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Adolescent Participation in the DOHaD Story

Changing power relations through collaborative narrative to catalyse the potential of DOHaD for intergenerational change

Jacqueline Bay

Abstract

The noncommunicable disease (NCD) crisis is one of the most pressing issues facing the world. Impacts influence all communities, but are most significant in those with limited resources. Evidence from Developmental Origins of Health and Disease (DOHaD) demonstrates that early life environmental exposures influence health in infancy and childhood, and later-life NCD risk, revealing the transgenerational nature of NCDs. Improved environmental exposures from the periconceptional period through to adolescence support primary NCD prevention.

During adolescence, cognitive, psychosocial and lifestyle behaviours that persist into adulthood develop. Interventions during this period promote NCD risk reduction for adolescents and their future offspring. The Healthy Start to Life Education for Adolescents Project (HSLEAP) is a multi-sectoral DOHaD intervention. It utilises adaptable educational programmes within science, and related core learning areas in schools, to support capability-based adolescent empowerment in relation to critical citizenship, DOHaD and NCD risk.

An extended mixed-methods approach investigated processes and outcomes associated with application of the HSLEAP model. Individually matched evidence from pre- to 12-months post-intervention was available from students in 30 classes from 10 New Zealand schools and 21 classes from 3 Cook Islands schools. Teacher participation evidence also included work within 24 classes from three Tongan schools.

Contextual application of the model promoted engagement in learning and capability development. Participants developed and retained understanding of associations between maternal environmental exposures and offspring health. In contrast, understanding of paternal exposures, not explored in the programmes, was unchanged. Students in both New Zealand and the Cook Islands engaged as science communicators within their families, extending the collaborative narrative initiated in the classroom into their personal lives. A significant proportion of students made and sustained nutritional behaviour changes, offering the potential for NCD risk reduction. Analysis of processes and resourcing enabled understanding of the potential of transformative learning and participatory research to support teachers to integrate HSLEAP programmes into practice. This research identifies structural and philosophical requirements for programmes of this nature, emphasising the essential role of context. It offers transferable evidence to inform future development of education-science partnerships supporting school-based interventions that enable adolescents to engage with and act upon DOHaD evidence.
Acknowledgements

I would like to acknowledge the collaboration partners that have worked with the Liggins Institute to examine the potential of adolescents as DOHaD-informed agents of change.

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- Nukutere College, Tereora College, Titikaveka College, Cook Islands Ministry of Education, and Cook Islands Ministry of Health;
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Part I | Introduction and Overview

Noncommunicable diseases (NCDs) are slow to develop, chronic health conditions, largely comprising cardiovascular diseases (CVD), cancers, respiratory diseases and diabetes. Collectively NCDs represent the greatest causes of death and disability in humans, accounting for 68% of deaths globally, 75% of which occur in low- and middle-income countries (LMIC). Approximately 45% of all NCD deaths and 82% of NCD deaths in LMICs are premature (prior to age 70), creating enormous social and economic burdens that are obstructing poverty alleviation and sustainable development (World Health Organization, 2015b). These unsustainable burdens, alongside the exponential growth of NCD incidence, and factors associated with NCD risk, have prompted integrated global efforts to curb the NCD crisis. The 2011 high level meeting of the United Nations General Assembly on the Prevention and Control of Noncommunicable Diseases, an action only once previously taken in regard to a health issue (HIV/AIDS), reflects the extent of this global crisis (United Nations General Assembly, 2011).

This meeting acknowledged the complexity of the NCD crisis and, for the first time at the level of the United Nations (UN) and World Health Organization (WHO), recognized the intergenerational nature of NCD vulnerability. This brought global attention to the field of Developmental Origins of Health and Disease (DOHaD). This field has uncovered evidence demonstrating associations between nutritional and non-nutritional exposures in early life (even before birth) and later life vulnerability to NCDs (Hanson and Gluckman, 2014). The political declaration called for integrated multi-sectoral efforts to contribute towards the long-term process of addressing the needs of those with NCDs, and reducing NCD vulnerability in children, young people and future generations. Amongst the recommendations within the political declaration were clear statements regarding risk associated with the periconceptional nutritional environment, and utilising education, including within schooling, to contribute to addressing the potential of primary NCD risk reduction in children and adolescents (United Nations General Assembly, 2011).

This thesis examines the role of multi-sectoral collaborations involving education, science and health in empowering youth to participate as critically engaged citizens in examining and acting on DOHaD evidence in support of primary NCD risk reduction. It draws on
research representing multi-sectoral collaborations led by the author in New Zealand, the Cook Islands and Tonga. These collaborations lie within an overarching project led by the author, known as the Healthy Start to Life Education for Adolescents Project (HSLEAP). The project utilises adaptable educational programmes embedded within science, and related core learning areas in schools to facilitate communication and translation of DOHaD knowledge, alongside capability development required to enable critically engaged citizenship in relation to DOHaD and NCD risk. Research has informed the development of the model and examined its potential to enable understanding and application of DOHaD knowledge by young people. The HSLEAP pilot, initiated and led by the author in 2009, established the project and identified the potential for narrative-based pedagogies to support knowledge translation and in turn enable adolescent-led health promotion. The research presented within this thesis is associated with the period 2012 – 2016 during which longer-term impacts were examined, learning programmes evolved in response to the pilot research and the project expanded to examine the influence of context on the potential of the model to support adolescents as agents of change in relation to NCD risk reduction. Given the format of this thesis as a series of articles, there will be elements of repetition between the chapters.

**Chapter 1** presents a review of the opportunity for primary NCD risk reduction offered during adolescence. The work presented is a chapter within a book to be published by *Springer Japan* examining the application of DOHaD science from a public health perspective. The chapter was via invitation from Dr. Fumihiro Sata, Vice Representative, Japan Society for DOHaD.

**Part II** presents theoretical frameworks for the development and evaluation of school-based multi-sectoral interventions to engage youth as active contributors to primary NCD risk reduction. **Chapter 2** is a peer reviewed invited paper published in *Healthcare*. This review presents theoretical perspectives from education, health and science and demonstrates how these can collectively inform the development of school-based DOHaD interventions targeting the adolescent life stage. Co-authors are DOHaD collaborators from science and public health.

**Chapter 3** is a peer reviewed debate paper published in *Health Promotion International*. This article examines the challenges associated with evaluation of multi-sectoral programmes. In particular, it examines the need to identify whether learning has occurred before the potential for health impacts can be understood. Co-authors are collaborators from
science, education and public health within the Worldwide Universities Network (WUN) Global Challenge Public Health (NCD) collaboration led by the author. This collaboration is investigating schools as a setting for NCD risk reduction.

**Part III** examines the pedagogical framework underpinning the HSLEAP school-based interventions presented in the thesis. This focuses on the development of collaborative narrative to facilitate transformative learning for students, teachers and participating scientists. **Chapter 4** provides an overview of the pedagogical concepts associated with collaborative narrative. The requirements of student learning resources designed to support examination of scientific evidence via narrative-based exploration of research are examined via a case-analysis. This article is currently being prepared for submission to a science communication journal. There are no co-authors.

**Chapter 5** focuses on transformative learning, examining how resources that facilitate exploration of scientific evidence within the HSLEAP programmes support the key stages of transformative learning. This is enabled via evidence from the Tongan and Cook Islands arms of HSLEAP. This article is currently being prepared for submission to a science education journal. Co-authors are from the Cook Islands arm of the collaboration.

**Chapter 6** examines the role of professional learning and development in addressing the contextual needs of education partners in multi-sectoral NCD risk reduction collaborations. Drawing on work from the Tongan arm of HSLEAP, this case study, published in the *Asia Pacific Forum on Science Learning and Teaching*, examines the role of collaborative narrative in supporting transformative learning in participating teachers. Co-authors are collaborators from Tonga.

**Chapter 7** presents a commentary published in the *Journal of Developmental Origins of Health and Disease* providing a vehicle for communication of concepts associated with the role of education in DOHaD translation interventions for scientists. This is presented as an example of a resource used to engage DOHaD scientists in collaborative narrative regarding the potential for multi-sectoral engagement. The co-author on this paper is a fetal physiologist who has engaged in all the collaborations presented in this thesis.

**Part IV** presents evaluative evidence evolving from the development and implementation of HSLEAP programmes in schools in New Zealand and the Cook Islands for which the author is the Principal Investigator. **Chapter 8** presents longitudinal evaluative evidence from the HSLEAP study conducted in New Zealand between 2010 and 2013. While the
early part of this study was conducted prior to registration for this degree in 2012, the latter section of the data was collected in 2012 and 2013. This enabled the essential analysis that was required to inform the Pacific arm of HSLEAP and without which the final analysis of the New Zealand arm of this project could not be published. The article is currently under review in a science education journal. The co-authors are collaborators from education, health and science.

**Chapter 9** presents evaluative evidence of Phase I of the Cook Islands arm of HSLEAP. During the period late 2013 - 2015 the New Zealand based project was deconstructed and the HSLEAP model was contextually reconstructed and implemented in schools in the Cook Islands to enable examination of its potential in a developing nation. The article is currently in preparation for submission to a journal with an emphasis on the role of education in development. The co-authors are collaborators from education, health and science in the Cook Islands and New Zealand.

**Chapter 10** presents a comparative case-study examining key differences in the approaches used in the New Zealand and Cook Islands versions of HSLEAP. The use of case study enables in-depth examination of process and outcome associated with contextual differences. The article is currently in preparation for submission to a journal with an emphasis on the role of education in development. The co-authors are collaborators from education in the Cook Islands.

**Part V** presents a conclusion drawing together key outcomes of this research portfolio, examining overarching limitations and identifying areas for future research development.
Chapter 1. DOHaD interventions: Opportunities during adolescence

1.1. Introduction
Evidence from the field of Developmental Origins of Health and Disease (DOHaD) has highlighted biological mechanisms underpinning the intergenerational nature of noncommunicable disease (NCD) risk. It is now understood that early-life environmental exposures contribute to vulnerability to a wide range of adverse conditions spanning the life-course. These include neurocognitive developmental challenges, overweight, obesity, and NCDs ranging from metabolic and cardiovascular diseases to musculoskeletal, allergic and mental health conditions (Hanson and Gluckman, 2014). Investigation of the mechanisms underpinning these observations has demonstrated that environmentally mediated epigenetic modifications result in the latent phenotypic influences that are associated with increased NCD risk (Jiang, 2016). This evidence has highlighted previously untapped primary prevention opportunities that could contribute towards interrupting the intergenerational cycle of NCD risk. The potential of such interventions is increasingly recognized as a valid NCD risk reduction strategy by global agencies (Chestnov et al., 2013).

The influence of socio-ecological factors on environmental exposures central to the DOHaD paradigm should always be considered in conjunction with the biological evidence.

The window during which environmental exposures may influence later-life health stretches from pre-conception through early childhood and adolescence (Hanson and Gluckman, 2014). While both nutritional and non-nutritional exposures are important, the focus of this thesis is nutritional exposures. Both undernutrition and obesogenic early-life environments have been shown to be associated with adverse later-life health outcomes (Vickers, 2011), some of which may be indicated by changes as early as childhood (Godfrey et al., 2011). Additionally, maternal pre-pregnancy obesity and excessive gestational weight gain are associated with adverse short-term maternal and offspring impacts as well as obesity-related adverse later-life outcomes in offspring (Patel and Poston, 2016). Evolving from this evidence has been extensive discussion of the potential of targeted interventions during pregnancy and early childhood (Balbus et al., 2013; Gillman, 2010). These are important and should be pursued, particularly if they support parents to understand "the
long-term influences of nutrition in early-childhood. However, there is strong evidence to suggest that opportunities to change environmental exposures associated with nutritional practices during pregnancy are limited (Crozier et al., 2009; Kubota et al., 2013; Morton et al., 2014). Additionally, once obesity is established it is extremely difficult to reverse the biological factors that support the ongoing condition in the individual (Blackstone, 2016). While evidence emerging from studies of weight loss prior to pregnancy in humans is limited, maternal surgical weight loss approaches appear to be beneficial for the offspring, as does limiting gestational weight gain (Nicholas and McMillen, 2016). However, evidence from animal models suggests that weight loss within the periconceptional period may be associated with negative downstream effects on metabolic health (Nicholas and McMillen, 2016). Therefore, while addressing the impact of poor-quality nutrition, overweight and/or obesity in the mother during the pregnancy is well founded, it is challenging. Including adolescence alongside pregnancy as a life stage target for DOHaD interventions offers the opportunity to address nutritional practices and parental overweight/obesity prior to conception. This supports reduced impact of environmental exposures in the periconceptional period and during pregnancy, and removes the need for periconceptional weight loss and the associated potential risks.

1.2. The opportunity of adolescence

Adolescence, the period of transition between childhood and adulthood (age 10 – 19 years) is a life stage of significant change during which life-long cognitive and psychosocial behaviours are established (Craigie et al., 2011; Steinberg, 2005). Many of these behaviours will influence future health, particularly those associated with the development of overweight, obesity, and associated NCDs (Alberga et al., 2012; Chandola et al., 2006). Therefore, adolescence is considered an important component of the life-course approach to the prevention of chronic diseases (Darnton-Hill et al., 2004; Sawyer et al., 2012).

Intervention during adolescence, even when this is significantly distanced from parenthood, provides an important opportunity to address environmental exposures across a wide range of critical and sensitive life stages. These include:

- gametogenesis and the periconceptional period during which unfavourable health status in either parent, and/or a poor maternal nutritional environment are associated with adverse short and long-term health consequences for offspring (Fullston et al., 2016; Hanson and Gluckman, 2014; Nicholas and McMillen, 2016; Watkins et al., 2010);
• pregnancy, during which:
  o maternal over-nutrition, and overweight or obese status are associated with a wide range of adverse obstetric, infant, childhood and later-life health outcomes (Catalano and Ehrenberg, 2006; Nicholas and McMillen, 2016);
  o maternal undernutrition when associated with poor fetal growth leads to a range of irreversible adverse biological and social consequences, and when associated with low birth weight followed by rapid catch-up growth in childhood and adolescence is associated with increased risk of nutrition-related chronic diseases in adulthood (Victora et al. 2008);
• infancy and childhood, where established nutritional practices of the parents influence the nutritional environment of the infant and child (Birch and Fisher, 1998; Lindsay et al., 2006), impacting current and later-life health;
• adolescence, where:
  o personal control over food choices increases (Videon and Manning, 2003)
  o the influence of family food environment on food choices reduces (Smith et al., 2016) while the influence of peer food practices increases (Salvy et al., 2012);
  o lifelong nutritional and related lifestyle practices are established (Todd et al., 2015);
  o and the opportunity exists to promote food and lifestyle choices that reduce weight gain (Hu et al., 2016) either before overweight and obesity are established, or before obesity reaches the point where biologically it will be very difficult to reverse (Blackstone, 2016).

The period of adolescence is almost universally dominated by formal education, encompassing schooling, followed for many by apprenticeships and/or tertiary training or education. The social structures within which formal education occurs support in-depth engagement with adolescents. In the schooling sector, this also engages the family/caregivers. Therefore, it is not surprising that recommendations regarding interventions associated with promoting adolescent health have a focus on multi-sectoral approaches and highlight opportunities associated with schooling (World Health Organization, 2013a, 2016b; United Nations General Assembly, 2011). Other social structures including religious organisations (for example churches, mosques and synagogues), sporting, service, arts and cultural clubs also support adolescent development and offer important opportunities that contribute to the development of wellbeing. While our focus is on the role of the formal education sector, aspects of the approaches described may also be applicable to informal education and community settings.
1.3. Schools as a setting

Many school-based health-promotion interventions have not been particularly effective (Khambalia et al., 2012). Lack of connection to the core mission of schools has been identified as a key issue associated with poor outcomes (Waters et al., 2011). This suggests that programme design has failed to attend to the need for shared vision that is inclusive of all participating sectors, known to be the most critical success factor associated with multi-sectoral partnerships (Wildridge et al., 2004). Heterogeneity of impact is a further challenge that is commonly identified as problematic when evidence-informed health policies and practices are applied to school-based health promotion (Keshavarz Mohammadi et al., 2010). In education, it is known that failure to address diversity within and between schools magnifies achievement variance (psychosocial and academic) (Haque, 2015). Heterogeneity of effect in school-based health promotion is likely to be associated with lack of connection to core principles of pedagogy and practice associated with recognizing and addressing diversity. This issue may be addressed through collaborative input of educators into school-based health-promotion design.

