teach science accurately and engagingly. While the virtual interactions were seen as useful, they were deemed to be far less valuable and have far less benefit or impact compared with the personal contact. It is noted though that none of the primary schools are connected yet to KAREN/NEN, hence the more advanced video conferencing tools were not able to be used.

One secondary school class interaction was completed using virtual communication systems—high speed videoconferencing using KAREN. The initial interactions with the teachers took place face-to-face with a professional development visit to Scion. During this visit, the teachers spent time with scientists discussing the research and projects scientists were involved in. The selection of scientists and topics was in response to upcoming units that teachers were prepared to modify. This opportunity was highly valuable, as it allowed the teachers to get a sense of what was possible through the partnership and through discussion with the scientists, negotiate a range of topics and contexts that were to be the focus for the collaborations, and to up skill themselves on the science and techniques used. Follow up sessions with the coordinator and scientists used video conferencing.

Due to logistical difficulties, it was not possible for Scion staff to have any face-to-face interactions with the secondary students in most cases—these generally taking place through the use of video conferencing. While the teachers indicated that it would have been valuable to have had the opportunity for at least some students to spend time at Scion, possibly working with scientists in the labs, or for the scientists to travel to the school to work with students in a mentoring role, due to logistical, time, and financial constraints, this was not practical. However, despite the lack of any physical interaction, the secondary teachers indicated the technology-mediated approach was highly suited to delivering the sort of outcomes they wanted. That is, allowing their students access to up-to-date knowledge and local examples and contexts linked to their classroom studies.

A non-direct interaction for a class doing an NCEA research unit involved students having little formal class time teaching, but having to write an assignment on a science topic. A forum on the school website which provides asynchronous and remote access was set up so students could ask questions of scientists. The benefits perceived by students and teachers related to being able to provide science-specific help to students. Some of the questions were generic but were answerable, due to the scientists’ general knowledge. Websites and other written resources provided the raw material for students to use in their research.
2.2.2 Pedagogical alignment

While the partnership approaches and the means of ‘delivering’ them differed considerably between the primary and secondary school examples, this did not appear to compromise the value schools gained from them. The most expensive partnership model was face-to-face interaction, but as the level of direct contact diminished the ‘benefit fall-off’ for the primary teachers was a lot more rapid than for secondary teachers. While teachers generally considered direct contact to be preferable and the most effective, secondary teachers considered technology-facilitated interactions almost as favourably, with a far shallower ‘fall off’ of perceived benefit being evident.

This is linked to the different pedagogical approaches adopted at different levels of the school, and the impact this has on the way in which science is taught. There is close alignment between teachers’ pedagogy (i.e., how they teach and the processes and strategies they use) and their views of how learning can occur, and that these are based on, or influenced by, different theories of learning. These theories exist on something of a continuum, with behaviourist theory informing pedagogies at one end, and constructivist theory informing pedagogies at the other – with a number of different ‘blends’ and variations existing in between. Specific details of these theories and the impact they have on pedagogy can be found in the literature review (Falloon, 2008), but generally, pedagogies aligned more with behaviourist theories tend to emphasise a more instructivist teaching approach, where the teacher is largely responsible for providing students with information and learning experiences to enable them to master content, usually for the purposes of passing examinations or other assessments. Such pedagogies in science can be often quite directive in nature, with the teachers providing demonstrations of experiments or investigations, or with students undertaking them but following prescriptive teacher directions. Such approaches tend to adopt methods that illustrate or demonstrate existing knowledge, or seek to validate what has already been discovered, rather than construct or build knowledge through personal experience or investigation.

2.3 Discussion of interventions

This section provides an overview of participants’ perceptions of the value of the different modes of interaction used in Science-for-Life, relative to the cost to Scion of facilitating the interaction.

In developing these charts, data were drawn from the following sources:

1. Interviews with teachers, principals, scientists and the programme facilitator before, during and after each interaction. Specifically, responses to questions related to their perception of the ‘value’ of each mode of interaction;
2. Estimation figures of time spent on each interaction and/or component of the interaction provided by Scion scientists and the programme facilitator;
3. Hourly charge out rates for scientists and the facilitator provided by Scion;
4. Analysis of other direct costs related to the interaction (eg: travel times and costs, online charges, using scientists’ annual leave entitlement, using scientists’ after hours time, repairs to equipment etc).

NB: These calculations do not take into account indirect costs such as the opportunity cost to Scion of scientists being away from revenue-generating projects and research.
The diagram (Figure 1) indicates that generally speaking for primary schools, while all interactions provided through Science-for-Life were perceived to add value to the classroom science programme, there was a considerable ‘gap’ between the value ascribed to totally virtual interactions which were lower than totally face-to-face interactions. Blended interactions which progressively involved more face-to-face interaction fell between these two points.

The primary school case studies indicated different values, concerns and priorities from the secondary schools, reflecting the more student-centred, constructivist-referred pedagogy adopted at primary level. Activities that involved face-to-face contact in scenarios where teachers and students were ‘mentored’ by scientists through practical investigations had the greatest impact, both on teacher practice, and student learning. This value was from the development of accurate and up-to-date science conceptual knowledge, improved knowledge of science investigation processes, and enhanced confidence through ‘demystification’ and improved accessibility - that is, being able to ‘do’ real science. While some value was gained from using technology this was aligned more to using technology authentically, than its use for building science understandings or for communication purposes.

Primary teachers rated very highly the opportunity to visit Scion - such visits being critical to the success of partnerships as they helped develop relationships and consolidated in the minds of teachers what opportunities and possibilities for partnerships existed. All primary teachers who participated indicated
that before the visit to Scion they had no idea of what the CRI did, and were therefore in a weak position to identify opportunities for any collaboration.

For senior secondary schools (Figure 2), while the general pattern was the same, due to geographical and time-efficiency issues there were fewer face-to-face interactions. Unlike their primary colleagues, they indicated that virtual sessions such as the video-conferenced lessons were almost as valuable for their purposes. It needs to be remembered in interpreting the diagram (Figure 2), however, that while indicating the relative cost advantage and overall effectiveness of video-conferenced student sessions, most of the costs for these lay in the preparation of materials and resources used during the sessions, rather than in the actual sessions themselves. The secondary teachers also placed high value on the trial sessions and the pre-interaction visit to Scion, and they had a much better idea of where possible collaborations could be built before they attended these sessions. The usefulness of the sessions was therefore primarily for updating their own science knowledge, which may not have been revisited in any formal way since their undergraduate degree.