Thus, to achieve the potential of DOHaD interventions that support the opportunities offered by the development of positive health-related practices during adolescence, attention must be paid to developing multi-sectoral and community-based participatory research (CBPR) approaches that engage with school communities. Interventions must connect to core goals in education as well as health and science, and recognize the important role that each school community has in adapting and sustaining programmes that are specific to their setting (Bay et al., 2016a; Bay et al., 2016c; Bay and Vickers, 2016). CBPR approaches are optimal, recognizing that knowledge and expertise from within the community in which the intervention is occurring should have a central role in determining the nature of the research question, intervention tools, evaluation methods and interpretation (Tucker and Taylor, 2004). Such approaches support the potential for interventions to not only link to core national education goals, but also to specific goals within each school community. This ensures that interventions can be enacted within the core business of the school. These approaches address issues of sustainability, while simultaneously facilitating the development of capabilities in youth that support action-oriented adolescent empowerment associated with engaged citizenship (Bay et al., 2016a).

It was therefore encouraging to see a shift in the thinking of the World Health Organization (WHO) in the recently published Report from the Commission for Ending Childhood
Obesity (ECHO), that explicitly identified the importance of engagement and consultation with the education sector to ensure educational rigor in intervention design, and enable interventions to be embedded in mainstream curricula (World Health Organization, 2016b).

1.3.1. Understanding the core mission of schools

Modern education systems are concerned with holistic development that “prepares young people to participate as critically engaged citizens and lifelong-learners able to negotiate present realities as well as futures that we cannot predict” (Bay and Vickers, 2016). To achieve this schools are equipped with structures that support cognitive, physical, and psychosocial (mental, emotional, social and spiritual) development, as well as pastoral care. This holistic approach has seen a shift away from silo-based didactic education of the mid-20th century towards integrated educational approaches that support youth to develop capabilities (knowledge, skills, attitudes and values) seen as being essential for living and thriving in the 21st century (Rychen and Salganik, 2003). These extend learning to include cultivation of skills and dispositions associated with critical and creative thinking, collaboration, leadership, entrepreneurship, and active participation in society (Perkins, 2014). This does not preclude learning associated with mastering content knowledge. Rather it stretches adolescents to develop capabilities that enable them to apply academic content knowledge to life situations, including complex contemporary problems such as the NCD epidemic, global warming, poverty and political instability (Hipkins et al., 2014; Perkins, 2014). This approach to education supports the development of critically engaged citizenship, a way of being that is associated with questioning, seeking evidence and understanding, assessing multiple perspectives and taking considered actions that are mindful of the complexity of the challenges and opportunities facing modern societies. Thus, the NCD epidemic and DOHaD provide a broad array of contexts that can be utilized by teachers in the delivery of education programmes that support curricula goals related to capability development across and within traditional learning disciplines (Bay and Vickers, 2016).

1.3.2. Capabilities that enable adolescents as critically engaged citizens

Capabilities developed during adolescence should enable critically engaged participation in all aspects of society. In the context of the NCD epidemic, critically engaged citizens will interact with the issue of NCD risk, burden and impact. They will question the status quo (particularly when this is associated with inequities), and seek out and examine
evidence from multiple perspectives. This process leads to active participation in evidence-based actions at personal, family and potentially community/societal level that address challenges associated with the issue. Specific capabilities required to achieve engaged citizenship related to issues associated with NCDs/DOHaD include scientific, health, environmental and sociological literacies, as well as key competencies and self-efficacy (Bay et al., 2016a). Literacies in this context refer to the ability to seek out, engage with, examine and use evidence to make informed decisions. For example, scientific literacy is associated with attaining and using relevant knowledge, skills, attitudes and values that enable individuals and/or groups to engage with and act upon scientific evidence relating to everyday experiences as well as complex, open-ended issues. Because of the complex and values-laden nature of issues related to the NCD epidemic, education programmes should also facilitate understanding of the need to integrate multiple perspectives from the sciences, humanities and arts, along with social and ethical perspectives into consideration when approaching decision-making (Kahn and Zeidler, 2016). This can be challenging but is transformative when it allows young people to identify and use frames of reference outside their current experience, that offer the potential to address issues of concern.

Intervention design must take account of the processes via which capability development and behaviour setting occurs during adolescence. Capability development during adolescence is a component of human development, influenced by complex interactions over time between the individual’s personal attributes and the socio-ecological systems within the environment(s) in which they are developing (Bronfenbrenner, 1989). This emphasises the nature of human development as a complex adaptive system. As such, capability development is a dynamic process involving a large number of elements interacting in a non-linear manner with each other and their environment. These elements can be influenced by the system’s history as well as its current context, and can be disproportionally affected by small changes (Eidelson, 1997). Bronfenbrenner’s bioecological model of human development, while acknowledging the complex interactions between the individual and both direct and indirect aspects of the environment, emphasises the strength of influence of the individual’s microsystem, being the most proximal layer of interaction that an individual has with their environment and processes within it (Bronfenbrenner, 2005).

The proximal environment of the adolescent is dominated by family, school, peers and community interactions (actual and virtual). The knowledge, attitudes, and beliefs that are
held individually by the adolescent and by social consensus within the environments in which they interact will influence their behavioural development and their potential to develop the habits of mind associated with critically engaged citizenship. There is increasing public awareness of overweight, obesity and related diseases known to health and science communities as NCDs. Media, politics, public health messaging and increasing community experience of these issues are contributing to this and reach adolescents through family, school and community interactions. However, this awareness is dominated by reductionist thinking that places the actions of the individual at the centre of the cause of overweight, obesity, and NCDs. In communities ranging from Japan, New Zealand, Pacific Island states, and Europe, levels of awareness of life-course perspectives of NCD risk in adolescents, parents, young adults and the public have been found to be very low (Bay, 2015a; Bay et al., 2012a; Bay, 2015c; Bay et al., 2015; Endo and Oyamada, 2013; Gage et al., 2011; Grace et al., 2012). Exposing adolescents to evidence that challenges this reductionist perspective should be a key objective of school-based DOHaD interventions.

**1.3.3. Intervention tools and frameworks**

If teachers are to use NCD/DOHaD related contexts to support the development of capabilities as we have described, they need access to learning resources that enable young people to examine evidence relating to NCD risk and incidence, as well as DOHaD observational and mechanistic evidence (Figure 1.1).

![Figure 1.1. HSLEAP learning and teaching module framework](Adapted from LENScience learning modules (Bay and Mora, 2014; Bay and Yaqona, 2016))
The use of narrative-based pedagogies has been shown to be very effective in supporting young people to explore and act on research evidence (Bay et al., 2012a). Narrative-based pedagogies are designed to enable learners to engage with the culture of science and develop deeper understanding of the nature of science as a knowledge system (Grace et al., 2012). By providing young people with reimagined scientific evidence to explore (Bay, 2016a) and interpret, students are able to construct understanding of both the process of science and the emergent evidence (Bay et al., 2012c). This process of constructing understanding is supportive of transformative learning that leads to action taking that can impact not only the young person, but also their peers and/or family (Case Study 1).

**Case Study 1: David, Auckland, New Zealand**

The Healthy Start to Life Education for Adolescents Project utilizes the trend for contextualization of science education in exploration of socio-scientific issues to support development of scientific and health literacy in the context of a life-course approach to NCD risk reduction. Matched pre-post questionnaire evidence demonstrates knowledge, attitude and behaviour (KAB) change, facilitating health-promoting actions that we have demonstrated are sustained in most to 12-months post-intervention (Bay et al., 2012a; Bay, 2015b). Triangulation with parental data contextualizes aspects of this quantitative evidence. David* is a 13-year-old of Pacific Island heritage from a low socio-economic community in New Zealand. Adult obesity within Pacific peoples in New Zealand is 65% (New Zealand Ministry of Health, 2015). David’s pre-post questionnaire data showed KAB change, including reducing the consumption of deep-fried chips from daily to once per week. Parental interview evidence places this change in context, demonstrating an association with peer-relationships.

“*There is a local take-away up here ... he would always go up after school to get hot chips with his mates. I am so glad that he has actually come away from that. Because he has learnt about diabetes and sugar and fat he has come away from that and he is not doing it.*” (Parent of David*, 12-week post-intervention interview.)

Parental data can uncover family-level impact. Questionnaires demonstrated that adolescents had facilitated changes in parental knowledge relating to evidence of the association between early-life nutrition and later-life health (p <0.001), with 72% of parents reporting relevant family-level learning had occurred during the period of the intervention. Qualitative data provides contextualization of this. Jonah* is from the same community as David. His parents spoke of family-level change, as well as reporting that Jonah stopped truanting school during the programme.
“He brought the [programme] book home and at dinner he told us all about what he has been learning in science about food…..And we talked about that and how it was different to what we were eating……and we have started eating salads every night since that week. We are proud of him and……he is attending class…. he is really motivated about school.” (Parents of Jonah, joint 12-week post-intervention interview.)

*Names have been altered.

1.3.4. Addressing gender equity issues

DOHaD interventions tend to emphasise adolescent girls and mothers. While this is important, if only females are exposed to programmes that support development of understanding of a life-course approach to NCD risk we cannot expect to change socio-cultural norms associated with reductionist thinking regarding NCD cause and/or lack of prioritisation of women and children’s health and wellbeing. Behaviours associated with food resources in households are inherently linked to socio-cultural norms. In many communities, gender equity issues contribute to the challenges associated with ensuring that adolescent girls and women are empowered to take actions that support wellbeing. These include simply having full access to available nutritional resources. Incorporating boys and young men into intervention programmes is of paramount importance in ensuring that males, through the development of understanding of the importance of nutrition for women and girls, and of their own environment, will be supportive of women’s efforts to initiate health-promoting change (Gates, 2014). While the NCD/DOHaD evidence is weighted strongly towards the role of maternal exposures before and during pregnancy, as noted by Richardson and colleagues (Richardson et al., 2014), public communication that ignores the role of paternal nutrition prior to pregnancy increases the likelihood of ‘mother at fault’ being the overwhelming message heard by society. In addition to the known social influence of males on resources for women and children in many societies, there is clear and growing evidence of the role of paternal pre-conceptional health in programming/conditioning of later-life health of offspring (Fullston et al., 2016; Lane et al., 2015). Therefore, consideration of gender equity issues, and engaging boys and men should not be overlooked in the development and implementation of adolescent interventions.
1.3.5. Teachers as partners in health promotion

Teachers from multiple learning disciplines have the potential to play a very valuable role in facilitating action-oriented health-promotion. However, this is not the core business of schools facing pressure to meet extensive and growing academic, psychosocial, and pastoral care demands within limited classroom contact time. For teachers to engage in collaborative programmes that promote adolescent empowerment regarding life-course NCD risk reduction they must be provided with appropriate professional development that (a) addresses pedagogical issues while also examining NCD and DOHaD evidence (Bay et al., 2016b; Bay et al., 2016d), and (b) enables teachers to identify added educational value emerging from programme participation (Case Study 2).

Case Study 2: Apii, Rarotonga, Cook Islands

Apii* lives in the Cook Islands, a Small Island Developing State (SIDS) in the Pacific with the adult overweight/obesity rates of 91%/72% and type 2 diabetes rates of 26% (Ministry of Health Cook Islands, 2016). At age 13 Apii participated in a Healthy Start to Life Education for Adolescents Programme that was co-constructed by his science teacher, working with a team from the Cook Islands Ministries of Health and Education and the Liggins Institute. The programme centred on exploration of Cook Islands NCD evidence alongside DOHaD observational and mechanistic evidence. Apii is an engaged student in a mixed ability class with a BMI within the healthy range. Pre-intervention evidence, demonstrated that some of his food-related behaviours were not ideal, placing him at increased future NCD risk. Three-month post-intervention data (questionnaire and interview) demonstrated a positive change in relevant food-related behaviours, typical of that demonstrated across intervention cohorts in the precursor programme.

In response to the positive cohort-wide educational impact of the programme, Apii’s science teacher redesigned the following year’s learning plan to include a module exploring relevant physiological systems, linking this to the learning goals of the national curriculum. Students were required to research and develop an oral and/or visual presentation examining impacts associated with poor diet in the Cook Islands. Apii (aged 14 years) sought out and presented national-level data on obesity, relating this to NCD risk and determinants of health in the local environment. Using his own data (BMI and life-style behaviours), he explored the concept of risk development over time and challenged his peers to examine and change their behaviours, as he explained he had as a result of the previous year’s learning programme. Assessment of capabilities associated with seeking out, interpreting and using data to present and act on a justified opinion regarding a
socio-scientific issue (an achievement objective within the Cook Islands National Curriculum) demonstrated that Apii was now working above the level expected for his age, and in relation to his prior academic performance. *Names have been altered.

1.4. Conclusions: With not to... the untapped potential of adolescence

Adolescents are frequently represented as “passive participants in social life with little agency in matters concerning them” when in fact they have considerable agency in food practices and actively contribute to and exert power in shaping of food consumption and lifestyle practices (Neely et al., 2014). If developed, the potential to harness this agency to drive positive outcomes for adolescents, their families, and their future offspring can be transformational. Achieving this requires investment in multi-sectoral partnerships that recognise that access to scientific evidence is a fundamental human right (United Nations General Assembly, 1948) that is all too frequently ignored.

The purpose of such partnerships must be seen as empowering, communicating with, not to. This requires resource investment that facilitates the sharing of research evidence in a manner that allows adolescents to construct meaning from and act on evidence in ways that are appropriate to their personal and social context. By collaborating with education and applying modern pedagogy and practice, it is possible to develop innovative interventions that can effect positive change at the level of participating schools, adolescents, and families. Unless such programmes are responsive (and hence messy), they will not be meeting the needs of the community in which they are being enacted. This can be challenging as it demands that power in the research relationship is shared, and that all participants (scientists, public health professionals, educators, students and families) are learners. Furthermore, adolescent voices need to be valued in the development of such interventions. We will therefore conclude with an excerpt from a speech given by Jasmine Crosbie, a 19 year-old high school graduate from Auckland, New Zealand who has participated in such intervention programmes since the age of 14, and is also a mother. Jasmine’s contribution to a forum in which members of the WHO Commission on Ending Childhood Obesity met with youth from New Zealand schools who had experienced such programmes led to her accepting an invitation to present on behalf of youth at the launch of the ECHO report during a side event at the 69th World Health Assembly. Her speech reflects a combination of her experience as a programme participant, and her role as a youth...
leader in supporting schools and research communities to ensure that youth perspectives are incorporated strongly into programme development.

“...There are two issues here. Firstly, the environment obviously needs to change. How can young people make healthy food decisions when they are being suffocated by excess unhealthy options in their communities? Secondly, young people need to be empowered as evidence-based decision makers. Environmental changes without empowerment are not the answer. Young people, just like adults, don’t follow rules that they don’t understand. We could throw in more fruit and vegetable stores of better quality... all to outweigh the unhealthy options. Could do, but the community won’t understand! They’ll simply head elsewhere for the food they’re used to, the food they’ve been raised around. You may remember being a kid and your parents asking you to do something, you responding with ‘why?’, and them answering with ‘because I said so!’ Did you ever do it? No, because you weren’t provided with any reasonable explanation of why you should. Young people need to be treated with respect and therefore given the opportunity to explore the issue and evidence and to make decisions based on evidence that work in our context. We not only need to change the obesogenic environment, but education also. I don’t believe the classes on healthy eating in Health Studies were enough, nor were the P.E lessons. We need to start education around this issue at primary school age, if not before, and in multiple different approved subjects in high school, not just Health and P.E. So, to be clear, I do not mean that we would have a few add-on lessons about this. What I am talking about is exploring issues such as obesity, NCDs, diabetes, and life-course evidence in depth within our ordinary subjects like science, social studies, food technology, health and PE, English and maths. Because young people ARE interested in issues. We DO care. We DON’T just live in the present. We DO think about our futures and the futures of our families. We are intelligent and we can be the decision makers. May I remind you that the Universal declaration of human rights states that it is the right of every human to “share in scientific advancement and its benefits” So to learn about the life-course approach to NCD risk reduction and the wider societal issues is empowering. As a young mother, that sense of empowerment was huge for me.”