These meeting were also valuable to scientists, as they helped the scientists assess the ‘level’ of their presentations and get an indication of the approaches teachers wished them to use with the students. The Scion facilitator gained understanding of the planning processes used in individual schools and the constraints they needed to work within, which helped in being able to tailor partnership models to best suit particular situations, which differed considerably from school to school.

In summary, these meetings hold considerable value for both parties, and should be considered an essential component of any wider-scale programme rollout.
2.3.1 Costs across different intervention modes and schools

When these understandings are interpreted in relation to the use of technology for partnership interactions a consideration is the overall costs of offering the different modes. If developed into a wider-scale initiative there would need to be some form of compromise reached which could, to a limited degree, trade-off impact for cost-effectiveness. Such decisions would depend upon how the implementation was funded, but in terms of meeting the overall goals of Science-for-Life and having the greatest potential impact, the merits of face-to-face versus virtual interaction appear quite clear for the different levels of school.

The direct intervention costs include (but are not limited to) time, transportation for Scion personnel, the online connectivity, personnel, operating costs and overheads. The indirect costs include the provision of loan equipment to support school inquiries, consumables, programme research, equipment purchase and maintenance.

Personnel costs are the major expense of any intervention. The interventions which provided the schools and students the most benefit were the ones where there was significant time investment into the school, and where the structure or the complexity of the intervention increased. Ironically, intervention modes...
had a lesser impact on total cost than expected, as more work went into preparing a presentation over video conference, than for in-person contact. Video conferencing minimised the personal and operational costs of travel, allowing reach to more distant schools, however, a single video conference is not conducive to a constructivist-oriented approach. With video conferencing group work is difficult, running divergent questioning sessions problematic, maintaining engagement with students is limited and the environment is restricted to just speaking and presenting, unless significant written material is also made available. Critical costs that are common to interventions are:

- Preparation time;
- Pre-intervention meeting times with teachers;
- Communication, clarification etc time;
- Travelling time;
- Presentation time;
- Questions and answer time – including post-visit questions;
- Evaluation;
- Research.

Arriving at accurate measures of the time taken for each intervention is difficult, due to the range of delivery blends possible, and the varying requirements of the schools. Therefore the figures in Table 2 should be interpreted as average indicative figures only, and are based on the actual interactions undertaken. Additionally, it needs to be noted that these figures also include initial setup and operational costs, and as such will be greater than the ongoing cost of interactions if a programme such as this was to be scaled up, where resources could be shared and interaction models duplicated. For each cost type, an indicative time range is also given (in hours). For partnerships of lesser duration, the figures provided should be factored accordingly.

**Table 2: Costs of specific interventions**

<table>
<thead>
<tr>
<th>Partnership type</th>
<th>Preparation</th>
<th>Teaching and planning</th>
<th>Other (travel, Interaction cost, VC preparation etc)</th>
<th>Total hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary schools.</td>
<td>20</td>
<td>12</td>
<td>9 (3 trips to Hamilton)</td>
<td>41</td>
</tr>
<tr>
<td>Totally face-to-face (per typical 3–5 week unit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary schools.</td>
<td>50 hours</td>
<td>22</td>
<td>pH strips</td>
<td>72</td>
</tr>
<tr>
<td>Totally face-to-face with scientist compiling resources and workbooks; and running the session with a syndicate of 90 students.</td>
<td></td>
<td></td>
<td>Resources: NIWA Stream resource Photocopying</td>
<td></td>
</tr>
<tr>
<td>Junior secondary (Years 9-10)</td>
<td>40+</td>
<td>16+</td>
<td>?</td>
<td>56+</td>
</tr>
<tr>
<td>Blended face-to-face with technology (up to 50/50), per typical 3-5 week unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior secondary (years 11-13 videoconference sessions, per 1-2 hour sessions)</td>
<td>80 (2 Scientists, and support)</td>
<td>4</td>
<td>0</td>
<td>84</td>
</tr>
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<td>---</td>
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</tr>
<tr>
<td>Integrated Module support</td>
<td>16</td>
<td>12 (4 hr *3 trips)</td>
<td>18 (6hr * 3 trips)</td>
<td>46 (to date)</td>
</tr>
<tr>
<td>Scion onsite one day teacher planning and preparation workshops/visit.</td>
<td>30 (facilitator coordination, preparation and communication)</td>
<td>40 (12 scientists 2 hours each min. Facilitation Presentation Preparation)</td>
<td>Airfares and travel per teacher Teacher release</td>
<td>70</td>
</tr>
<tr>
<td>Teacher workshops onsite in schools (e.g. GIS workshops)</td>
<td>60 hours (one off); 4 hr repeat</td>
<td>11</td>
<td>Airfares and accommodation</td>
<td>71</td>
</tr>
</tbody>
</table>

1 NB: This represents a high initial one-off preparation component. This will decrease significantly as resources are developed and become available for re-use and sharing across CRIs.
3  Future – ensuring success

Science-for-Life has been very successful in engaging schools, teachers, and students, with noted benefits for student engagement, interest, and participation in science.

3.1  On-going research requirements

Science-for-Life has established a basis for CRI engagement with schools and has identified effective models of engagement with teachers and students. More research is needed to embed science learning and engagement options in schools. In particular, the development of interactions and interventions with students using the advanced network for schools (NEN) offers new opportunities, which we see as providing new modes of interaction that were not present at the start of this project.

Inquiry and constructivist-informed pedagogies are critical to science teaching success. Our engagements with schools show that understanding of inquiry in science is limited which impacts upon the effectiveness of teaching and learning. Significant international work (e.g. Enquiring Minds and Science Education Now: A renewed pedagogy for Europe; European Commission, 2007) shows that Inquiry programmes within schools are effective, but need to be supported with external and internal expertise.

Scion would like to extend the intervention models:

- To develop structured partnerships with schools using some pre-prepared themes, NEN and LMS delivery options;
- To investigate and undertake evaluation research as the programme develops and progresses;
- To develop NCEA achievement standard exemplars based on Scion research;
- To investigate and develop remote operation or observation of science (one request already);
- To further investigate and implement the use of technology within schools - including advanced computing and scientific technology (from iPads to Biotechnology equipment);
- To include other CRIs research and capabilities;
- To investigate and develop strategies for embedding specific aspects of constructivist-referred pedagogy in science, in responsive school environments (e.g.: Albany Senior High School).