Jasmine Crosbie, Geneva, May 2016 (Jasmine Crosbie)
Part II | Theoretical Frameworks

The field of Developmental Origins of Health and Disease (DOHaD) has moved into a phase where depth of evidence is demanding that translation of knowledge into actions supporting primary NCD risk reduction should become a priority. The significant potential for application of DOHaD evidence has been an acknowledged driver for DOHaD science from its inception in the 1980s. However, the depth of evidence required to shift towards enacting this potential is relatively recent. Achieving the goal of effective knowledge translation demands a broadening of the scope and membership of the DOHaD community to include a focus on public health. This requires engagement with sectors through which potential for intervention exists, including government, health practitioners, education, environment, and social services. DOHaD evidence is broad, as is the potential reach. Our focus is on the potential of education-science-health collaborations to facilitate translation during adolescence of one of the core elements of DOHaD evidence, the impact of early-life environmental exposures on vulnerability to later-life NCD risk.

Evidence demonstrating the potential offered by intergenerational interventions enabling improved environmental exposures during adolescence is strong. It has been highlighted by recent reports from the United Nations and the World Health Organization recommending the prioritization of multi-sectoral actions supporting interventions targeting these life stages. However, multi-sectoral collaborations across complex adaptive systems (health, science, education) and set within the complex socio-scientific issue of the NCD crisis are challenging. Comprehensive literature exists in science, public health, and education on sector-specific evidence and theory regarding the components that should contribute to multi-sectoral strategies within the context of schooling. However, the literature examining application of evidence and theory within multi-sectoral collaborations and from multi-sectoral perspectives is limited.

Chapter 2 presents a review paper examining theoretical frameworks underpinning the design of multi-sectoral interventions supporting school-based interventions empowering adolescents to engage in translation of DOHaD evidence into actions. Chapter 3 presents a debate paper examining from a multi-sectoral perspective theoretical frameworks underpinning evaluation with respect to school-based interventions.
Chapter 2. Multi-Sectoral Design Frameworks

Preface

The invited review presented in this chapter was published in a Special Issue of the Journal Healthcare, “Developmental Origins of Health and Disease (DOHaD): Implications for Health Policy and Health Promotion”.

The purpose of this Special Issue was to explore implications of the rapidly growing field of DOHaD in terms of public health and health promotion/prevention. The invitation reflects the increasing awareness within the DOHaD community of the importance of adolescence as a life stage during which intervention has potential, and the associated need to engage with the education sector in examining intervention opportunities. This peer reviewed paper addresses a gap in the literature with respect to combined application of theoretical evidence from science, education and public health to inform intervention design. It presents a review of evidence informing theoretical frameworks for adolescent DOHaD interventions that is accessible collectively to all relevant sectors. It is intended for audiences spanning science, health and education. Consequently, the paper is designed to enable accessibility to readers with varying levels of knowledge of the literature within each field.

2.1. Introduction

Escalating rates of obesity and associated avoidable noncommunicable diseases (NCDs) have increased global attention on impacts, prevention, and control. NCDs, primarily cardiovascular diseases, cancers, chronic respiratory diseases and type 2 diabetes mellitus, are responsible for 68% of global deaths, with 40% occurring prematurely (before age 70). Low- and middle-income nations bear 75% of all, and 82% of premature, NCD deaths (World Health Organization, 2015b). The World Health Organization (WHO) and United Nations (UN) have heightened societal awareness of this issue, calling for multi-sectoral evidence-based actions focused on prevention and equity (Chestnov et al., 2013).

Principles and approaches guiding fulfilment of the vision, “a world free of the avoidable burden of NCDs”, propose multi-sectoral, empowerment-based knowledge-translation strategies, including life-course approaches to prevention and control (World Health Organization, 2013a). Life-course approaches draw on evidence from the field of developmental origins of health and disease (DOHaD). This identifies that nutritional and non-nutritional exposures during development (from gametogenesis to early childhood) contribute towards later-life NCD vulnerability (Hanson and Gluckman, 2014), and that maternal health (including preconception), and maternal, infant, childhood and adolescent nutritional quality, contribute to NCD prevention and control (World Health Organization, 2013a).

Pregnancy, lactation and infancy were rapidly identified as life stages appropriate for DOHaD-informed interventions (Gillman, 2010; Gluckman et al., 2011). However, evidence demonstrates that health prior to conception, along with nutritional environments during the periconceptional period, contribute to programming-conditioning of later-life health and disease (Hanson and Gluckman, 2014). Therefore, addressing determinants of health prior to conception, and periconceptional environmental exposures, is extremely important.

Adolescence is a determining point for nutritional, physical activity, and cognitive behaviours that persist into adulthood (Craigie et al., 2011; Steinberg, 2005) and influence future health (Alberga et al., 2012). Consequently, these behaviours will influence periconceptional environmental exposures and health prior to conception. Even if pregnancy is a considerable distance from adolescence, behaviours that develop during adolescence contribute towards later-life NCD vulnerability in offspring. Thus,
adolescence is a life stage offering significant potential for transgenerational primary prevention of obesity and NCD risk (Todd et al., 2015).

Reports recommending inclusion of adolescent interventions within prevention strategies suggest multi-sectoral approaches, highlighting the potential of schools as intervention settings (World Health Organization, 2013a, 2016b; United Nations General Assembly, 2011). Realizing this requires education to partner with health and science in intervention design, delivery, and evaluation. While multiple other intervention foci are possible (including community-, family-, and healthcare-based approaches), our emphasis is on the potential identified by school-based interventions and the theoretical frameworks informing these.

Having led the development of multi-sectoral education–science–health adolescent intervention partnerships in Oceania (Bay et al., 2012a; Bay and McIntyre, 2013), and supported UK colleagues to develop culturally adapted versions of our interventions (Woods-Townsend et al., 2015), we observe that even when key multi-sectoral partnership success factors of shared vision, strong relationships, and resourcing (Woulfe et al., 2010) are available, it is challenging for partners to understand and integrate contributing perspectives into intervention design. We suggest that sector-specific literature exacerbates this challenge. This paper, intended for science, health and education audiences, addresses a gap in the literature, examining conceptual frameworks underpinning adolescent DOHaD intervention design from a multi-sectoral perspective. It is intended as an enabling tool supporting participating sectors to recognize sectoral-specific perspectives. From this collaborators may gain understanding of evidence and drivers from partner sectors, and consider how evidence and practice can be integrated to achieve the potential of transgenerational NCD risk reduction offered within adolescence.

2.2. Multi-Sectoral Partnerships

Multi-sectoral partnerships are recommended where complexity determines that no single sector has the required expertise or resources to bring about change (Bailey, 2010). It has been identified that this is the case with the NCD epidemic (World Health Organization, 2013a; United Nations General Assembly, 2011). Multi-sectoral partnerships are known to be challenging, time consuming, and often fail. However, when multi-sectoral partnerships are successful, they achieve more collectively than partners achieve alone (Wildridge et al., 2004). When addressing the potential for DOHaD-informed interventions supporting NCD
risk reduction for adolescents and their potential future offspring, key partners are education, science, health, and social/community agencies.

2.2.1. Schools: A Setting for Multi-Sectoral Adolescent Intervention

Multiple social structures offer settings for DOHaD-driven interventions aiming to empower adolescents to engage in evidence-based preventive actions. Settings need to enable individuals and/or communities to examine evidence (health, scientific and sociological), identify the significance of this evidence for their context, and identify and engage in evidence-based risk-reducing actions. To facilitate the potential of positive health-behaviours prior to parenting, intervention settings should engage adolescents before and within the reproductive years. Participation should be sustained for long enough to allow in-depth interaction and effect learning and development that leads to evidence-based actions. Intervention settings sit within and are impacted by the social, environmental and political context of the community. This influences resourcing (available and required) to support adolescent empowerment, the type of actions adolescents will identify as opportunities for change, and the manner in which adolescents may approach empowerment-based social disruption to bring about change in the health status of their families and communities.

Schools offer established social networks wherein education can facilitate development of competencies (knowledge, attitudes, skills and values) that empower adolescent-led evidence-based actions within the socio-ecological context of the individual and their community (Bay et al., 2012a). However, not all adolescents are positively connected with schooling, therefore community-based interventions are also important. Cultural, service, religious, sporting, or hobby-based groups that meet regularly and engage in informal or formal learning linked to themes associated with health and wellbeing, offer further intervention settings for adolescents and adults (Brown et al., 2012; Kohlstadt et al., 2015).

2.2.2. Shared Vision within Multi-Sectoral Partnerships

Shared vision is the most significant critical success factor for multi-sectoral partnerships (Wildridge et al., 2004). Also required are: resources (human and other), leadership, organisational structure and capacity, appropriate membership, quality of relationships, and understanding of external and contextual factors (Woulfe et al., 2010). This list could be applied equally to multi-disciplinary collaborations. However, unlike multi-disciplinary
interactions, multi-sectoral partnerships require negotiation of language, knowledge, and practice across sectors. Furthermore, sector-specific goals essential to achieving shared goals must be recognised and respected.

Within multi-sectoral partnerships it is known that differing goals lead to devaluing of others’ strategies by partners, and that this limits success (Fawcett et al., 2010). In school-based health-promoting programmes it is reported that lack of connection between the programme and the core mission of the school is the most common reason for failure (Waters et al., 2011). This suggests that programme goals are typically not shared by the participating sectors, and lack relevance to education. Addressing this issue is essential.

The science and health sectors share goals related to improving nutrition and associated factors in childhood and adolescence, promoting transgenerational NCD risk reduction (World Health Organization, 2013a, 2016b; United Nations General Assembly, 2011). While health and wellbeing are important to the education sector, overarching goals in education focus on development of competencies empowering adolescents as life-long learners capable of engaging in current and future issues; negotiating ethical dilemmas, conflicting evidence, and application of evidence within the frame of social and cultural values (Hipkins et al., 2014). Although these sector-specific goals for education are different to those for health and science, when integrated the combined goals offer the potential to enhance outcomes for each sector. By reframing the health/science vision relating to transgenerational NCD risk reduction to include related educational goals, it is possible to create a vision that all participating sectors can value, Figure 2.1. This mandates recognition of each sector in planning, development, delivery, and evaluation.

<table>
<thead>
<tr>
<th>Health/Science Sector Goal</th>
<th>Education Sector Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A world free of the avoidable burden of NCDs. Improving nutrition and associated factors in childhood and adolescence, supporting transgenerational NCD risk reduction.</td>
<td>Empowering adolescents as life-long learners capable of engaging in current and future issues; negotiating ethical dilemmas, conflicting evidence, and application of evidence within the frame of social and cultural values.</td>
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**Reframed Vision**

**Multi-sectoral Partnership Goal**

Development of capabilities empowering adolescents to participate as critically engaged citizens, using evidence-based health-promoting actions to facilitate reduction in NCD risk for themselves, their potential future offspring, and their families, and contribute towards reducing negative social and economic impacts of NCDs in their communities.

Figure 2.1. Reframing of sector-specific goals to enable a multi-sectoral goal that identifies shared vision while including and respecting sector-specific vision.
Achieving shared vision requires investment in partnership development, including recognition and respect for sector-specific goals (Bay and MacIntyre, 2013). The impact of investment in inter-sectoral consultation was demonstrated recently in the published reports (from draft to final) of the WHO Commission on Ending Childhood Obesity (ECHO) (World Health Organization, 2015a, 2016b; World Health Organization Commission on Ending Childhood Obesity, 2015). The final report proposes school-based interventions as one component of the six strategies identified to support reduction in childhood obesity and contribute towards long-term NCD risk reduction. It identifies the need for engagement and consultation with education, acknowledging that interventions must have educational rigor, be co-constructed with teachers and embedded within mainstream curricula (World Health Organization, 2016b). Inclusion of this statement, not seen in the interim report (World Health Organization Commission on Ending Childhood Obesity, 2015), followed consultation with education (Commission on Ending Childhood Obesity, 2015). This transactional process supported recognition and respect of partner sector perspectives. By investing in inter-sectoral consultation the Commission moved the report from a draft document imposing health-driven guidelines on education, to a document proposing action via multi-sectoral partnership. This significant change in approach offers potential to address recurrent failure of school-based health interventions resultant from lack of connection with the core mission of schools (Waters et al., 2011).

2.2.3. Partnership Engagement

Education, often seen as a panacea for multiple social ills, may react sceptically when yet another issue to be addressed in schools is identified. While science/health has recognized adolescence as a valid point to disrupt transgenerational obesity/NCD cycles, this is not core business for education. To accept and sustain the invitation to lead intervention design and facilitation, the education sector (both leaders and teachers) needs to examine the relevant scientific and health evidence in depth, and consider the potential for the NCD/DOHaD context to support educational goals. We intentionally define education as the leader of intervention design. Health and education leaders within our DOHaD translation partnership programmes believe that inviting education to lead intervention design has achieved significantly more than when health develop and offer interventions to schools (Iro and Townsend, 2016), which inevitably do not fit with schools’ core missions, and as commonly cited (Waters et al., 2011), as a result are not sustained.
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Non-educators involved in partnerships need to appreciate modern pedagogy and practice. Shifts in understanding of the nature of knowledge (epistemology) in the past 20 years have seen a move from positivism towards constructivism, promoting learner-centred classrooms (Land et al., 2012). While this move towards learner-centred classrooms promotes development of competencies recognized as essential for 21st century learners (Hipkins et al., 2014), it also challenges the enduring belief that teaching is “primarily about the transmission of subject matter from teacher to student” (Timperley H., 2011, paragraph 11). Multi-sectoral engagement must therefore provide opportunities for partners to explore and challenge personal attitudes, beliefs and perceptions (about NCDs and education), enabling others’ perspectives to be considered.

2.3. Intervention Design: Theoretical Underpinnings

It is appropriate that intervention design is informed by the core contributing fields; science, education, public health. This adds challenges to the process of intervention design as each contributing sector must engage with and develop an appreciation of all relevant evidence. We present in this section important theoretical contributions from relevant contributing sectors.

2.3.1. Sense-Making in Complex Adaptive Systems: Challenging Reductionist Thinking

Intervention design facilitating multi-sectoral action to empower adolescents as agents of transgenerational NCD risk reduction can be usefully informed by complexity theory, “a theory of change, evolution, adaptation and development for survival”, which challenges reductionist approaches to understanding phenomena (Morrison, 2008). Both the NCD epidemic (Pearce and Merletti, 2006) and schools (Morrison, 2008) are classified as complex adaptive systems. They are dynamic, involving multiple elements interacting non-linearly with each other and the environment. Elements evolve in response to interactions, influenced by historical and current settings. Small changes within the system may produce disproportionately significant consequences (Plsek and Greenhalgh, 2001; Snowden and Boone, 2007). Thus, actions to address transgenerational NCD risk require change about and within interacting complex adaptive systems.

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1 Positivism refers to a position where knowledge is only determined by empirical observation. Constructivism identifies that people construct understanding of new knowledge based on previous knowledge, understanding and experiences.
Sense-making is a social process involving exploration and interpretation of divergent perspectives to make sense of and respond to current and future issues (Snowden, 2005). The Cynefin model, describing knowledge in relation to cause and effect as known, knowable, complex (or emergent) and chaotic (Kurtz and Snowden, 2003) supports this process. While developed for organizational management, it is applicable to health (Van Beurden et al., 2011) and education (Rosebery and Puttick, 1998), and useful within multi-sectoral planning and resultant interventions.

Reductionist thinking, promoting individual responsibility or blame over understanding of complex social and biological determinants of risk, is frequently used in relation to NCDs/DOHaD, particularly at the level of public communication. Legitimate in the context of defined best-practice, where cause and effect relationships are, or can be, made evident to everyone, this perspective is inadequate in relation to causality of NCD risk. Application of the Cynefin sense-making approach to inform health promotion strategies addressing complex issues “challenges preferential engagement with ‘down-stream’ issues and validates contextualized emergent practice within communities when working with complex issues” (Van Beurden et al., 2011). In relation to school-based interventions, sense-making, because it focuses on exploring multiple perspectives, can support:

- intervention design by multi-sectoral teams;
- contextual adaptation and integration of interventions within schools; and
- age-appropriate exploration of dynamic relationships between knowledge (known, knowable and emergent) and system agents contributing to the determination of NCD risk by participating adolescents, leading to evidence-based decision-making.

2.3.2. DOHaD: Biological Evidence Supporting Adolescent Intervention

The rationale for primary and transgenerational prevention of NCD risk via adolescent intervention, outlined briefly in the introduction, emerges from the field of DOHaD. This evidence must be made accessible to all partners in a manner that enables it to be understood and contextually interpreted by programme facilitators.

In animal models, under-nutrition and obesogenic early-life environments result in offspring with a propensity towards subsequent development of metabolic or cardiovascular diseases (Vickers, 2011). Evidence exploring the timing of environmental insults impacting development shows that from gametogenesis through fetal development, impacts from environmental exposures may contribute towards adverse long-term
outcomes (McMillen et al., 2008; Watkins et al., 2010). Longitudinal human cohort studies have identified the contribution of early life environmental exposures to long-term health and wellbeing within differing socio-ecological settings (Godfrey et al., 2011; Joglekar et al., 2007; Roseboom et al., 2000). Importantly, these data highlight relationships between sociological and physiological determinants of long-term health. We emphasize contribution, rather than absolute determination of adverse outcomes, a point important in communicating and translating DOHaD evidence.

Evidence of mechanisms underpinning the impact of early life environmental exposures on later-life health has demonstrated that during critical life-course periods, developmental plasticity creates the potential for environmental exposures to influence regulatory pathways by altering gene expression in response to favourable or unfavourable conditions. The latent phenotypic influences resulting from developmental plasticity may be associated with increased neuro-cognitive developmental challenges (Räikkönen et al., 2012; Shenkin et al., 2004), early puberty (Sloboda et al., 2007), overweight and obesity, metabolic syndrome (Fall, 2011; Godfrey et al., 2010), type 2 diabetes mellitus, cardiovascular diseases (Blackmore and Ozanne, 2013), osteoporosis (Holroyd et al., 2012), allergic diseases (North and Ellis, 2011), affective disorders (Räikkönen et al., 2012; Schlotz and Phillips, 2009), and altered reproductive function (Chadio and Kotsampasi, 2013). Current evidence strongly supports the hypothesis that epigenetic mechanisms, such as DNA methylation, histone acetylation and non-coding RNA expression, are responsible, at least in part, for altered phenotypes (Godfrey et al., 2011; Lillycrop and Burdge, 2012; Wang et al., 2013). In some cases these changes could be transmitted across generations as well as between mother and fetus (Aiken and Ozanne, 2013; Skinner et al., 2011), and are not always stable, offering the potential for modification via targeted nutritional or other intervention (Burdge et al., 2012).

Collectively, these data suggest that two forms of preventive intervention are theoretically possible. First, by improving adverse nutritional and environmental exposures before and during pregnancy, predictive adaptive or conditional responses that lead to phenotypic vulnerabilities such as increased later-life NCD risk could be minimized, Figure 2.2. Secondly, the potential to identify mechanisms to reverse epigenetically mediated modulation of gene expression for key genes and regulatory pathways could lead to focused interventions. Currently, very limited evidence of the potential to reverse the impacts of programming exists and is predominantly based on outcomes from experimental animal models (Vickers, 2011; Vickers and Sloboda, 2012); therefore, significant further evidence is
required before such approaches are considered. This leaves behaviour change relevant to improving environmental exposures prior to and during pregnancy, childhood and adolescence as the primary focus for interventions. Combined with evidence of the role of adolescence in the setting of health-related behaviours (described earlier), this established the biological basis for DOHaD interventions during adolescence. To design and facilitate school-based interventions, teachers, no matter what their discipline, should be provided with opportunities to examine and make sense of these data.

Figure 2.2. Life-course view of noncommunicable disease (NCD) risk.
Risk increases in a nonlinear way as a result of declining plasticity and accumulative damage from lifestyle-imposed or other challenges. The effect of mismatch between developmentally and evolutionarily influenced phenotype and adult environment also increases through the life-course. Interventions in adults, especially those at high risk, can be beneficial, but only to a degree. Screening in middle-aged adults may also be too late to reduce risk substantially. Interventions in adolescents and young adults are likely to be more effective and, importantly, can reduce the risk of NCDs in the next generation. The prenatal period establishes risk through interaction between genetic, epigenetic and environmental factors. (From Hanson and Gluckman 2014, Physiology Review 94: 1027–1076, with permission.)
2.3.3. Science Communication: Challenging Transmission, Promoting Transaction

DOHaD research evidence has reached a point where, if applied in community settings, it has the potential to improve health and wellbeing (social and economic). This does not mean that new evidence will not continue to emerge, but does mean that the right of every human to “share in scientific advancement and its benefits” (United Nations General Assembly, 1948) must be respected. Thus, effective communication and translation of DOHaD research evidence must be prioritized.

Core to this science communication/translation process is the concept that programmes must facilitate contextual interpretation of evidence within communities for whom it has relevance, so that individuals and/or groups can decide how to use (or not use) the evidence. Hence, we need to examine the concept of science communication, and how this is interpreted by sectoral partners within intervention design to enable individuals and communities (not scientists and health professionals) to decide on contextually relevant evidence-based actions.

Traditional views of science communication, defined by positivist epistemology, identify knowledge as descriptions of phenomena that can be observed, measured and absolute. This leads to the belief that knowledge can be transmitted from expert to public, creating an informed society that uses scientific evidence in decision-making (Wynne, 1991). Established by the Public Understanding of Science (PUS) movement in the 1980s and underpinned by deficit models of learning (Siune et al., 2009; Wynne, 1991), transmission-based communication models lack meaningful engagement, supporting neither development of trust nor empowerment of citizens to use science knowledge in decision-making (Nisbet and Scheufele, 2009). More enlightened ideals associated with the Science in Society movement (Siune et al., 2009), alongside concepts of Knowledge Translation, Knowledge Exchange, and Integrated Knowledge Translation (Gagnon, 2011), support transactional communication and engagement. These recognize that knowledge application is situated, and that requirements for interaction between research and knowledge-user communities necessitate this process to be social (Bennett and Jessani, 2011), and consequently dependent on relationships. This represents a constructivist epistemology, common in education. Constructivism identifies that because knowledge is situated, it cannot be transmitted, meaning that individuals construct understanding based on previous knowledge and experiences (Ultanir, 2012). However, what do we mean by knowledge?
Should we be discussing knowledge at all? Has it not been proven that knowledge does not contribute to behaviour change? While it is known that knowledge does not necessarily lead to behaviour change (Bruun Jensen, 2000), it is also known that knowledge is necessary, but not the sole factor required to facilitate behaviour change (Worsley, 2002).

Knowledge is a multi-dimensional concept that encompasses more than a collection of facts. It can be categorized as declarative (or content), procedural, and epistemic. The ability to use knowledge in decision-making is influenced by attitudes, competencies and context. In modern schooling, rather than transmitting declarative knowledge, teachers facilitate learning experiences that allow students to examine, question, challenge, and formulate their own ideas, opinions, and conclusions (Ultanir, 2012). As well as supporting the construction of understanding such learning promotes: exploration of values and dispositions; development of skills associated with interpretation and analysis of evidence from varying perspectives; and capabilities associated with acting on evidence. This process is learner-centred and transactional, recognizing that social processes support students to question beliefs and negotiate uncertainty and diverse ideas. This does not reject core disciplinary knowledge. Teachers facilitate opportunities for students to access established disciplinary knowledge from which they can examine their own and others’ perspectives (Hipkins et al., 2014).

When research evidence is explored in open, non-linear learning environments that present multiple perspectives on an issue alongside core scientific and sociological concepts, development of understanding that leads to conscious decision-making initiated by adolescents is possible (Bay et al., 2012a). This transactional process is enabled via use of narrative, known to facilitate learning and enable access to evidence (Bay et al., 2012c; Grace and Bay, 2011). Therefore, teachers need access to narratives that humanize the process by which this evidence has evolved (Barker, 2008; Bay, 2016b; Bay, 2016a), enabling exploration of the journey of scientific and/or sociological discovery, as well as stories of NCDs and their impacts within communities (Bay and Yaqona, 2016). These narratives simultaneously facilitate development the capabilities required to negotiate evidence and complex socio-scientific issues.

Transactional, learner-centred programmes that facilitate construction of meaningful understanding of evidence from which decision-making can emerge differ significantly from transmission-based science communication, such as that used to facilitate mass public awareness. Campaigns such as “5+ a day” transmit declarative knowledge via mass media,
pamphlets, posters etc. without the opportunity to enable the public to engage with evidence that has led to the knowledge. Furthermore, in such programmes little opportunity exists for collaborative construction of contextual understanding of this knowledge. Thus, it is not surprising that such programmes are known to improve awareness but not change behaviours (Ashfield-Watt, 2006). While often labelled as “education programmes”, use of the term education in this context differs significantly from education as a transactional learner-centred process. Therefore, it is important to unpack what we mean by education, as when working across multi-sectoral science-health-education partnerships we have identified that differing understanding of terms such as education, curriculum, knowledge, capabilities and learning are a key issue that if not addressed can lead to significant misunderstanding.

2.3.4. Complexity of Risk and Impact: Why Educators are Enthusiastic about NCDs

The complexity of NCD cause and effect must underpin intervention design. This complexity, while challenging, presents significant educational opportunity with respect to development of competencies enabling critical engagement in open-ended social issues (Hipkins et al., 2014), validating partnership engagement for education. From a citizen’s perspective, the challenges in making sense of NCD cause and effect stem from the:

- extremely broad profiles of NCDs as a disease cluster;
- latency between environmental exposure and potential identification of risk;
- extended time over which risk and morbidity develops;
- breadth of physiological systems that may be impacted; and
- complex interaction of sociological, environmental, genetic and epigenetic factors that contribute to NCD risk profiles for individuals, families, and populations, including
  - the double burden of maternal and child malnutrition alongside child and/or adult overweight, obesity and NCDs found in low- and middle-income countries and socially/economically disadvantaged populations, and
  - impacts emerging from climate change, nutritional transitions, and food insecurity.

DOHaD evidence is a component of this complexity. The impact of early life exposures on later-life NCD risk is neither isolated nor absolute, but resides within a life-course approach to understanding NCD risk, disease and prevention (Ben-Shlomo and Kuh, 2002). Furthermore, DOHaD mechanistic evidence frequently comes from tightly controlled animal models. When over-simplified, these models can inadvertently suggest individual
blame, with the mother’s actions determining outcomes in the next generation (Richardson et al., 2014). While this contrasts from commonly held views of individual lifestyle determination of NCD risk, both are inadequate.

This matrix of interacting factors impacting NCD risk creates multiple rich contexts for learning that is designed to facilitate development of capabilities required for critical engaged citizenship. Intervention design should enable age-appropriate exploration of current and historical influences on and beliefs about NCD risk, facilitating students to identify and challenge beliefs and assumptions (personal, family, and societal) and negotiate concepts of: association rather than determination; transgenerational risk; and interaction between environmental and biological factors within a broader societal context. Learning such as this supports competency development, and empowers evidence-based actions.

2.3.5. Capabilities Required to Negotiate Socio-Scientific Issues: Partnership Value of and for Education

Initiated by the 1970s Science, Technology and Society movement, examination of socio-scientific issues is a universally agreed component of schooling (Millar and Osborne, 1998; NGSS Lead States, 2013). Despite extensive literature examining learning frameworks (Levinson, 2006; Sadler, 2009), science education remained strongly focused on development of universal and decontextualized knowledge (Levinson and Thomas, 1997), lacking exploration of social and political interactions with science. Only recently has education planning and design examined the need for adolescents to develop capabilities required to engage actively with open-ended, complex, and socially relevant issues (Hipkins et al., 2014) within and across multiple subject areas. These capabilities encompass key competencies, scientific and health literacies, and self-efficacy. Their development via exploration of NCDs should be central to intervention design and offers validity to the education sector in joining partnerships.

2.3.5.1. Key Competencies

In response to challenges of increasing social complexity, the education sector, via the Development and Selection of Competencies (DeSeCo) programme, defined competencies required for individuals (beyond the basics of reading, writing, and calculating) to “lead an overall successful and responsible life and for contemporary society to face present and
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future challenges” (OECD, 2001). They sit within a matrix of context-specific capabilities associated with:

- interactive use of tools (language, text, knowledge, information, technologies);
- interactions within heterogeneous groups (the ability to relate well to others, cooperate, manage and resolve conflict); and
- the ability to act autonomously (act within the big picture, form and conduct life-plans and personal projects; defend and assert rights, interests, limits, and needs) (Rychen and Salganik, 2005).

In the context of NCDs, these competencies contribute to the ability of adolescents to engage with evidence (sociological and scientific) and decide how individual, community and societal actions may be beneficial. Capabilities associated with knowledge and understanding of science and health are also required.

2.3.5.2. Health Literacy

Health literacy describes a set of capabilities supporting and enabling evidence-based decision-making related to wellbeing and health at personal, community and societal levels and is therefore an important aspect of intervention design. While definitions are variable and at times confined to health-service literacy, the asset model of health literacy proposed by Nutbeam considers the capabilities required to enable critical informed engagement in decision-making.

“Health literacy implies the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions. Thus, health literacy means more than being able to read pamphlets and make appointments. By improving people’s access to health information, and their capacity to use it effectively, health literacy is critical to empowerment.” (Nutbeam, 1998).

Nutbeam’s ongoing refinement of this model presents the capabilities within a frame of increasing cognitive demand. Useful from an educational perspective, it moves from basic/functional literacy, associated with skills for daily living, towards communicative/interactive literacy, and finally critical literacy, associated with capabilities required for decision-making within complex contexts (Nutbeam, 2000). Importantly, for application to primary NCD prevention, this definition is based on a salutogenic framework (Lindström and Eriksson, 2005), focusing on wellbeing rather than disease, and recognizing the role of individuals and community in determining the potential of available resources.
in health-related decision-making. This correlates strongly with perspectives of capability development required for critical engagement in open-ended social issues (Hipkins et al., 2014).

2.3.5.3. **Scientific Literacy**

Scientific literacy is associated with the ability to use scientific knowledge and understanding in decision-making at personal, community and societal levels (Laugksch, 2000). Therefore, in conjunction with health literacy is a critical component of intervention design. Scientific literacy describes capabilities enabling suitably motivated individuals to engage in discourse about science and technology to:

- explain natural and technical phenomena;
- evaluate and design scientific enquiry; and
- interpret data and evidence scientifically (OECD, 2013).

This recognizes that attitudes associated with interest and engagement in the role of science and use of scientific knowledge within society are components of scientific literacy (OECD, 2006). It identifies that required capabilities include more than just knowledge; however, that knowledge is important. Furthermore, it highlights the importance of understanding processes by which scientific knowledge is derived and validated (OECD, 2013).

Intervention design should support development of capabilities associated with scientific literacy within three increasingly complex levels of engagement: personal/family, community, and societal (nationally, regionally, and globally). They are moderated by development of attitudes and dispositions promoting engagement in social issues. As such, scientific literacy contributes to the matrix of capabilities required for critical, informed and responsible citizenship (Rychen and Salganik, 2003) required to enable societal interaction with NCD and DOHaD evidence.

2.3.5.4. **Self-Efficacy**

The matrix of capabilities described above contributes to individuals or groups engaging with and acting upon scientific and sociological evidence. The extent to which intention leads to sustained action is impacted by self-efficacy and the social/emotional environment. Self-efficacy is the extent to which individuals or communities believe they have the capacity to accomplish a task. Self-efficacy may fluctuate. It is influenced by past experiences, vicarious experiences (modelling from significant others), verbal persuasion,
and physiological feedback (Bandura, 1977). Self-efficacy understanding and development should be integrated into intervention design.

2.3.6. Investing in Teachers: Developers and Facilitators of School-Based Interventions

Teacher quality, preparation, beliefs, and commitment are significant controllable factors that enable educational change and influence student learning (Darling-Hammond et al., 2009; Hattie, 2012). Health workforce capacity development is an agreed NCD prevention and control strategy (Barry et al., 2013). Where the workforce comprises teachers, intervention design must include teacher professional learning and development (PLD) encompassing education, health, and science.

Within multi-sectoral partnerships, lead providers are likely to develop intervention frameworks and core resources, enabling schools to lead intervention adaptation to create contextually appropriate programmes contributing towards educational and health goals in each community. Participatory teacher research, a collaborative process whereby teachers, via critical analysis, develop, implement, and evaluate education interventions, is an effective form of PLD to facilitate change (Henson, 2001). This requires teachers to be learners, a fundamental condition for educational development (Weinbaum, 2004). This process is inclusive of pedagogy, health and science, and should identify how NCDs/DOHaD can be usefully employed as contexts for learning, contributing towards both health and education goals (Bay and Mora, 2014).