3.2  Funding

CRIs require funding to implement any form of interaction or intervention programme involving schools. Options include funding implementation into CRIs individually, or funding a facilitator role that can work across CRIs. Discussions (pre-CRI review) have identified the lack of funding as the impediment to any significant engagement, and for some science education programmes stopping.
4 Recommendations and steps for successful CRI/school partnerships

From analysis of the case studies and the potential partnership options above, it is possible to identify a number of options that could be used to guide the development of partnership models for science organisation-school interactions. These are:

4.1 Adopting constructivist pedagogies

In designing and working with students, an understanding of constructivism and being aware of constructivist-informed pedagogical principles is highly desirable, as it provides an effective basis for long-term science learning for students. Specific constructivist principles are those which:

- Take into account student thinking. Eliciting the existing ideas held by students at the beginning of a topic in relation to the science knowledge or concepts to be explored, and the subsequent use of this in the formation of teaching plans and selection of teaching strategies, is essential. Understanding the alternative (to ‘known science’) perspectives students hold can provide teachers with valuable starting points for knowledge transformation;
- Take into account and build on students’ experiences, cultures and values. This relates specifically to an acknowledgement that not all students hold identical values and world views, or exist within or come from a single cultural setting. Science programme design should as much as possible be of an inclusive nature. Some preliminary work has been undertaken on the ‘culture’ of science and the problems some students from some cultures have in adapting generalised examples, which includes moving from a culture where age, seniority and wisdom is respected and not questioned, to a science culture where a predominant value is to question and debate;
- Focus on learning activities and strategies that celebrate and promote thinking. Learning in science is an intellectual activity which requires learners to think about science and the purpose of science. Learning strategies which encourage higher level thinking such as creating, evaluating and analysing should be included;
- Position science within relevant contexts. Effective pedagogies for learning in science utilise contexts which are relevant to students, and allow them to make links between their existing understandings and experiences, and the science to be learnt;
- Provide students with high quality formative feedback. In order to provide this to students, ‘teachers’ need to have sound understanding of the underpinning science knowledge and appropriate ways of progressing student understanding towards this;
- Recognise the importance of science content. Effective pedagogies recognise the extent to which the content of science shapes the manner in which teaching and learning occurs, and that there exists a convergence between teachers’, students’ and scientists’ views of concepts in arriving at specific outcomes;
- Encourage classroom discussion and communication about science. A variety of techniques to encourage students to communicate their ideas about science both with each other and with the teacher should be encouraged (adapted from Hipkins et al., 2002).
4.2 Emphasis on the Nature of Science

In order to support the goal of enhancing levels of general science literacy, any partnerships with schools should include a significant component of activity related to the Nature of Science objectives from the New Zealand Curriculum Framework (2007). The Nature of Science objectives are concerned with developing understanding about science, developing investigative skills in science, communicating in science, and participating in and contributing to science endeavours. These objectives are particularly important for the development of a positive attitude towards science, building understanding of the relevance of science to our lives, and helping with informed decision-making relating to the application of science and technology to human activity.

4.3 Building a PAN CRI-School partnership programme

This section details a range of ideas for how a national programme based on the knowledge created in Science-for-Life could be structured and managed, should it be rolled out on a more wide-scale or national basis:

- Communicating with all CRIs to determine their level of interest in the programme, outlining the operation and findings of the pilot including sharing some of the case studies of teacher and student transformation as a result of their participation, detailing benefits for schools and the CRI, outlining wider science literacy goals etc, and clarifying implications for involvement;
- For CRIs opting in to the programme, identifying capability that could potentially be used to support school programmes;
- Engage with schools through a range of channels;
- Meet/conference with interested teachers and discuss specific needs either on a school by school basis for help with achievement standards, units or other science-related activities, or where general needs, interests or concerns are evident, log these and use this information to develop collective workshops or PD days. Engage primarily with enthusiastic teachers who are prepared to commit to the programme and have specific interests or needs, rather than attempt to work on a ‘whole school’ basis;
- Coordinate, facilitate and manage the partnerships;
- Monitor the implementation and performance of the partnership as it progresses, offering redirection where needed;
- Carry out internal evaluation of the partnership at its conclusion;
- Coordinate external research;
- Coordinate national professional development days for groups of teachers where collective needs or concerns are evident (e.g. GIS PD days). Using the national database to identify CRI staff with the specialist knowledge who may be able to assist with running these;
- Being proactive in developing a range of workshop options for primary teachers, perhaps focusing them on ‘starters for science’ (topic ideas, basic investigative methods, handy everyday resources etc), and then providing support, either through use of the database or from themselves, to ‘mentor’ teachers through their units;
- Collate and manage all resources created and used in the partnerships (PowerPoint’s, units, investigations, data generated, experiments etc) into a searchable national resource repository.
(online), so that participating CRIs are able to benefit from the work of others, thereby enhancing preparation and planning efficiency.

4.4 Steps to the establishment of CRI/school partnerships

The following are important steps in establishing meaningful partnerships between CRIs and schools:

4.4.1 Collaboration and involvement in planning and the development of intervention schedules

As the needs of teachers are highly variable, and their ‘starting points’ in teaching science are so diverse, collaborative planning from the earliest possible stage is essential. The planning days were critical to the success of the interventions as they merged the planning, managerial and assessment requirements of schools with the capacity of Scion to meet them. The outcome of this process is an intervention schedule.

4.4.2 Focus on developing both teacher and student knowledge and capability

The results from the interventions indicated that teachers valued upgrading their own science knowledge. In considering the focus of partnerships, therefore, thought should be given to providing specific opportunities for teachers to update their science, without necessarily working directly with students.

4.4.3 Balance technology support with face-to-face support

CRIs partnering with local schools should endeavour to incorporate elements of face-to-face interaction, supported by synchronous (video/audio conference) and asynchronous (online) technology-mediated communications. Primary teachers particularly cited a lack of time, information overload (or ‘not knowing where to start’), and lack of science understanding (validating materials) as disincentives for using online ‘pre-packaged’ science resources.

4.4.4 Partnerships should be diverse

Teachers value both long and short term interactions. CRIs should look at forming long-term liaisons and short term, more limited interactions based on specific school events or topics.

4.4.5 Make CRI resources available for school use

CRIs should consider making available equipment, data or facilities that support school programmes, to help overcome resource limitations in schools.
4.5 Establishing a portfolio of intervention options

These are the major different types of intervention models that can be implemented by CRIs as discussed below:

4.5.1 Within school Interactions: Personalised partnerships

These interventions are based on a partnership with teachers, CRI facilitator and scientists, in order to tailor the interaction to the school’s specific learning requirements. The experience of Science-for-Life and the interviews with teachers and CRIs show that common ground needs to be established for successful interventions.

The typical approach to initiating and implementing a partnership follows a sequence such as:

- Initial contact, normally from teachers, and a response to the teacher. The response may include a written summary of the CRI expectations from any engagement;
- A meeting with scientists and key, if not all, teachers involved in the unit – via video conferencing or in person:
- The teacher brings as much of the planning undertaken to date as possible. This does not have to be finished and it is preferable that is isn’t, so that the scientists can have input into what is being undertaken;
  A clear understanding of what the requirements of the school are is negotiated. Typically, this includes requests for visits to the science centre or for a scientist to visit the school. Other requests are for (easily accessible) information, equipment for loan etc. This will also normally identify the time when the collaboration is to occur;
- The scientist and facilitator evaluate and respond – what is best, what can be improved, using the levels of science literacy (as above) as a guiding framework;
- Some ideas for what can be achieved are negotiated. Normally this will be the first interaction and others may continue within the unit. Key learning benefits occur when a science interaction is sustained over time;
- The mode/s of the interaction with teachers and students is negotiated;
- Discuss cancellation procedures, especially if the scientist is undertaking a key role in an intervention;
- Any other documentation, especially around data collection and evaluation, is agreed to. It would be expected that some interactions would have quality data collected and developed into case studies (see examples) to evaluate the impact of the programme and benefits to the school.
- Further meeting(s) are held to firm up ideas and confirm dates and resourcing as required;
- As a whole, schools have no money for any resources and primary and intermediate schools have very limited science resources, so experiments and trips etc need to be discussed early if there is expense involved. Most equipment needs to come from the science organisation;
- Collaborations may require a ‘dry run’ if a presentation (esp. to NCEA) is being undertaken.
- Interactions with the school are finalised;
- Further meetings and interaction cycles are timetabled, and an intervention evaluation process is arrived at.
Initial meetings provide significant benefits to teachers and students, hence time should be taken to
develop a clear understanding of what is being taught, what teacher or student activity is to be supported,
and what is expected to be learnt. The level of human resources required, unsurprisingly is related to the
intervention type and depth. Interventions where scientists are just talking about their work, where there
is limited shared planning and short time frames may require fewer hours, whereas delivery of a complete
support programme integrated with the curriculum and targeted to specific classes, can require
considerably more resources. Most interventions will be multi-mode, and many schools are willing to
open blogs etc on school internal websites so that student-to-scientist communication can occur, and
resources can be shared.

Schools need to understand that the rationale for CRI involvement is long-term improvement in science
literacy, so that interactions in school need to be deep are of good science, and not just ‘entertainment’. A
quality interaction with a scientist will also ‘stretch’ the teacher and may be seen as valuable professional
development.

The success of an intervention is dependent upon the relationship between scientists, schools and
teachers. Five areas can affect the quality of an intervention:

- Communication of expectations and of what can and can’t be undertaken or delivered;
- Understanding of the timeframes involved for both parties. Most interventions with schools are
time critical, and occur within defined periods. Also, scientists are working to deadlines and may
not be available. A clear understanding of commitments and response times is required;
- Clear buy-in from teachers and schools - this includes senior school management being aware
and supportive of the interaction;
- Clear communication to schools about the rationale and expectation of a CRIs involvement (e.g.
in deepening the science being undertaken; opportunities for practical and outside the classroom
experiences; developing and introducing nature of science opportunities; the types and forms of
pedagogies being used) and so on;
- Clear understanding from schools on what students will know (or should know). This is especially
important when talking to senior high school teachers.

Schools operate on a very short time frame where interventions are time-critical, and where the whole
teaching programme can be affected if an intervention is not delivered upon. As a general rule, teachers
will not have back-up plans for times where a scientist is providing some input. As part of the expected
delivery, there needs to be explicit and clear understanding of expectations and responsibilities between
the scientists and teachers. This may require several meetings to clarify responses and what will be
undertaken by the scientist.

The expectations from scientists to teachers are:

- Teachers will share in depth and detail the unit plan, so that the scientist can identify what is
  being taught;
- Teachers will guide scientist through how learning outcomes are taught;
- Teachers will be present in the classroom or field, but that the teacher is responsible for
classroom management and is in parent loci. The scientist is never left in a classroom by
themselves (in the field situation, a scientist may be supervising students in close proximity to the teachers).

The expectations from teachers to scientists are:

- Scientists are responsive to communication requests;
- Scientist actively engage in the science learning to be undertaken, suggesting options and other ideas;
- The scientist can explain concepts and science ideas to teachers in understandable language.

4.5.2 Within school interactions: Structured partnerships

Structured partnerships are where the CRI has pre-prepared some common approaches to science subjects that are taught in many schools. Examples from the interventions undertaken were a water quality unit and a unit on renewable energy, where Scion scientists prepared the technical aspects of the unit undertaken such as the experimental methods, and guides of data analysis and interpretation. Forests-of-Life identified these as ‘science toolboxes’.

4.5.3 Adoption of core curriculum themes

Programmes such as Forests-of-Life can be developed to be focused on core curriculum themes rather than just on core pedagogy. Meta teaching guides can be developed that can be adapted by teachers for their own use. The teaching guides integrate the science learning and investigative process within Inquiry pedagogy, and introduce options on experimentation, resources, developing classroom practice on discourse, identifying and correcting miss-conceptions etc. In as much as teachers scaffold student learning, these guides would scaffold aspects of the learning environment and science content knowledge.

4.5.4 NCEA integration with CRI research programmes

NCEA standards have exemplar units developed and stored on www.tki.govt.nz, that describe what student work is required to obtain pass, merit and excellence grades. Many achievement standards have topics and themes that are directly related to CRI science, where NCEA exemplar units can be developed in whole or in part.

4.5.5 Supporting other programmes

There are a series of different initiatives being undertaken by other organisations interested in developing science literacy within students. This list is not comprehensive, but identifies additional ways in which CRI scientists can support science learning:

- Royal Society Programmes such as Crest, National Waterways, Globe, and Primary and Secondary teacher fellowships, which to varying degrees require scientist or CRI assistance.
• Professional association programmes, for example the IPENZ FutureInTech programme which uses scientists as ambassadors to schools; and school subject associations which run Science Olympiads for gifted students.

4.6 Teacher interactions

The provision of professional development for teachers is a highly beneficial interaction. Forests-of-Life ran several full day PD courses for teachers undertaking Inquiries within the Living World strand of the Science Curriculum, and two PD interactions were undertaken within Science-for-Life. Professional development has become even more of a need and opportunity since the dis-establishment of the Science Advisory component in Teacher Support Services.