Through PLD processes, teachers will adapt programmes to ensure they are supportive of learning for and within school communities. This addresses the ever-present challenge of diversity within and between schools, suggested as a reason why evidence-informed health policies and practice applied to school-based health promotion do not always yield similar outcomes (Keshavarz Mohammadi et al., 2010).

Schools are constantly challenged by change and the need to respond to change (Morrison, 2008). Diversity within and between schools, created by multiple dynamic social, cultural and economic factors, contributes to this complexity. When diversity is not addressed, achievement variance (social and academic) is magnified, indicating under-servicing of some groups (Haque, 2015). Non-prescriptive or devolved education policies (such as national curricula) promote school-level autonomy, creating opportunities to address heterogeneity. This recognizes that because of complexity, application of best practice is frequently not
legitimate in school settings. Educators are required to be adaptive experts, “retrieving, organizing and applying professional knowledge in light of the challenges and needs presented by the students they are teaching” (Timperley H., 2011). This reflects the ‘teaching as inquiry’ cycle (Weinbaum, 2004), promoting evidence-based actions by teachers, not as generalizations, but as differentiated responsiveness, ensuring that learning is meaningfully and efficiently directed to all students (Hattie, 2012). Difficulties related to heterogeneity suggest programme design may lack adequate educational input, including opportunities at the outset for school-level contextualization followed by development/adaptation in response to reflective critique.

2.4. Conclusions

Biological and sociological evidence points to the potential of schools as a setting for interventions that support transgenerational interruption of the NCD/obesity cycle; however, historically, school-based health interventions have been problematic. Recognition of evidence from multiple sectors and disciplines offers the opportunity to address these historical challenges, which may have occurred due to lack of true partnerships demonstrating mutual respect within multi-sectoral engagement.

On investigation, educators identify in NCD/DOHaD socio-scientific issues of relevance to multiple communities with significant potential as contexts to facilitate learning. When the breadth of later-life health issues impacted by early life environment is linked to social determinants such as poverty, food security, sustainable energy, climate change and technologies, the potential of the context across learning areas ranging from science and health to humanities, arts and languages is identified. This breadth enables multiple exposures via related learning experiences, increasing intervention dose and strength.

Educators need to create the conditions in which adolescents can be empowered as agents of change with respect to obesity, NCDs and socio-ecological impacts. This can only occur when educators are themselves empowered as facilitators of this change, a process that requires transactional engagement between education, health and science communities so that collectively the opportunities can be recognized and enabled.

In effective school-based partnerships, intervention design, while co-constructed, will be led by educators, ensuring links to the core mission of schools. Interventions should:

- support educational and health goals in equal measure;
be underpinned by appropriate pedagogies utilizing constructs such as student-centred learning, constructivist and inquiry-based epistemologies and epistemic thinking;
• support fulfilment of national-level curriculum, assessment and pastoral care policies and objectives;
• enable integration into school-level curriculum and policies (academic and pastoral), and support strategic development goals;
• provide resources that are designed to be adapted by teachers to meet social, cultural, pastoral and academic needs within their school community and classes, thus supporting development for all learners;
• be evaluated via protocols that are inclusive of the school community and the sectoral partners; and
• acknowledge that learning environments, scientific and health evidence are dynamic constructs, and that programmes should evolve over time.

There are currently some programmes addressing the potential for DOHaD informed adolescent interventions based on the principles described in this paper occurring in a range of socio-cultural settings. Evidence is emerging, but needs to be developed. The complexity of the school setting, and NCD risk is challenging, and there is room for further exploration of interactions such as those between the school, the adolescent, the family and the community. Research into how such partnerships are developed and maintained should be prioritized, as should publication of evidence that is inclusive of education perspectives. Examination of the impact of programme initiation at different phases of child development (for example pre, vs. post pubescent), the impact of ongoing programme engagement from childhood into adolescence, and the potential for family-involvement should be explored in greater depth. Detailed analysis of intervention tools and empirical evidence relating to education and health, including case studies from a range of contexts and eventually prospective studies, are required.
Chapter 3. School-based primary NCD risk reduction: Education and public health perspectives

Preface

The debate presented in this chapter was published in Health Promotion International. It presents a body of work that has evolved through a Worldwide Universities Network collaboration for which I am the academic lead. This collaboration has brought together a multi-sectoral team from education, public health, and science working in developed and developing nations spanning Oceania, Asia, Europe, the Americas and Africa. The focus of the collaboration is the appropriate evaluation of multi-sectoral intervention programmes associated with opportunities for primary NCD risk reduction in the adolescent life-phase. The paper examines the challenges associated with enabling assessment measures that account for education and health viewpoints in determining the potential efficacy of schools as a setting for primary NCD risk reduction.

As in Chapter 2, this paper is intended for audiences spanning science, health and education. Consequently, the paper is designed to enable accessibility to readers with varying levels of knowledge of the literature from each field.

3.1. Introduction

The incidence of noncommunicable diseases (NCDs) and prevalence of related risk factors are rising rapidly, creating social and economic burdens across both developed and developing nations. This threatens the considerable progress in economic growth and social standards achieved in the past century (Bloom et al., 2011). Primarily comprising type-2-diabetes mellitus (T2DM), cardiovascular diseases (CVDs), cancers, and chronic respiratory diseases, NCDs are the leading causes of preventable morbidity, related disability, and premature death globally. The greatest impact is in low and middle-income economies, transitioning populations, minority ethnic groups and socially disparate populations (World Health Organization, 2011).

An estimated 80% of premature deaths caused by T2DM and CVDs may be prevented by changing risk behaviours, such as unhealthy diet, physical inactivity, tobacco and harmful alcohol use throughout the life course (World Health Organization, 2011). Of significant concern are the rapidly rising rates of overweight and obesity, major NCD risk factors directly associated with T2DM, CVDs and some cancers (Park et al., 2012). Once established, risk factors (e.g. overweight, obesity and smoking) are difficult to reverse, and if established by adolescence, may continue into adulthood (Robinson and Bugler, 2010; Waters et al., 2011). One consequence is high proportions of overweight or obese women of reproductive age (Hillemeier et al., 2011), thus perpetuating the disease cycle across generations (Hanson and Gluckman, 2014).

Traditionally, strategies addressing NCD risk focus on secondary prevention and treatment, addressing overweight and hypertension once emerged, aiming to reduce disease development (Müller et al., 2001) or curb progression once established. While these approaches help to reduce morbidity and mortality, and should continue, some are prohibitively costly, particularly in lower income countries (Beaglehole et al., 2011a). Incorporating primary NCD risk prevention strategies would slow the exponential growth of the global NCD burden by precluding development of risk factors, that when present, may lead to disease onset (Hanson et al., 2012).

Primary prevention strategies typically centre on children, adolescents and young women, and support actions facilitating long-term, sustainable behaviour change to prevent the development of risk factors and subsequent disease onset in later-life or future generations. The validity of these approaches arises from evidence of developmental components of
metabolic disease risk (Balbus et al., 2013). Development of sustainable health-promoting
behaviours in critical and sensitive periods prior to conception and during early-life
development offers opportunities to establish low-risk trajectories for future metabolic
disease with far greater effect than traditional secondary strategies (Hanson and Gluckman,
2014).

Our focus is the potential of school-based programmes implemented during adolescence, a
significant life phase during which patterns of future health are established (Todd et al.,
2015). These patterns are influenced by complex interactions between puberty,
development of neurocognitive maturity and social role transitions within the adolescent’s
social context (Sawyer et al., 2012). Schooling is a significant component of this context,
strongly influencing cognitive, behavioural and social development. Patterns of adolescent
behaviour, including diet, physical activity and cognitive development, track through to
adulthood (Craigie et al., 2011; Steinberg, 2005).

The potential role of education in primary prevention of NCD risk was highlighted at the
2011 United Nations’ Meeting on the Prevention and Control of NCDs. While focusing
mainly on secondary prevention strategies for adults, the emerging declaration formally
recognized the role of early-life development in NCD risk (paragraph 26) and identified
education (both in and out of school) as an essential component within cross-sectoral

Although schools are a common setting for health promotion, their value in reducing risk
factors for NCDs is unclear (Khambalia et al., 2012). This paper aims to examine aspects of
cognitive development required to support and sustain behaviour change. It identifies both
immediate and longer-term outcomes that should be measured to assess the efficacy of
school-based programmes linking learning relevant to school curricula to learning
supporting long-term health and wellbeing. Thus we focus on development of personal
skills and capacity, one of the five strategies for health promotion identified within the
Ottawa Charter (World Health Organization, 1986); acknowledging that this occurs within the
socio-ecological context of students, their families, school communities and wider society.

We believe this discussion is critical and long overdue. The physiological and mechanistic
evidence for primary intervention to support reduction in NCD risk factors prior to disease
onset is strong. However, without application of education theory alongside health and
scientific theory, attempts to capture the potential of school-based primary NCD prevention
interventions are likely to be minimal. Neither health programmes nor education alone can effectively capture this potential. Multi-sectoral collaborations that measure whether or not learning which has the potential to stimulate empowerment leading to sustainable behaviour change has occurred, thereby conceivably altering health trajectories, have significant prospects for long-term health and social gain.

3.2. Discussion

3.2.1. Requirements for programmes empowering youth to take and sustain health-promoting actions

The challenges associated with developing and sustaining health-promoting behaviours associated with reducing NCD risk factors, are significant. They encompass complex interrelated socio-ecological determinants of health-related behaviours (individual and societal). For adolescents to engage in issues pertaining to NCD risk and its impact on individuals, families, communities and society, they need to become empowered life-long learners who possess the capabilities required to seek out and use appropriate evidence in health-related decision-making. These capabilities are core within school curricula internationally. Utilizing schools for primary NCD risk reduction requires understanding of what these capabilities are and how they may be developed. Impact assessment should examine whether appropriate learning and capability development has occurred and, if so, whether this leads to sustainable health-promoting behaviours. Thus, factors relevant to both education (engagement, learning, and development of capabilities supporting evidence-based decision-making) and health (resultant behaviour, impact on current and future health) must be assessed in tandem. As programmes are set within schools, evidence of positive contributions towards achievement of learning outcomes, defined by national and local curricula, should be identifiable to validate the use of school time. Therefore, measurement of the impact of education programmes aiming to contribute to primary NCD risk reduction requires multidisciplinary approaches acknowledging the core learning and development role of schools.

The capabilities required for evidence-based decision-making and actions concerning health-related socio-scientific issues such as NCDs are associated with the development of key competencies for living, health and scientific literacies, and self-efficacy (Bandura, 1977; Laugksch, 2000; Nutbeam, 2000; Rychen and Salganik, 2005). Within schools, learning supporting development of these capabilities is initially related to decision-making and
action at individual, family and peer group levels. As learning advances, this extends to the analysis of potential evidence-informed actions at community and societal levels (OECD, 2013), such as those required to address the impact of inequities on health and wellbeing. These educational constructs, central to the potential of school-based contributions towards primary NCD risk reduction, are explored below.

3.2.2. Key competencies for engaged citizenship

The increasing societal impact of complex socio-scientific issues has been a key driver for change in education over the past 20 years (Rychen and Salganik, 2005). Socio-scientific issues (SSIs) are complex, socially relevant issues with conceptual or procedural links to science (Sadler, 2004), many of which impact health and wellbeing. Complex issues involve multiple factors with the potential to interact with each other and the environment in non-linear and unexpected ways, impacted by historical and current social and physical contexts (Plsek and Greenhalgh, 2001). Responses to complex issues are values-laden and require consideration of divergent perspectives (Hipkins et al., 2014). Examination of how education should respond to prepare adolescents for such complexities resulted in the Organisation for Economic Co-operation and Development (OECD) Definition and Selection of Competencies (DeSeCo) programme, which defined the key competencies for a successful life and well-functioning society (Rychen and Salganik, 2003). This characterizes capabilities contemporary youth need to participate as critical, informed and responsible citizens, proactively facing current and future challenges, including those associated with health (Rychen and Salganik, 2005). Examples of SSIs applied as contexts for learning aiming to empower authentic action include climate change, food security and social inequities. Crossing multiple learning disciplines SSIs provide contexts for the development of competencies for engaged citizenship (Hipkins et al., 2014).

3.2.3. Health and scientific literacies

Health and scientific literacies are related capability sets supporting evidence-based decision-making leading to action at personal, community and societal levels. Health literacy relates to health and wellbeing. It requires application of skills, capabilities and understanding that allow an individual or group to access, interpret and act upon health-related information (Nutbeam, 2000). Scientific literacy relates to relevant issues for which the application of conceptual and procedural understanding is linked to science (OECD, 2013). As with health literacy, these capabilities are associated with access to, and
interpretation of, scientific information relevant to the context or issue in question. ‘Literacies’ in this context describe the possession of knowledge, skills and dispositions that allow engagement in aspects of modern life (Harlen, 2001). School-based education occurs in learner-centred, transactional environments where, rather than information being transmitted (which by necessity occurs in mass media based health promotion), learners interact with evidence and construct meaning from which may emerge understanding and actions. Thus, the development of capabilities that enable meaning-making is essential for empowerment that provides opportunities for evidence-based decision-making. Scientific evidence is significant in health-related issues, making scientific literacy highly relevant to health literacy, and offering potential for co-development in schools (Grace and Bay, 2011). These authors argue that health literacy is a precondition for education for sustainable development and citizenship and cannot be isolated from scientific literacy. Furthermore, it is increasingly argued that the examination of SSIs within future-focussed learning requires integration of concepts and thinking relevant not only to science and health, but also environmental education (Zeyer, 2014). This concept of interdisciplinary learning is increasingly promoted in modern educational thinking. Re-organisation of curricula from isolated disciplines to network-based learning draws together multiple disciplines to examine ‘life and world problems and opportunities’ that provide context for future-focussed learning (Perkins, 2014). While still not common-place (particularly in secondary education), this evolving approach to learning and teaching offers significant potential to empower young people to embrace engaged citizenship and challenge socio-ecological determinants of health inequities, including those that promote increased NCD risk across the life-course.

### 3.2.4. Self-efficacy and engagement

Capabilities are defined as requiring the integration of knowledge, skills, attitudes and values. Inclusion of attitudes and values underscores the importance of being disposed to act on new learning, precisely the challenge posed by the intention of school-based programmes to facilitate NCD risk reduction. Capabilities also draw attention to the importance of ongoing learning, and learning how to learn (Hipkins and Cowie, 2014). Some programmes also specify a focus on ‘being’, that is, the qualities that education systems aspire to nurture in young people (Hipkins and Cowie, 2014). The values component plays a critical role, by nurturing young people to become active builders of their own lives, rather than passive recipients of what happens to them (Hipkins, 2005). This concept of being is
associated strongly with self-efficacy, the fourth component of development required by school-based programmes designed to support life-long health and wellbeing. Self-efficacy is the extent to which a person or group believes they have the capacity to learn, carry out a task, take action, or function socially (Bandura, 1977). This is influenced by a matrix of factors that, in adolescents within a school environment, can be enhanced to encourage positive development (Gibbs and Poskitt, 2010). Self-efficacy is also associated with engagement in learning, an essential precursor to the achievement of learning outcomes, such as development of the aforementioned capabilities (Gibbs and Poskitt, 2010). Engagement is a complex construct encompassing interactions between behavioural, emotional and cognitive dimensions (Fredricks et al., 2004). Levels of engagement vary over time, impacted by internal factors such as self-efficacy, and external factors determined by teaching style and context (Hipkins, 2012). Collectively, development of key competencies for engaged citizenship, health and scientific literacies and self-efficacy, within the socio-ecological context of the young person and school community, impacts programme effectiveness.