Professional development can be in science themes and also in the use of technologies. All professional development has to be practical and tailored to teacher needs. Science-for-Life found that significant professional development benefit arose when teachers were able to question and interact with scientists on specific subjects of their choosing, and where the scientists didn’t necessarily have prepared presentations, but were able to respond to specific questions using props, whiteboards or visits to the lab.

Professional development such as within NCEA topics or using technology is best and very effective when it is also part of an in-school unit of learning.

4.7 Remote and asynchronous school interactions

Non personal and asynchronous interactions can be a useful and cost-effective form of engaging with students in specific areas. Modes of interaction include simple email, wikis, pre-prepared material developed on learning management systems, or e-learning environments.

4.8 Resource development

Forests-of-Life undertook some resource development with its schools and found that formal, prepared units of work were of limited use to teachers unless they were very comprehensive and detailed. In most cases better material was available on the internet and it was found that teachers generally re-wrote any information provided. What was useful to teachers was specific science information and recommendations of good websites, sources of information, and useable experiments. To be effective, any resource development needs to be undertaken in partnership with teachers and trailed so that it is tailored and will be used.

4.9 School visits to science centres

Most CRIs have requests to bring students of all ages to their premises for tours. The value of these is that the student-scientist interaction can help break down stereotypes of what a scientist is and does. It is perceived that there is not a lot of long-term benefit from a tour for many students, especially if it is unrelated to any other partnership interactions that are taking place. PowerPoint presentations by scientists or students viewing of scientific posters can actually be detrimental to building science interest
and engagement in students. Scion hosted local high schools (junior school) several times where the teachers were specifically trying to demonstrate through the visits that science was useful and relevant. Scion provided demonstrations of science in laboratories and equipment, but individual scientists found that many students were not engaging. The visits tended to reinforce positive aspects to those students who were already science-engaged, and made little difference to those who had ‘rejected’ science. As a whole, one-off and short term interactions with scientists do not change behaviours or thinking.

Beyond the scope of this programme, there is a significant volume of literature on student learning at science centres, particularly museum and encounter-type organisations. The design of display materials, and presentations and activities for students is advanced and complex and requires significant work beyond the scope of this initiative.

4.10 Using the Internet

Both Forests-of-Life and Science-for-Life were supported by a website (www.forestsoflife.org). As an interaction mechanism, the website was not entirely successful. Teachers didn’t engage with it, as they didn’t have enough time, nor was sufficient time put into updating the website. In time, with the website as a repository of information, units etc, then it may have been successful. However, there are other services that are specific to this purpose, for example, WikiEducator, Digistore and the Science Learning Hub.

From our interactions, Internet usage has to be as a tool – as a means to an end, and not an end in itself. Successful usage of the internet includes video conferencing and using ‘Web 2.0’ type interactions, e.g. Wikis for providing information or questions. Effective use of websites would be those that encourage scientist-student interactions and provide specific information for students and teachers on specific subjects. Where Web 2.0 interactions have occurred, these have been created on school website infrastructure, where the communications can be monitored and access controlled.

4.10.1 Communities of practice and social media

As part of trying to improve science literacy in students and teachers, Science-for-Life is exploring the development of a community of practice around science teaching, science learning, and specific science interventions. This evaluation is underway and may use blogs, wikis and social media tools such as Facebook and Twitter to achieve programme objectives.

4.10.2 Ultra-fast broadband service delivery

A significant opportunity for CRIs is the current rollout of the broadband fibre network to schools. Figure 3 shows the network architecture of a fibre network to schools. The opportunity for Science-for-Life comes from the provision of services on the application layer and the type of services that can be offered where there is high speed and high bandwidth Internet capability. The options for future trialling are oriented to improving the affordances of video conferencing, e.g. where multiple VC session can be used to classrooms, tele-operation and monitoring of experiments, use of Internet enabled whiteboards (e.g. Epsom), virtual laboratories, and so on. More immediate opportunities arise from service provision of content served on learning management systems, developed in-conjunction with teachers.
**Application Level**
Equipment, Services and Information e.g. email, LMS, Video Conference, SMS etc

**IP (Internet) Level**
IP Address Layer and Network connectivity between network participants, network operator and ISP

**Data Level**
Data and communication switching, Firewall and network infrastructure

**Cable Level**
Fibre termination to the cabinet in the school building

**Trunking Level**
Physical trunking in the street, includes wireless where appropriate.

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**Figure 3 Layer architecture of network.**
(from Wenmoth, 2010, pers comm)
5 Acknowledgements

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6 References


Appendix A. Forests-of-Life

The forerunner to Science-for-Life was Forests-of-Life, an in-school programme developed by Scion under Ministry of Education Digital Opportunities (DigiOps) funding. This programme ran for four years and focused on improving science learning outcomes for students in the middle school years (10 – 15 years old). The programme engaged students in authentic science investigations using Inquiry pedagogies. Students developed their own research questions and methods, and implemented their research under the supervision of teachers and Scion staff. The Forests-of-Life project encouraged students to take a “Think Global - Act Local” approach to their research by acting on the findings of their research in practical ways.

Forests-of-Life tested the ability of schools to:

- Engage with a Crown Research Institute in authentic and collaborative science research projects;
- Use ICT appropriately for data collection and communicating results and conclusions;
- Improve science literacy and develop student thinking skills in a real-life context;
- Integrate science learning with other curriculum areas such as technology, social studies and arts.

The project was originally a partnership with Massey University and a Wellington based Web company – Revero, but it was ultimately developed by a Scion project team based in Rotorua. The team developed the Inquiry programme in conjunction with the staff and principal of a local intermediate school.

A.1. Outcomes from Forests-of-Life

Critical understandings that developed from this programme were:

- Science learning had to be encapsulated within a wider framework of children’s experiences and expectations. The learning needs to be purposeful and future-oriented;
- Science learning and teaching needs a new pedagogical basis to replace the transmission of seemingly unrelated and irrelevant facts to students;
- Students need to be able to use the science learning for some purpose or action. Forests-of-Life used the common ‘Think Global and Act Local’ slogan to reinforce some contextualisation of the learning;
- Metacognitive practice and learning is as critical as learning science knowledge. Students need to understand how the knowledge is useful and how they could take their learnings and apply them to different situations;
- Strategies are needed to promote science learning and PCK for teachers;
- Students need to be held jointly responsible for their own learning;
- Teaching as a profession and a science is more than just knowledge communication;
- Passive resources and interactions that require a lot of extra work by teachers are most likely to fail;
- Expectations of teachers’ knowledge and capability across a number of fields were unrealistically high;
- Scion was not in a position to effect the wider organisational changes many teachers needed for their support;
- Support for teachers to ‘own’ the vision had to be embedded in the professional development workshops and has been necessary for longer-term sustainability of the project. Teacher decision-making is central to this process.

A.2. Outcomes for students

The specific outcomes for students include:

- The opportunity to work alongside scientists. This connection has been of great benefit to both students and scientists. Students were encouraged to see scientists as partners in their research and not just as information providers. Several teachers commented that a programme highlight was ‘seeing the excitement of students working with ‘real scientists’’ (Teacher School B);
- Teachers had the opportunity to explore more deeply the prior knowledge many students held about forests and science which in some cases was quite extensive. This created a platform for some deep and quite meaningful science;
- For immersion activities, students were often exposed to a wide range of learning opportunities. These included:
  - Learning experiences outside the classroom in the form of fieldtrips to bush reserves/camp bush activities;
  - Appropriate use of technology in relevant contexts – for example: students used proscopes, laptops, and digital cameras, to identify and digitally record the adapted features of the pohutukawa;
  - Numerous visitors talked to classes and these included Scion scientists;
  - The programme encouraged students to work with resources and materials created by other organisations;
  - Use of a wide range of new technologies not experienced previously - including proscopes, night vision video, GPS, digital sound software programmes and others, and a wide range of resources such as videos and internet sites.
- Teachers commented that students loved the experimental process and eagerly anticipated results of experiments. The students involved in the Forests-of-Life project felt special and had a certain group identity as the ‘FoL kids’. They felt as though they had done something different. The project allowed some students to delve deeply into the Living World strand of the curriculum. One teacher said that “for some students their imagination was captured by what was going on” and considered that the research structure of the programme would take some students a long way in science. The principal of School A said that for her one of the great benefits of the programme was “the ‘incidental’ career education for students” that allowed students to “focus on the possibilities of science for further education and careers”;
- Initially overlooked in the planning of the process and development of the model was the need to explain the Inquiry process to students and explain to them why their learning was different, and what their new roles in the learning process were. The need to explain the process to students became part of the professional development structure for teachers’ workshops during Year 3.
A.3. Pedagogical knowledge and practices

Teachers liked the ‘real life’ or authenticity of the Inquiry approach. They were impressed with the method of leading the students through scientific Inquiry.

*The programme... uses real life situations and follows a format that is accessible to the student. I like, as a science teacher, the methodology and the processes involved so that students are carrying out scientific Inquiry without even knowing about it.* (Teacher, School E)

Teachers were also impressed by the fact that students came to see science as more than an activity carried out only in the science laboratory.

*Interestingly students seem to see science as carried out in the lab with chemicals; nothing else, not physics or biology or field trips gathering information.* (Teacher, School E)

The ‘so what?’ at the end of an Inquiry provided great potential for engaging students in real life contextual learning. For example, the students involved in a lagoon Inquiry were considering some possible social action options with their local city councillors after their request to undertake a lagoon restoration was turned down.

Teachers thought the Inquiry process they were using for the Forests-of-Life programme had the benefit of being transferable to other curriculum areas. Flexibility and continuous reflection and evaluation of the programme were an aspect that was highly valued by teachers.

In retrospect the Scion team believe that while they made the right choice in adopting an Inquiry approach in terms of current curricular changes, they also over-estimated teacher knowledge of Inquiry processes and the ability of schools to implement it effectively. Few teachers entered the project with any prior experience of using Inquiry approaches in teaching and learning.

A.4. Conceptual knowledge and practices

One of the greatest values of the project for teachers and students alike was the close association of schools with a science organisation, and students and teachers working directly with scientists.

*The partnership between teachers and scientists, working together co operatively and learning aspects of each other’s specialties has huge value for engaging young people in science and science education.* (Principal, School A)

The professional development workshops for staff were considered particularly effective.

Scion itself recognised that Forests-of-Life was not simply a promotional exercise, but an opportunity to go to the heart of some of the major issues facing science in the education system. The programme was not just about fostering new scientists, but growing a wider understanding of the value of science to our society.
A perennial issue has related to the role of the Forests-of-Life website in the project. The team considered various rationales for the website over the lifetime of the project. Although the web appeared to be ‘just such a fantastic mechanism for the delivery of information’, the Scion team had questions ‘about the web as a mainstream mechanism for delivering a programme for teachers’ classroom use’. A simpler and more utilitarian website had been developed by the end of year 3.

A.5. Inquiry as an approach to teaching science

Forests-of-Life demonstrated that Inquiry approaches to science education engage students in a meaningful way, delivering immediate science educational outcomes but with the additional benefit of improving long-term science literacy.

Constructive approaches, similar to those adopted by Forests-of-Life, optimise opportunities for students to be immersed in interesting research areas, which stimulates learning and makes it more personally relevant (Brown, Collins & Duguid 1989). Such approaches enhance student motivation and deepen cognitive engagement.

Constructivism is a theory of how people learn, and not a theory of teaching - it does not directly instruct teachers on how to implement programmes within a classroom. Lebrow’s (1993) lists seven primary constructivist values which also mirror in the way in which scientists work, making it a sensible approach to adopt in the educational environment. The values are:

- Collaboration,
- Personal autonomy,
- Generativity,
- Reflectivity,
- Active engagement,
- Personal relevance, and
- Pluralism.

A.5.1. Issues and considerations for Inquiry approaches

Scion encountered a number of issues when attempting to implement science inquiries through Forests-of-Life:

- Constructivist classroom approaches require teachers to make fundamental shifts in how they think about instruction, from dispensing content, to placing students’ attempts-to-understand at the centre of the learning process. The traditional approaches need to be replaced by those that are more complex, interactive and unpredictable. Such teaching is not easy and is difficult to put into practice;
- Teachers need to be attuned to their students’ developmental processes;
- Teachers need to have a familiarity with disciplinary knowledge and the principles underlying a topic of study, so as to be prepared for the variety of ways these principles may be explored by learners. For most teachers, familiarity with scientific knowledge and the principles underlying various areas of a study are very limited;
• Managing classroom interaction and discourse was found to be difficult at a number of levels;

  One has to be able to be quick thinking to be able to fill the gaps with questions, and ideas at the critical metacognitive stages of Inquiry such as reflecting on a field trip, and drawing out questions. It is quite easy to flick back to a transmission type teaching approach or overly direct the class (personal comm. Scion Scientist).