3.2.5. Education and health: sector-specific differences in approaches to impact measures

While the relevance of health-associated learning programmes is supported by education and health sectors, programme purpose and associated impact measures are often defined differently by each (St Leger et al., 2007). Health-driven programmes generally are relatively short-term and focus on physical health outcomes associated with prevention of risk factors and disease (Dobbins et al., 2013; Lobelo et al., 2013). Some only target significantly at-risk populations, while others employ school- or cohort-wide approaches. Alongside measures of attitude and behaviour, measures of change in physical health status indicators (e.g. blood pressure, body mass index (BMI) or lipid profiling) are commonly used as key indicators to evaluate such programmes (Khambalia et al., 2012). However, in general, less attention is paid to evaluating whether or not learning has occurred that enables development of the capabilities required to engage in health-promoting behaviour change, and, if so, whether capability development achieved has potential for life-long application. Programmes driven by the education sector tend to link directly to curriculum and learning goals, emphasizing application of pedagogies supporting health as well as educational outcomes. These focus attention on the development and assessment of capabilities supporting young people, either individually or collectively, to make informed sustainable
decisions about their health and wellbeing (Grace and Bay, 2011). Measures of capability development, knowledge, attitudes and behaviours are often used in assessment. However, these programmes tend not to include objective measures of physical impact.

### 3.2.6. Comprehensive measures accounting for both educational and health outcomes

Learning is a complex process that evolves over time and is impacted by interactions between the individual, their life history and their environment. Comprehensive assessment of the potential for learning programmes to support reduction in NCD risk factors should acknowledge the complexity of both learning and NCD risk development. Examination of multiple interacting factors contributing to processes leading from participation in an educative programme to sustained longer-term health-promoting behaviour change is required. These include programme design, implementation strategy (within the context of the classroom, the school, national educational policy, and the community (Samdal and Rowling, 2015)), and factors pertinent to the impact of the programme on individuals within classroom settings. These impact factors should be relevant to the programme and the setting and include:

- attitudes towards NCD-related health issues
- engagement in the learning programme and issues under investigation
- knowledge of NCD impact, risk and prevention across the life-course. (Impact, risk and prevention are inclusive of individual, family, community and society and include socio-cultural, environmental, economic, physical, emotional, and familial (genetic, epigenetic and social) factors)
- health behaviours – personal, family and peer group
- key physical and metabolic markers of health and wellbeing indicative of current and projected NCD risk.

Assessment at this depth is a significant undertaking. Restrictions associated with funding, time-related barriers in schools and families, and intrusiveness of evaluation strategies on participants will impact decisions regarding the extent of evaluation.

### 3.2.7. Indicators of development and application of capabilities

Assessment of complex learning, leading to the development of capabilities that enable potential for decision-making relevant to socio-scientific issues, is challenging (Acar et al.,
Theoretically such assessment should centre on evidence demonstrating that, when given the opportunity to participate in learning experiences that facilitate examination of socio-scientific issues, participants are motivated to engage in developing understanding and making evidence-based decisions relevant to their context. In a research setting this is typically assessed by combinations of pre/post questionnaires, focus groups or interviews, and examination of learning artefacts, such as student writing, presentations and reflective journals (Bay et al., 2012a). Learning artefacts, in particular, require significant educative interpretation. These diverse evidence sources must be combined to arrive at more generic metrics for purposes of further analysis (e.g. correlation with other measures).

The limitations associated with the resources required to measure authentic action emergent from learning mean that measures of capability development in schools typically may not extend to identifying whether students take and/or sustain actions. This is a challenge for the education sector. For example scientific literacy, one component of the required capabilities we have identified can be measured via assessments such as those presented in the internationally validated Programme for International Student Assessment (PISA) (OECD, 2013). These assessments present students with real-world problems and questions requiring use of capabilities associated with application of scientific literacy. However, such theoretical assessment is one step removed from making and justifying evidence-based decisions in life. Addressing this shortcoming requires measurement of actions initiated and potentially sustained in response to the exploration and analysis of evidence relating to complex social issues such as the impact of food insecurity on the prevalence of obesity in a defined community. Assessment measures of this type have the potential to provide indications of whether or not students will apply capabilities required for evidence-based action to their own lives. Knowledge, attitude and behaviour (KAB) questionnaires, tracked pre- to post-intervention through to at least 12 months, can provide evidence of such change. Behavioural measures utilise tools such as food, activity and health-risk behaviour frequency questionnaires, adjusted for contextual relevance (World Health World Health Organization, 2013). This type of self-reporting is accurate in adolescents for non-sensitive behaviours (e.g. diet and physical activity) (Norman et al., 2010), but may be compromised for sensitive issues (e.g. alcohol consumption or sexual behaviour) (Brener et al., 2003) and could be enhanced by the use of more resource-intensive measures such as food recall diaries and real-time activity monitoring. Comparative KAB data can provide evidence of capability use, associated with scientific and health literacies, to support
evidence-based decision-making (Huque et al., 2015). Where such questionnaire data are triangulated with interview data, the evidence is strengthened (Bay et al., 2012a). However, these examples represent the shortcomings of many assessment frameworks. They both lack evidence of physical health indicators over time, which if combined with the KAB data, could enable more definitive evidence of programme impact.

Examination of learning artefacts offers further evidence to evaluate whether learning facilitates change in capability development associated with evidence-based decision-making. Teachers have specialized skills in this type of assessment. For example, the tracking of capability development in science education should monitor improvements over time in the ability of students to ask questions, interpret evidence, make decisions and justify these from a combination of evidence and context analysis (Osborne, 2013). While challenging to achieve and interpret, evidence of this type can be used to demonstrate the development and application of competencies within and beyond the current academic year for individual students and cohorts. Additionally, this evidence validates the use of curriculum-based learning time. Utilization of data collected by schools, examining the relationship over time between capability development supported by a programme, and the degree to which participation leads to sustained behaviour change offers important information regarding programme design and how future learning, relevant to health-promoting behaviours, should be developed. Importantly, in a school setting, such data are collected from individuals as well as cohorts. Continuity of learning over time, an essential element within educational design and assessment, appears to be largely ignored by the health sector in analyses of using schools for promoting risk reduction for NCDs.

Processes enabling assessment of capability application in evidence-based decision-making are equally relevant to health and scientific literacies. However, perspectives differ on the meaning of health literacy and measurement of its development in terms of learning outcomes (Paakkari and Paakkari, 2012). In the context of adolescents and the role of schools in facilitating development and application of capabilities associated with health-promoting behaviours, we believe that health literacy should be viewed within a salutogenic framework (Lindström and Eriksson, 2005). This emphasizes a focus on wellbeing rather than disease, and recognizes that decisions and actions are determined by individuals, or communities, in the context of available resources. School-based education usually promotes critical health literacy models, through which, "students develop raised awareness of socio-ecological determinants of health, and recognise that individual and
collective actions may lead to modification of damaging determinants” (Sinkinson, 2011, ePub para.14). However, the literature also includes assessment of health literacy based on ability of individuals to obtain, process and understand basic health information and services (Ratzan and Parker, 2000). This model emphasises basic or functional health literacy, which while important, has a narrow focus, not accounting for the potential of individuals to take pre-emptive health-promoting actions.

Multiple interacting psycho-social factors relating to individuals will impact on whether or not adolescents move from decision-making to action-taking in relation to enactment of capabilities associated with both scientific and health literacies. The wider environment of the adolescent, including that of the family, is important in achieving sustained health-related behaviour change (Todd et al., 2015). In the context of school-based learning, the wider environment relates not only to the sociocultural context of the students and their family, but also to the wider context of the school community and the way in which the students and their family interact with the school community. These complex interacting factors are core considerations for teachers when designing learning programmes to meet the varying needs of students and unravelling factors influencing variable programme effects, Figure 3.1. Evaluation measures seeking to identify and understand these factors should include perspectives from the family, who are considered to be the most significant partner in supporting learning. As well as elucidating understanding of standard data held by schools relating to socio-economic and cultural factors, family perspectives can assist in determining whether learning has an impact beyond the individual, and confirm self-reported questionnaire data from the adolescent. Within schools the teaching as inquiry model (Weinbaum, 2004) is an established methodology used to examine relationships between context, mechanism and outcomes, and justify decisions pertaining to educational programme development. It is important to appreciate that learning programmes in schools are not static, but continually evaluate and respond to the context of the individual and community within which they are a critical socio-cultural component. Pawson and Tilley’s theory of realistic evaluation based on concepts of generative causality sits well with typical evaluative practice in schools, and similar to the teaching as inquiry cycle, recognises that evaluation findings are contextual, and thus have the potential to explain how, why and for whom particular programmes work (Pawson and Tilley, 1997).
3.2.8. Sense-making: examining evidence from multiple perspectives

‘Sense-making’ is a social process supporting the use of divergent perspectives related to decision-making (Snowden, 2005). In school-based programmes supporting linked health and education outcomes, sense-making may involve collaboration between teachers, public health professionals, community leaders and researchers. Collective examination of evidence (e.g. using Snowden’s framework) can provide insight otherwise hidden to researchers. In particular, in-depth consideration of perspectives of teachers responsible for programme adaptation and implementation should be utilized in addition to the traditional evaluations which tend towards the perspectives of researchers.

Prior to using externally developed learning resources, teachers engage in a process of analysis, examining potentials for resources to support the prescribed and/or intended curriculum. A process of interpretation and local adaptation follows, creating a programme plan designed to support the learning needs of students in a manner contextually appropriate.
for the school community, Figure 3.1 (Bay and Mora, 2014). Impacted by multiple interacting factors this nonlinear process determines the nature of final enacted programmes within classrooms. The impact of heterogeneity of programme enactment within and between schools can be explored through examination of teacher planning, learning artefacts and focus group data (teacher, student and family), triangulated with quantitative KAB and health data. Teachers implementing programmes should not be restricted to contributing evaluation data; they should be integral in bringing a unique lens to evidence interpretation. Alongside recognition of requirements for learning programmes to evolve and be responsive to strategic goals in schools and the needs of their community, this supports the potential for long-term sustainability.

3.2.9. Appropriate use of physical measures to assess long-term impacts on health

Sustainability of health-promoting behaviours is a key objective of school-based health-promotion; the potential is far reaching. However, obtaining and interpreting appropriate physical health measures is challenging.

Criticism of school-based interventions often centres on the lack of evidence of short-term change in clinically-acquired impact assessment factors (e.g. BMI) (Van Cauwenberghe et al., 2010). Although BMI is an easily collected objective measure, its utility remains controversial, and there is significant resistance to its use in some school communities (Nihiser et al., 2009). Challenges associated with BMI interpretation include: inadequate data across multiple ethnic groups where BMI cut-offs are not easily standardised (WHO Expert Consultation, 2004); and variable and continuous changes in adolescents (World Health Organization, 2000). Furthermore, BMI does not measure body fat distribution. BMI should not change significantly over periods of school-based interventions, particularly those associated with formal learning programmes. If achieved, such short-term BMI change may in fact indicate inappropriate nutritional or physical activity behaviours (Sahota et al., 2001). Supplementary physical measures (e.g. waist circumference or waist-to-height ratios) may provide additional valid evidence since waist-to-height ratio values do not require standardization for age or gender (Taylor et al., 2011). When collected, any physical measures should be accompanied by relevant background information for teachers and learning activities that allow adolescents to understand the measure and its meaning, and explore evidence such as associations between BMI and NCD risk (Bay and Mora, 2014).
The focus of evaluation should be on small, manageable long-term behaviour changes offering maximal long-term impact with minimal potential for harm (Todd et al., 2015).

Some challenges associated with the collection of physical measures such as BMI may be reduced by collaboration between school-based programmes and regular health profiling in school settings. Surveys such as WHO Global School-based Student Health Survey (World Health Organization, 2012), or school health centre-based assessments that already include measurements such as BMI. Over time these measures could be mapped against learning programme impact data and in this way the analyses combine longitudinal dimensions that accommodate gradual change in BMI, evidence of sustained behavioural change, and more episodic classroom-based learning.

3.2.10. Metabolic and epigenetic profile data: broadening the scope of evaluation

Metabolic data, with phenotypic profiling, could provide additional quantitative evidence that, when tracked alongside KAB and education data, could increase the likelihood that if health impacts are occurring as a result of school-based programmes, these are measured. Additionally, it offers the potential to understand the depth and reach of impact with respect to metabolic health. Tracking of suitable biomarkers over longer time periods offers potential to map appropriately paced changes in the trajectory of risk factors, particularly those associated with nutritional behaviours. Metabolomics, an analytical technique identifying and quantifying small metabolites, may overcome challenges associated with self-reporting of dietary intake (O’Gorman et al., 2013). Similarly, epigenetic profiling may quantify impacts of dietary changes because nutrients and bioactive food components can, via epigenetic mechanisms, alter gene expression, which in turn may impact metabolism and disease susceptibility (Choi and Friso, 2010).

This is an evolving field. Currently, epigenetic analysis provides limited evidence of associations between environmental factors and disease susceptibility (Ling and Groop, 2009). As capacity to identify and analyse metabolomic and epigenetic biomarkers improves, the potential for profiling risk, and measuring the impact of risk reduction following behaviour change, will offer improvements in tracking long-term effects of school-based programmes (Martínez et al., 2014; Zeisel, 2007).

Several important factors need to be considered before introducing such data collection techniques. These include ethical considerations relating to the collection and storage of
samples that, while not originally intended for this use, offer the potential for future DNA profiling and phenotype trait mapping; cost in relation to increased evidence; invasiveness (physical and cultural) of sampling techniques; ability for meaningful reporting of data to young people and their families. Whatever the sampling, it is essential that there are appropriate learning opportunities for students, access to information and opportunity for discussion for the school community. If school-based programmes leading to the application of evidence-based decision-making are to offer effective health promotion and learning opportunities, the entire programme, including impact tracking, must respect the rights of the adolescent, their family, and the school community as informed decision-makers.

3.3. Summary

3.3.1. Realizing the potential of schools as a setting for reducing risk factors for NCDs

The potential offered by primary NCD prevention to reduce the continuous expansion of the social and economic burden of NCDs must be acted upon, particularly within developing nations and communities where social and economic disparity exists. Adolescence offers a unique opportunity for educational programmes supporting psychosocial and cognitive development, building life-long capabilities associated with scientific and health literacies, citizenship and self-efficacy. By participation in such programmes, short-term attitudinal, cognitive and behavioural change should be accomplished. In the longer term, if continued development is supported, it should be possible to measure physical and metabolic impacts of sustained health-promoting behaviours, as well as transference of cognitive capabilities across health-related contexts.

However, to achieve this, greater cooperation between education and health is required, along with an acknowledgement that within the school setting, all programmes must contribute to ongoing cognitive and psychosocial development within the framework of local and national curricula. Impact measures are challenging, particularly health measures within a school setting. However, by ensuring that understanding of impact measures is embedded into the process of learning, and allowing adolescents to engage with and take ownership of these measures, the demand for objective physical evidence could be met in a manner respectful of the rights of adolescents over their physical, cognitive, social and emotional development. Rather than rejecting physical and metabolic measures as
imposing and potentially dangerous in a school setting, educators should examine the potential that, if well managed, these offer benefit for educational development.

Future work should focus on improved inter-sectoral interaction; publications, accessible to all relevant professional communities, supporting understanding of evidence from both sectors; development and longitudinal analysis of school-based educational interventions supporting health promotion that account for both educative and health goals; examination of effective long-term tracking incorporating existing educative progress analysis in schools; examination of particular challenges associated with developing nations and context of deprivation; and analysis of the potential for long-term health tracking using emerging technologies.
Part III Facilitating Collaborative Narrative

Fundamental to the research presented in this thesis are resources that facilitate the development of the collaborative narratives that enable HSLEAP programmes. These encompass books, learning activities, workshops, student conferences, web pages, videos and articles. The analysis of their potential to facilitate development of multi-sectoral collaborations that support adolescents to engage with and act on DOHaD evidence while simultaneously supporting learning in core subject areas in schools is an essential component of our ongoing research and development of HSLEAP programmes.

This section examines the concept of collaborative narrative as a core component of our pedagogical model. Chapter 4 outlines components of the pedagogical model used within HSLEAP programmes. We analyse an example of a core resource from HSLEAP programmes to identify how this is designed to support the development of collaborative narrative.

Chapter 5 examines how resources provided for teachers support their development as facilitators of collaborative narrative in classrooms and facilitate transformative learning associated with application of scientific perspectives as a component of decision-making for adolescents.

Chapter 6 presents a study demonstrating how the use of participatory action research in Tonga facilitated the development of collaborative narrative that facilitated teachers to transform their approach to the use of questions in science learning.

Chapter 7 presents a commentary published in the Journal of Developmental Origins of Health and Disease as a resource to support DOHaD scientists to engage in collaborative narrative with regard to the potential of collaboration with education in support of DOHaD translation.