• Teacher understandings of the concepts and processes involved in implementing an Inquiry approach was also limited;

• The impact of classroom cultures, dynamics, expectations and norms can create issues for adoption of constructivist approaches;

• The respective role of teachers talking, controlling the intellectual activity of the classroom to ensure uniform “exposure” to the curriculum, with students listening or engaged in quiet independent activity, is a dominant image and one that is hard to overcome;

• The ‘just in time’ aspect of some Inquiry approaches to student learning was seen as a high-risk option by some teachers;

• Teachers need to have the confidence, resources and knowledge base to respond to student interest, questioning and direction. More simplistic approaches such as the transmission of knowledge, highly guided or structured Inquiry, or even an abdication to the scientists to take the lead, were seen as preferred options in some cases;

• Students encountered difficulties with asking questions that were both feasible and scientifically worthwhile, and teachers needed to support students in seeing the scientific merit of the question. In many cases Scion facilitated the development of student research questions. Scientists could intuitively scaffold student research taking into account time and resource constraints, and also suggest potential experimental methods and equipment;

• Students encountered difficulties in gathering data from the worldwide web. They needed support with use of keywords, systematic searches, and reading and evaluating material online. Scion scientists recognised a need for teacher support and resources in framing-up online investigations. Scientists can very easily identify quality websites, and guide teachers and students;

• Students in planning and designing investigations had difficulty grasping how to create controlled environments, tending to confuse variables, often misjudging the feasibility of what they were trying to do and stay focussed on the research question;

• Students varied in how systematic they were in carrying out their plans, working together, and allocating tasks around the group and staying focussed on collecting the data they intended to collect;

• Students did not necessarily appreciate the need for consistency in measurement, following through on procedures, or maintaining experimental controls;

• Students rarely pursued the scientific implications of the observations, or considered what they may suggest about other related questions or investigations;

• In analysing and interpreting data, the students often focused on data that interested them or that seemed to bear out their ideas, rather than consider all the data available;

• Students also often failed to articulate how they arrived at conclusions, or created logical arguments using their data to justify conclusions;
• Some teachers didn’t have the confidence to redirect or refocus students and insist on rigorous methods being applied;
• Some teachers preferred to accept any attempt to frame up a science investigation as a success. Low expectations of what the students could achieve generally resulted in lower quality science;
• An additional issue observed by Scion, and one that may be a uniquely New Zealand curricular issue, was the notable reliance on fair testing as the preferred approach or frequently the only scientific method to be taught in the classroom;
• Scion realised how little science knowledge was held in schools at the Intermediate school level. Limited teacher scientific knowledge and understanding was to be major challenge that needed to be addressed through professional development sessions.
Appendix B. Research Method

A collective case study framework was used in collecting data for the Science-for-Life research. Erickson (1986) defines a case study as:

> the intensive investigation of a single object of social inquiry such as a classroom... and that it holds major advantages in that it allows the immersion of oneself in the dynamics of a single social entity and enables the uncovering of events or processes that one might miss with more superficial methods.

_Erickson, 1986, p.238._

Stake (2000) terms a collective case study as being when the researcher identifies a number of cases in order to “investigate a phenomenon, population, or general condition” (Stake, 2000, p.437). By adopting this strategy which utilises multiple instances which may or may not be selected according to the presence of common characteristics, Stake (2000) claims that the researcher is seeking to gain a “better understanding, perhaps a better theorising, about a still larger collection of cases” (p.437). Collective case studies often lead or contribute to the generation of theories or generalities, which can be used to make predications about performances within other instances of a similar type (Stake, 2000). By utilising a multiple case approach for this project, it was expected that data would be collected which provides a range of different approaches highlighting varying degrees of Inquiry-model adoption, and explores a range of different CRI-school collaborations.

Quantitative research was not undertaken as:

- Mechanisms for generating control data where some students are specifically excluded from interventions are problematic. There are also ethical issues, in that it is expected that some students would benefit over others from the interventions. Also, it would be extremely difficult to isolate the effect of the intervention on student achievement, as it would be only one variable amongst many that impact on learning;
- The measurement of educational outcomes improvement requires mechanisms for formal, consistent, and uniform assessment of student learning;
- The assessment of student learning also needs to address key aspects of the constructivist learning theory and competencies such as higher-order thinking skills;
- The costs of establishing a formal experimental design were beyond the allocated budget;
- Scion was engaging with schools on a voluntary basis without being able to significantly fund them for this project.

B.1. Data collection tools

Consistent with interpretive studies of this nature, a range of qualitative data collection methods will be used in this study. These include participant interviews, researcher observations and field notes, and a survey/questionnaire.
**B.1.1. Interviews**

Cannell and Kahn define the interview as “a conversation with a purpose” (1957, p.149) while Cohen and Manion (1994) categorise interviews as one of the most effective and frequently used methods in qualitative research. This study will utilise semi-structured interviews in gaining data for later analysis. Individual interviews will be held with the participating teachers and where possible students, and if time permits, also as part of a focus group either face-to-face or via audio conference. In both instances the interviews will use pre-determined interview schedules.

**B.1.2. Researcher observations and field notes**

Anderson (1995) defines researcher field notes as a “record of everything the researcher hears, sees, experiences and thinks” (p.152). He further sub-categorises these into two types – descriptive and reflective (Anderson, 1995). Field notes typically contain information about the subjects, a reconstruction of the dialogue between the subjects, a description of the research setting, accounts of events, and details of observer strategies and behaviours. According to Anderson (1995), field notes are an integral component of case study research and serve as an ideal tool for collecting authentic data, as and when it happens.

It is anticipated that extensive field notes will be taken by the researcher/s while undertaking visits to the participating schools during the intervention. The field notes will describe researcher interpretations related to specific aspects of the inquiry, namely: the nature of planning and teaching practices and how they have evolved or changed in response to the inquiry-focus of the intervention; the nature of the CRI-school collaborative model being developed and used; and the nature of student learning processes and outcomes, and how they have evolved or changed in response to the inquiry-focus of the intervention.

**B.1.3. Survey/questionnaire**

Time and resource permitting, a short questionnaire will be posted online for participants to respond to. The questionnaire will survey participants’ perspectives on specific elements of the intervention, and ask them to rate, using a Likert scale, features of the programme and the extent to which they impacted upon their practices and science learning experience. It is proposed that this quantitative data will be used to supplement and validate qualitatively-based findings.

**B.1.4. Teacher reflective journals**

It is anticipated that teachers involved in the case studies will develop a reflective log documenting and describing their involvement in the project from commencement through to completion of the studies. A reflective journal can be described as...

...a personal record of your learning experiences. It is a space where you can record and reflect upon your observations and responses to situations, which can then be used later to explore and analyse ways of thinking and being in contexts. Journals, although generally written, can also contain images, drawings and other types of reference materials (RMIT, 2006).
Data could be collated in a log book and/or in digital format, using multimedia resources such as digital cameras, video etc which could be processed later for use in case studies.