These chapters cannot capture the full breadth of resource development undertaken to enable the empirical research presented in Part IV of this thesis. They are intended to provide an appreciation of the depth of resourcing that is required for effective community based multi-sectoral development alongside evidence of the efficacy of examples used in the school setting.
Chapter 4. A Narrative Pedagogy: Structure and resourcing

Preface

The education community values the potential offered by the contextualisation of learning in exploration of socio-scientific issues. This has been shown to support capability development associated with scientific literacy, and more broadly critically engaged citizenship. Sectors beyond education are likewise seeing value in enabling young people to examine and act on evidence. However, evidence from science is not commonly reported in formats that are appropriate for use in schools.

For young people to construct meaning of, and contextually interpret scientific evidence, they need to be given opportunities to examine and debate the evidence. The Healthy Start to Life Education for Adolescents Project has developed and utilised a narrative-based pedagogy to support this process. This requires resources that enable students to engage with and interpret data. This chapter examines the use of narrative as a vehicle for enabling young people to access and explore scientific evidence. Via exemplar analysis, we examine the requirements of narrative-based resources that facilitate adolescents to engage in capability development resulting in the translation of scientific evidence into contextually relevant actions.

The publication associated with this chapter is listed below, and reproduced in full in Appendix 4A.

4.1. Introduction

The Healthy Start to Life Education for Adolescents Project (HSLEAP) is based on a narrative pedagogical model designed to facilitate development of scientific and health literacies in support of engaged citizenship (Grace and Bay, 2011).

Scientific literacy encompasses the capabilities (attitudes, values, knowledge and skills) required to apply knowledge and understanding of and about science in decision-making relating to everyday occurrences as well as complex open-ended socio-scientific issues (SSIs) (OECD, 2016; Roberts, 2007). Health literacy similarly describes a matrix of capabilities that contribute towards individuals and groups making evidence-based decisions about health-related issues (Nutbeam, 2000). We have argued previously that scientific literacy is integral to the development of health literacy (Grace and Bay, 2011) and concur with the increasingly common view expressed in the literature that capabilities specific to the arts and humanities are also essential to enabling evidence-based responses to SSIs (Kahn and Zeidler, 2016; Zeyer, 2014).

Engaged citizenship reflects a commitment to active engagement in the building of stronger, healthier and safer communities (Zaff et al., 2010). We argue that development of engaged citizenship starts at the level of family, peers and school communities, building over time towards engagement at the level of community, society and eventually engagement as a global citizen. This is reflected in the hierarchy of contexts in which scientific literacy can be applied outlined in the PISA definition of scientific literacy (OECD, 2016) and in many curricula internationally. In this hierarchy, scientific literacy development progresses from application of scientific evidence and perspectives in decision-making at a personal level to engaging in the application of science in problem solving at a societal and global level. A similar hierarchy of development is seen in Nutbeam’s model of health literacy (Nutbeam, 2000).

The science for health literacy pedagogical model employed in HSLEAP evolved from exploratory work undertaken by the Liggins Institute between 2007 and 2009 (Grace and Bay, 2011). It utilises collaborative narrative to facilitate learning that enables adolescents to explore contextual application of a scientific frame of reference when considering personal and societal challenges associated with health related socio-scientific issues (SSI) (Bay et al., 2012c). Contextual application accounts for socio-ecological and cultural perspectives, considering how scientific evidence and thinking may be incorporated with
these perspectives in problem solving processes. The particular SSI addressed within HSLEAP programmes is the noncommunicable disease (NCD) epidemic, a complex socio-scientific issue of global significance (Beaglehole et al., 2011b). The NCD epidemic offers a valid context for learning due to:

- its relevance to all communities;
- the potential for intervention during adolescence to support long-term change;
- the potential for actions within the control of adolescents to contribute to long-term change and;
- the potential for applicable contextualisation of learning linked to objectives across multiple core learning areas in schools (Chapter 2) (Bay et al., 2016a).

Frames of reference reflect a specific worldview, based on assumptions and expectations involving values, beliefs and concepts (Dirkx et al., 2006). These form over time through experience and the development of understanding, and are influenced by epistemic assumptions about what is and can be known and the role of evidence in problem solving (Mezirow, 2011).

Collaborative narrative enables individuals and groups to join stories from within their personal and cultural context with stories from outside of their experience to construct meaning (Lauritzen and Jaeger, 1997). Within HSLEAP this process is relevant for youth, educators, health professionals and scientists alike. It aligns to a constructivist perspective, appreciating that interpretation of evidence and development of understanding is determined by factors associated with personal and socio-ecological context, and impacted by opportunities and exposures.

Scientific literacy development is central to the HSLEAP framework as without it students cannot be expected to engage with frames of reference that reflect a scientific perspective. This is inclusive of examination of the epistemology of science, usually referred to in education as the nature of scientific knowledge (NOS). The importance of NOS understanding in support of scientific literacy is well established (Roberts, 2007) and has resulted in NOS being the central component of science curricula internationally (Fouad, 2014). Scientific literacy, science literacy and NOS are complex constructs. Debate regarding these concepts and the nature of science education appropriate to the needs of adolescents is ongoing (Douglas and Rodger, 2014). Known as Vision I and Vision II, different meanings are associated with the terms science literacy (Vision I) and scientific
literacy (Vision II) (Roberts, 2007). The HSLEAP learning programmes are supportive of scientific literacy development associated with the use of science knowledge in decision-making in combination with knowledge from sociological and cultural perspectives. Key to this is the concept that scientific literacy should enable individuals and communities to decide if, when, and how scientific evidence may be applied in their setting. This is aligned to development of NOS understanding within a Vision II scientific literacy framework rather than one confined to science literacy and the dominance of scientific perspectives in decision making as represented in Vision I (Douglas and Rodger, 2014).

The specific frame of reference exposed within the narratives used in the HSLEAP learning programmes is the Developmental Origins of Health and Disease (DOHaD) theory, presenting scientific evidence of associations between early-life environmental exposures and vulnerability to overweight, obesity and NCDs in later-life (Hanson and Gluckman, 2014). Awareness of this evidence is very low in adolescent and adult populations (Bay, 2015a; Bay et al., 2012a; Bay et al., 2015; Endo and Oyamada, 2013; Gage et al., 2011; Oyamada, 2015). The HSLEAP programmes facilitate exploration of DOHaD perspectives in the context of NCD risk and impact. Learning experiences that facilitate exploration, discussion and reflection of a particular perspective on an issue offer opportunities for learners to challenge and shift existing beliefs, values and behaviours associated with experiences and perceptions (Sharpe, 2016). Change of this nature, if it were to occur, would embody transformative learning; a process occurring when exposure to frames of reference outside of one’s own experience encourages examination of assumptions and beliefs, facilitating construction of new or revised frames of reference (Mezirow, 2011). In particular, transformative learning experiences challenge ‘taken for granted’ frames of reference that may be associated with social and cultural norms (Mezirow, 2003). While developed to support adult learning, transformative learning theory is applicable to secondary school settings (Williams, 2013).

Critical thinking is integral to the development of scientific and health literacies in support of evidence-based responses to SSIs (Vieira and Tenreiro-Vieira, 2016). The HSLEAP framework recognises that competencies associated with critical thinking, problem solving and resilience are required if adolescents are to engage in collaborative narrative supportive of evidence-based actions beyond the classroom setting. These competencies are encompassed within the ‘key competencies for living’ defined in the OECD Definition and Selection of Key Competencies (DeSeCo) project (Rychen and Salganik, 2003) and are
reflected in many curricula internationally. As the HSLEAP programmes emerged from New Zealand and examination of potential for adaptation for use in developing nations was led out of the Cook Islands, we have paid particular attention to the interpretation of the competencies defined by the DeSeCo project in the New Zealand and Cook Islands curricula (Cook Islands Ministry of Education; Ministry of Education, 2007).

**Figure 4.1** Interrelated components of HSLEAP
Interrelated component of education programmes supporting development of capabilities associated with evidence-based decision-making in the context of a health-related socio-scientific issue

**Figure 4.1** offers a diagrammatic representation of the pedagogical model, demonstrating the importance of integrated learning in the development of engaged citizenship. While represented in the diagram as a linear process, learning is messy, not linear. Each step influences variably forwards and backwards, creating a cumulative and ongoing process of development that will be unique for each learner. The emphasis on capability development at the core of HSLEAP programmes ensures that adolescents are equipped with the resources required to critically engage with socio-scientific issues relevant to their communities. It also ensures that programmes link to curriculum-based learning objectives. This ensures that HSLEAP programmes can be embedded in core learning programmes and support the core business of schools (Bay et al., 2016a). It addresses key concerns
regarding the lack of connection between health promotion in schools and the core business of learning (Waters et al., 2011).

The reliance on the support of curriculum-based learning to enact HSLEAP programmes ensures capability development and encourages ongoing programme development by schools. This supports sustainability of the opportunity for adolescents to access and use DOHaD evidence in support of personal, family and community wellbeing. However, this is dependent on access to DOHaD and relevant health evidence in the form of narratives that can be used to facilitate learning. This provision sits outside the capabilities of teachers in schools due to limitations associated with access to evidence, time to develop resources, and access to deep engagement with the community from which the evidence has emerged. This chapter examines the requirements of such resources via analysis of an exemplar from within the HSLEAP programme. This provides understanding of the requirements of narrative-based resources that facilitate adolescents to engage in capability development resulting in the translation of scientific evidence into contextually relevant actions.

### 4.2. Developing science stories supportive of collaborative narrative

#### 4.2.1. Narrative as a form of science communication

The use of narrative is an established format for the communication of science to non-expert audiences (Dahlstrom, 2014). A relatively small group of scientists with a combination of extensive scientific credibility and unique communication capabilities have become adept at this form of science communication within the public arena. Literary stories are another form of narrative that can effectively communicate science to the public (Negrete and Lartigue, 2010), along with fictional narratives that look at potential futures based on scientific evidence. These are all important forms of science communication. However, what they often lack is the potential to enable the participant to explore rather than ‘be told’ of evidence, and to integrate their own stories into the narrative to develop contextual evidence-based responses.

#### 4.2.2. Narrative vs story

To create collaborative narrative that allows engagement with data within a school setting we use both narrative and story. Differentiating between narrative and story is a useful exercise in considering the design of learning resources and experiences purposed to facilitate the assembly, consideration and use of different frames of reference when
addressing complex issues such as the NCD epidemic. Denzin’s definition of narrative and story assists us to understand that while these terms are very similar, an important distinction should be made associated with the influence of the process of narrative on the interpretation of story (Denzin, 2002).

“Narrative is a telling, a performance event, the process of making or telling a story. A story is an account involving the narration of a series of events in a plotted sequence which unfolds in time. A story and a narrative are nearly equivalent terms. A story has a beginning, a middle and an ending. Stories have certain basic structural features, including narrators, plots, settings, characters, crises, and resolutions. Experience, if it is to be remembered, and represented, must be continued in a story which is narrated. We have no direct access to experience as such. We can only study experience through its representations, through the ways stories are told.” Denzin, 2002, p. xi

Narrative incorporates judgement, and therefore is complex (Brophy, 2009). The storyteller makes decisions about what to leave in and take out, how to interpret and how to present the story. These decisions are influenced by the socio-ecological context of the storyteller. Multiple players in the collaboration can take the role of storyteller at different times. The storyteller(s) may be the:

- writer(s) of the learning resources
- teacher(s) facilitating use of stories to contextualise learning
- adolescent(s) telling their stories within the classroom and peer setting or retelling the scientists’ stories in their family, peer, or community setting
- community member(s) telling experiential stories relating to NCDs
- scientist(s) telling their stories of science and of their own NCD experiences

Those engaging with the story through the narrative of the storyteller will interpret and make meaning of the story. This interpretation will be dependent on the personal and wider socio-ecological context(s) that form the lived experience of the listener. Interpretation is also dependent on associated learning experiences that allow listeners and storytellers to engage in discussion about the stories that form the collaborative narrative. This process of engagement may reflect sense-making, a social process whereby potentially divergent perspectives are engaged to empower evidence-based actions (Snowden, 2005). This is particularly true if the storytelling process engages the participant in the analysis of the evidence rather than presenting pre-determined facts. This form of engaged narrative is achievable within educational environments if appropriate stories are made available.
4.2.3. An evidence-based approach to the development of narrative

The development of the narrative-based resources within HSLEAP is a collaborative process involving educators in the DOHaD community and in schools, DOHaD scientists, adolescents, and health professionals. Educators embedded in the scientific communities within which the evidence has emerged lead the process. Evidence from education, science and health alongside feedback from participating teachers, adolescents and scientists inform development. This ensures collaboration between those whose story is being told, those who understand how narrative can be used in educational settings, and those for whom these narratives are being developed (Bay et al., 2012c).

Embedding science educators within the scientific community is beneficial, although not common. Over time, these educators find themselves belonging equally in both the science and education communities. They develop deep understanding of the science, offering significant advantage in the process of resource development. This dual belonging is supportive of relationship building and trust relevant to the development of learning resources and the ongoing development of relationships within education/science/health partnerships (Bolstad and Bull, 2013). The process of collaboration required to develop the narratives also contributes significantly to the collaborators exploring differing perspectives about the communication of scientific evidence and applying this to programme and intervention design.

4.2.4. ‘My First 1000 days’ | An analysis of narrative developed to enable adolescents to access and engage with scientific evidence

“My First 1000 days” explores the science from which DOHaD emerged and looks at its relevance to the NCD crisis (Bay, 2016a). Written for Year 7 – 10 students, it tells the story of a group of scientists from the University of Southampton who engaged with the community to explore whether early life experiences could influence later-life risk of hypertension, coronary heart disease, stroke and metabolic syndrome. The studies described are from the Hertfordshire Cohort Study (HCS) (Hertfordshire Cohort Study, 2012).

Figure 4.2 My First 1000 Days
Full text in Appendix 4A
“My First 1000 Days” was written in 2014 using materials developed and tested over a period of eight years. During this time, the author and colleagues used versions of the story with Year 7–13 classes at the Liggins Institute and in New Zealand schools, and with Year 9 classes at the University of Southampton. At the Liggins Institute, this involved direct contact with over 50,000 students in face-to-face school-university partnership programmes (Bay et al., 2012b; Bay et al., 2012c). The author worked with members of the HCS team to ensure the science and the story was accurate. The final resource was tested in schools in the Cook Islands and Tonga prior to publication in 2016. It is generic in nature, designed for use across cultural boundaries.

The structural analysis of “My First 1000 Days” is intended to support educators, scientists and public health professionals to understand how research stories can be used within a narrative pedagogy to communicate science in support of improved health outcomes and support capability development relevant to educational goals associated with the development of scientific literacy.

In examining the design in relation to development of NOS understanding we reflect on those characteristics presented by Lederman, 2013, as being relevant to the needs of K-12 learners. These are that scientific knowledge is tentative, empirically based, and subjective, requires human inference, imagination and creativity to develop, and is socially and culturally embedded (Lederman et al., 2013).

The resource is not designed to stand-alone. It is designed to contribute to the development of scientific literacy and related capabilities within HSLEAP programmes that utilize a range of resources made available to teachers. Each teacher will use the resources variably to design a learning programme exploring NCD/DOHaD contexts that is contextually relevant to their students (Bay et al., 2016c). Details of the concept of contextual adaptation of resource to meet the needs of students are discussed in Part II.

4.2.5. Rationale

The HCS studies are highly significant in the emergence of DOHaD science. They established links between low birth weight, weight at 1 year of age, and hypertension, coronary heart disease, stroke and metabolic syndrome. This demonstrated that in communities characterised by poverty, poor nutrition, overcrowding, and infection, children often died early in life, or if born had low birth weights, suffered from poor development, and as adults had increased risk of cardiovascular and metabolic diseases.
Studies that followed showed that even if the children moved from poverty into affluence, the impacts of the poor start to life persisted (Hanson and Gluckman, 2014).