The following guidelines/questions have been developed to assist teachers in the data collection process for their reflective journals:

- A statement of motivations, reasons and goals for participation in the S-4-L programme.
- A personal (self report) appraisal of existing teaching practices in science.
- Personal reflections on the following processes, activities or outcomes involved in S-4-L:
  - Planning and identification of possible collaborations;
  - The value of resources (human/equipment etc) provided as part of the collaboration;
  - The impact of the collaboration on student learning, engagement or interest in science;
  - The impact of the collaboration on the teacher’s professional practice in teaching science;
  - How the collaboration contributed to the attainment of student learning outcomes;
  - Any impacts of the programme on the wider school community (e.g. other teachers, admin/management, parental/community interest or involvement etc);
  - What factors impacted upon the overall effectiveness of the collaboration;
  - Ways in which the collaborations could be changed or improved for future iterations.

- An overall statement relating to teachers’ opinions of the value of the programme and thoughts on the role of organisations such as Scion (CRIs) in supporting school science and the development of general science literacy.
Appendix C. Scion Draft Ethics Guidelines for Research with Teachers and Students

This research was carried out consistent with Anderson’s (1995) guidelines for ethical research. These are:

• That informed consent has been obtained and appropriately documented, and participants are given the right to withdraw from the research at any time;
• That the risks to participants are outweighed by the anticipated benefits of the research;
• That the risks to participants are minimised by research procedures that do not unnecessarily expose subjects to risks;
• That the rights and welfare of the participants are adequately protected; and
• That the research will be periodically reviewed.

Appropriate documentation for signing was developed and sent to all participants. This outlined the purpose and nature of the research, the data collection processes to be used, how the findings will be recorded and shared, and what time commitment was expected on their behalf. The research was carried out in a manner consistent with the principles of ‘informed consent’, with participants having the right to withdraw from the research at any time without prejudice up until data analysis commences.

The initial case studies have the following additional specific ethical guidelines:

• Only teachers and senior high school students were interviewed by the research team;
• Recordings were made of interactions with classes, where specific permission was given. The recordings were not published where individuals can be identified in any form, and not published at all in audio form. Recordings will be erased 3 years after results are published. Recordings will be held in a safe environment.

C.1. Research information for student participants

C.1.1. Purpose statement

The overall purpose of this research is to report on a range of partnership interactions that CRIs could explore in their efforts to support science education at senior primary and/or secondary levels of schooling. This is in response to an identified need to promote and support higher levels of science literacy in the general population, and also to encourage interest and engagement in science and science-related careers and activities.

The goal of this research, therefore, is to monitor the impact of these partnerships on both the ‘trial’ CRI (Scion) and the schools involved, in an effort to determine which of the partnership approaches prove to be of the greatest value to the schools, taking into account principles such as cost-effectiveness, manageability and sustainability.
C.1.2. Research goals

It is anticipated that involvement in this project will have a formative impact upon schools, in terms of both supporting the development of Inquiry learning models in science, and assisting them in developing more effective science programmes through involvement in CRI partnerships.

The broad goals of the study are:

- To report on the efficacy of a range of CRI/school partnerships or other collaborative models for supporting science teaching and learning;
- To explore how CRI/school partnerships can be successfully integrated with elements of Inquiry learning in some science units taught in participating schools.

C.2. Data collection tools

Consistent with interpretive studies of this nature, a range of qualitative data collection methods were used. These include participant interviews, researcher observations and field notes, and possibly a survey/questionnaire.

C.2.1. Interviews

This study will utilise semi-structured interviews to collect data for later analysis. Individual interviews will be held with the participating teachers and where possible students, and if time permits, also as part of a focus group either face-to-face or via audio conference. In both instances the interviews will use pre-determined interview schedules.

C.2.2. Researcher observations and field notes (where relevant)

It is anticipated that field notes will be taken by the researcher/s while undertaking visits during the partnerships, if needed, to participating schools. The field notes will describe researcher interpretations related to specific aspects of the Inquiry, namely: the nature of planning and teaching practices and how they have evolved or changed in response to the Inquiry-focus of the partnership; the nature of the CRI-school partnership model being developed and used; and the nature of student learning processes and outcomes and how they have evolved or changed in response to the Inquiry-focus.

Notes may also be taken at meetings, or meetings recorded and transcribed (if relevant) for later analysis. These meetings may be face-to-face or via video or audio conference.

C.2.3. Survey/questionnaire

A short questionnaire may be posted online for participants to respond to. The questionnaire will survey participants’ perspectives on specific elements of the partnership, and ask them to rate, using a Likert
scale or similar, features of the partnership and the extent to which they impacted upon their practices
and science teaching/learning experience. It is proposed that this quantitative data will be used to
supplement and validate qualitatively-based findings.

C.3. Use of case study data

The case studies will be used in the development of a final report for the Ministry of Research in Science
and Technology that will be submitted at the end of 2010. The report will draw together significant
outcomes and findings from each of the partnership studies (along with estimated costings) to help
prepare a proposal to government to support wider-scale roll out.

C.4. Confidentiality

In the development of the case studies, data will be used in such a way as to not make it attributable to
specific research participants. Pseudonyms will be used for teachers, students and school names, and
other potentially identifying data will be altered accordingly.

C.5. Withdrawal from research

Participants may withdraw from the research (and thereby the programme) at anytime, up until the
conclusion of the data collection process.

C.6. Informed consent

If you have any questions or are unsure of any aspects of the Science-for-Life research, please make
contact with __________, using the contact details below.

Please keep a copy of this document for your records. By signing this document, participants acknowledge
that they have read the above and are in agreement with it.

Name:       School:

Signed:       Date:

C.7. Contact information

If you have any questions relating to this research, or requirements it, please do not hesitate to make
contact at:
Appendix D. Reports and Case Studies Written

The following reports have been written.

- Crown Research Institute Engagement with the Compulsory Education Sector: Results from Interviews
- Effective Science Learning: Literature Review
- Students’ attitudes to secondary school science and science teaching: A synthesis of findings comparing recent NZCER research with Scion research.
- 1st Year University Science Students Workshops Report
- Science Teachers’ Workshops Report
- A Synthesis of the Science for Life Project
- A Living Inquiry (Newstead Model Country School)

Case studies

- Newstead Model Normal School
- Lynmore Primary
- Wellington College – Underway
- St. Mary’s – Underway
- Rotorua Boys High School – Underway