The decision to use the story of the Hertfordshire Cohort Study (HCS) in the HSLEAP programmes was based on both scientific and educational perspectives. The story:

- is a focal point from which DOHaD has emerged into a global scientific community informing a wide range of health related socio-scientific issues
- provided the first evidence to challenge reductionist perspectives that associate NCD risk with affluence, overindulgence and adult lifestyle factors
- represents science conducted in response to an SSI (high premature death rates from heart disease in the UK in the early part of the second half of the 20th century)
- is about science that engages in community collaboration to examine and make sense of an issue of significance to the collaborating community
- demonstrates that science can cross cultural and contextual boundaries as this evidence has formed the basis of a multitude of studies that are now informing health-related action globally
- creates opportunity for narratives that
  - expose aspects of the nature and process of science supportive of development of key epistemic, procedural and substantive knowledge of and about science
  - tell a people-based story enabling students to explore the culture of science as a human endeavour that is situated in communities (scientific and lay).

### 4.2.6. Science as a human endeavour embedded in social context

Science is a human endeavour that engages with understanding the natural and physical world. The development of characters in the narrative offers an important connection to this concept, as well as making the story accessible to adolescents. The characters are:

- *The students’ families*, facilitating connections between the scientific evidence that is uncovered by the story and the lives of the students
- *Professor David Barker*, the epidemiologist who led the scientific team
- *Miss E. Margaret Burnside*, a midwife whose work in the early 20th century to try to improve outcomes for infants in the Hertfordshire region enabled the research
- *Mr Ron Farr*, a study participant who engaged with the HCS team to support communication about the study. Mr Farr’s family gave permission for use of his
story in *My First 1000 Days*, providing community and personal context for adolescent readers.

The story is interactive requiring engagement and action from students. Action tasks are designed to engage students in building the narrative while supporting development of understanding of the nature of scientific enterprise.

The story opens not with scientist, but with the family of the students in the class being the first characters ([Appendix 4A](#)), p.1). Basic facts about reproduction are provided to link to prior learning and stimulate interest. In our experience students tend to be either fascinated or appalled by the idea that the cell that forms a human egg develops in a female while still a fetus in her mother’s uterus. Discussion around this fact stimulates engagement and creates an entry point for consideration of the impacts of intergenerational environmental influences on health and wellbeing. The question “*What was the world like when your grandmothers were pregnant with your mum and dad?*” is an example of how the resource provides entry points for teachers to encourage students to bring their stories into the narrative. If teachers use this opportunity, it initiates a collaborative narrative linking the students’ stories with the scientists’ stories. We have observed teachers use this opportunity variably from a passing comment in the class through to students interviewing grandparents and bringing the stories back into group discussions. The social studies learning resources that have been developed and tested by teachers in the Cook Islands use this as the entry point for examination of the impact of social and political change over 200 years on the nutritional environment ([Barrett-Watson, In Press](#)).

Barker is the next character introduced into the story, [Figure 4.3](#). Earlier in the programme students undertake research to explore perceptions of health and wellbeing in their family or community ([Bay and Yaqona, 2016](#)). Barker’s research question (marked in yellow) is intentionally worded to link to this concept, creating a bridge to the prior learning experience. This is intended to support students to identify that Barker and his team were interested in ideas that they have been exploring. Referral in the story to the research *team* is intentional, encouraging understanding of science as a collective enterprise.

The introduction of Baker as a scientist who was trying to address a health issue impacting a community (marked in green) supports students to identify that the research occurred in response to a social need. This creates links to the concept that science is culturally and socially embedded ([Lederman et al., 2013](#)) and can influence and respond to social needs ([Moss, 2001](#)).
We recommend that teachers facilitate exploration of NCD related issues in their community prior to using this resource. Short stories of local NCD monitoring research are supplied (e.g. Bay and Yaqona, 2016, In Press). If used, these create the opportunity to link between current social needs in the community in which the school is set and social needs in the community in which Barker was working. This enables exploration of the concept that research exploring ways to improve the health and wellbeing of communities is a universally applicable enterprise.

4.2.7. Pattern Seeking | The empirical nature of scientific knowledge

A key NOS concept is that which identifies science as an empirically based process that via interpretation of observations asks questions and develops understanding. Development of an appreciation of the distinction between observation and inference, and the tentative nature of scientific knowledge is also important (Lederman et al., 2013). Activities that engage students in exploring data within the story are designed to support students to construct understanding of the evidence while also developing appreciation of the role of observation and evidence in science.

The key observation that led to the development of the HCS was that in England and Wales regional prevalence of infant mortality in the early 20th century was similar to regional
prevalence of CVD related mortality in the second half of the 20th century. The resource presents this story in a manner that enables students to explore the evidence and identify these patterns. Experience from extensive use of these data with Year 7-10 students prior to the writing of the resource identified the level of scaffolding required. This is reflected in Activities 1 – 3 (Appendix 4A, p 3-6).

Activity 1 “Looking for Patterns” requires students to apply comprehension skills to identify Barker’s research question, and engage with and interpret the data from which this question arose, Figure 4.4. In addition to building a picture of the evidence, this activity supports understanding of science as an empirically based knowledge system that uses interpretation of observations to ask question and draw conclusions. The data map is the original used by Barker. Compass directions have been added to support students to describe the patterns. The pictorial nature of the data map is supportive of visual learners and learners who experience challenges associated with numeracy. We acknowledge that the use of red-green to differentiate between high and low is a significant shortcoming for red-green colour-blind students. This is discussed in PLD to ensure teachers are aware of the potential difficulty it poses for this group. Classroom observations and student discussions in New Zealand, the Cook Islands and Tonga indicate that the data map is interpretable by most 11-14 year olds. This is important as the exercise is designed to support students to identify that they can engage with ‘real’ science.

Figure 4.4 My First 1000 Days: Activity 1
(Bay, 2016a), p. 3 | Full text in Appendix 4A
Activity 2 “Comparing Patterns” builds on the interpretation of the data in Activity 1 to support development of understanding of the concept that questions emerge from observations. The pattern-seeking task comparing the data in the two maps requires application of thinking skills. In particular, issues arise as a result of white representing the lowest incidence of mortality in the 1901-1910 map and the mid-range in the 1968-1978 map. This is not insurmountable for more able students, and usually stimulates discussion. For less able students, we recommend that teachers provide additional scaffolding. A simple way to achieve this is to overlay orange onto the white sections of the coloured map, or provide students with a copy that they can colour themselves. Importantly, the activity engages the students in thinking about and interpreting the data.

The students are not told what the scientists interpretation of the data was until the next page in the story. Asking students to identify the pattern before informing them of the scientists’ interpretation of the data builds confidence in students that they can interpret patterns as a scientist would.

**Figure 4.5  My First 1000 Days: Activity 2**
(Bay, 2016a), p. 4 | Full text in Appendix 4A
4.2.8. **Questions emerge from observations**

Misconceptions relating to the nature of hypotheses are known (Carey et al., 1989). We have observed that students often refer to a hypothesis as ‘a guess’ and have engaged in discussion with teachers who had been framing the concept of hypothesis in this way (see Chapter 5). Activity 3 “*Making an Hypothesis*” (Appendix 4A, p. 5-6) supports understanding of the concept that hypotheses may be developed from observations and are testable through scientific enterprise (Moss, 2001). The story describes the scientists as being surprised by the patterns they observed in the data, providing students with reasons why the scientists were surprised. If teachers facilitate exploration of the concept that Barker’s team identified that the observations appeared to contradict current scientific knowledge this may support students to understand the concept that interpretation of evidence is subjective (Lederman et al., 2013) and that observations that contradict current knowledge can generate new questions (Moss, 2001). Activity 3 requires students to use a comparison of what was known with what was observed to identify the hypothesis that the HCS team developed. This supports development of understanding that scientific knowledge is tentative and assists students to unpack the thinking that the scientists engaged in to develop their hypothesis. Lederman et al discuss concerns regarding the conflation of NOS with the process of scientific inquiry (Lederman et al., 2013). These are undoubtedly different. However learning that is structured to explore the thinking underpinning decisions made in designing a scientific research process contributes towards understanding of both procedural and epistemic knowledge, key requirements in development of scientific literacy (OECD, 2016).

4.2.9. **Serendipity and Persistence**

School science is a contentious issue with ongoing debate around purpose, focus and strategy (Bull, 2011; Osborne, 2007; Roberts, 2007). Science education in the latter 20th century was strongly focussed towards development of substantive knowledge with limited exploration of procedural or epistemic knowledge. This created inaccurate representations of science as a body of facts ascertained by following a rigid method that could be mimicked in the school setting. This is still seen in aspects of science education today. The mid-section of the story takes students on a journey in which characteristics that discredit the idea of science as a rigid set of facts are exposed. These include curiosity, serendipity,
creativity, problem solving and perseverance, all of which play a significant role in scientific enterprise (Moss, 2001).

Activity 4 (Appendix 4A, p. 7-8) requires students to explore data in a page from the birth records from Margaret Burnside’s team of midwives, used as the basis for the HCS investigation. Students are asked to identify whether this is scientific data and explain their reasons. This offers potential to engage students in considering the nature of scientific data. The task demands that students think about their own birth records, encouraging students to think about their early life experience and link the evidence they are exploring to their own story. Activity 5 (Appendix 4A, p. 9-10) explores the process of connecting with the adults whose birth records were found. This exposes students to the concept of science as a collaboration with the community. Role-play is suggested as a means of engaging students with the story at a level that would allow them to re-tell it to peers and family.

Evidence indicates that students’ perceptions of science and scientists is broadening (Hillman et al., 2014). However, the experience of the LENScience team over a period of 10 years has not infrequently been that some teachers perceive the story of the HCS studies as not representing ‘real science’. Collectively these activities challenge perceptions of what science is, how it is conducted, and who conducts it.

4.2.10. Reimagining science: Making complex data accessible

The most challenging component of creating the narratives that are used in HSLEAP is the reimaging of scientific data into age-appropriate formats. The process requires input from scientists, educators, and students. Educators and scientists work together to visualise and create representations that are scientifically accurate and account for the developmental level of the target group and the focus of the programme. In our experience the process of observing students using the resources has almost always led to improvements. The data represented in the final section of ‘My First 1000 Days’ only tells part of the story, Figure 4.6. However, it provides enough information to enable discussion of the key findings – that babies born smaller were more likely to be susceptible to higher blood pressure later in life. A trend we have observed in data reimaging is that for Year 7-9 students, data is more accessible if it is presented with only one variable manipulated. This is often not the reality in science. We have found that Year 10-13 students easily cope with data representing several variables if this is structured to provide scaffolding supporting identification of each variable (Bay et al., 2012c).
Key factors making the data presented in this example more accessible to Year 7-10 students include:

- replacement of numbers on the vertical axis with an arrow
- addition of coloured indicators of normal and high blood pressure
- replacement of the figure legend with a simplified title
- the use of an image of a blood pressure monitor alongside the figure

![Blood Pressure Diagram]

Figure 4.6  Reimaged data used in Activity 7, My First 1000 Days:
(Bay, 2016a), p.12 | Full text in Appendix 4A

4.2.11. Evidence: Concepts of certainty and risk

The tentative nature of scientific knowledge is identified as a key concept that should be explored in school science (Lederman et al., 2013; Osborne et al., 2003). This is represented throughout the story, use of which should provide significant opportunities to facilitate exploration of the concept.

Understanding of risk or conceptualising uncertainty is a separate issue that is highly relevant to the application of scientific literacy to support evidence-based actions. Rather than pertaining to the tentative nature of scientific evidence this issue is associated with the concept that in most instances scientific evidence presents information about risk levels rather than certainty.

Risk, and communication about risk, are complex. Communication about risk involves exploration of the certainty of the evidence of the risk, the level of the risk, and the potential effect of the risk (Calman, 2002). Risk and understanding of risk are features of scientific knowledge that contribute to mistrust of science (Engdahl and Lidskog, 2014). The story of
the HCS studies presented in “My First 1000 Days” provides an opportunity to explore risk in a context of relevance to adolescents. However, if risk is not explored, the story offers an opportunity to contribute to mistrust in science.

Communication of risk is a dynamic process enabling individuals or groups to make evidence-based decisions (Calman, 2002). The HSLEAP programmes are communicating scientific information about risk related to NCD vulnerability within and between generations. The key difference between the HSLEAP programmes and many science communication efforts is that the programmes support development of the capabilities required to explore evidence of risk, while exploring this evidence.

The resource provides ‘black-board ideas’ (Appendix 4A, p. 13) that teachers may use to initiate discussion about risk. If teachers have explored NCD risk levels with students prior to engaging in the story, students will enter the story having identified that NCD risk is relevant to their family and/or community. The story is part of a phase of learning about the issue. It contributes to development of understanding of the level of certainty of scientific knowledge around the associations between early-life experiences and later-life NCD risk. The story from HCS only presents the evidence pertaining to low birth weight. The initial ‘black-board’ presents information showing that there are other patterns in early-life that cause a similar response. Having explored (in a small way) the certainty of some evidence from DOHaD, students can engage in connecting this with evidence of NCD risk in their community, their environment, and their family history, and consider risk levels and responses. Ideas for activities beyond the story associated with further exploration of evidence and the development of contextual responses are provided for teachers (Bay et al., 2016d; Bay and Yaqona, In Press).

Evidence suggests that the lay public often look for black and white representations of scientific evidence (Kimmerle et al., 2015), which in this case could be interpreted to imply mother blame, an issue that the DOHaD community are well aware of, (Richardson et al., 2014) or a fatalistic negative conclusion dependent on birth weight rather than an understanding of early life environment as one important contributor in determining risk. The way information is communicated is known to influence responses to information, with positive framing leading to optimistic responses and negative framing supporting pessimistic responses (Kimmerle et al., 2015). The HSLEAP programmes are intentionally framed positively and designed to support critical engagement with both the issue and the evidence.
4.3. Conclusions

There is growing evidence for the relevance of adolescent-led actions to support positive change in NCD vulnerability and the potential for multi-sectoral collaborations, involving education, to contribute towards this goal (Crosby et al., 2009; Hanson, 2016; World Health Organization, 2016b). In parallel, there is wide evidence for the validity of contextualisation of learning as one strategy that contributes to development of scientific literacy via conceptual understanding of and about science (Sadler et al., 2004; Sadler et al., 2016) and capabilities associated with critical thinking and argumentation (Dawson and Venville, 2013).

Opportunities that support goals associated with both education and science/health via narrative-based learning in schools offers significant potential (Bay et al., 2012a; Grace et al., 2012). However, this requires specialised resources that enable the learner to engage with the evidence in an age-appropriate format. A common theme emerging from discussion with teachers utilising resources of the genre is the opportunity they provide to experiment with contextualisation of learning – a concept they understood theoretically but lacked resource to enact (discussed in Chapter 5). Our analysis of “My First 1000 Days” as an example of a learning resource supportive of the use of narrative pedagogy to meet such goals offers some key evidence that could be applied to the development of such resources across contexts.

Developing resources to enable adolescents to engage in and act upon contextual exploration of SSIs in via school-based learning requires the development of trust between the collaborating partners. Hupcey et al, 2001 propose an interdisciplinary scientific definition of trust that provides a useful basis on which to consider the development of trust in the building of relationships from which science narratives for use in schools can evolve.

“Trust emerges from the identification of a need that cannot be met without the assistance of another and some assessment of the risk involved in relying on the other to meet this need. Trust is a willing dependency on another’s actions, but it is limited to the area of need and is subject to overt and covert testing. The outcome of trust is an evaluation of the congruence between expectations of the trusted person and actions.”

(Hupcey et al., 2001)

Resources enabling adolescents to engage with the scientific evidence have value to scientists as communication tools reaching a key target audience. To educators the value is as learning tools enabling cognitive and psychosocial development. Neither the educator nor the scientist can meet the needs of the adolescent alone, yet both have resource that
collectively may facilitate empowerment of adolescents as critically engaged citizens capable of facilitating positive change in society.

Risk is a key element of teaching and of science. However, the risk involved in engaging in cross-sectoral partnership occurs outside of the environment of trust that is usually established within disciplinary-specific professional communities. To build trust across disciplines or sectors takes time, and requires understanding of shared and sectoral specific goals (Bay et al., 2016a). The outcome of risk taking dependent on the expectations set entering into the relationship (Hupcey et al., 2001). For the science sector, outcomes are likely to be associated with outputs related to communication of science and evidence of the effect of this communication. For the education sector, outcomes will be associated with perceived and measured efficacy of the resource to support educative goals. In each case, these will be measured against the burden of resourcing as a limiting factor associated with development.

The depth of potential offered by narratives such as “My First 1000 Days” can be established via a combination of structural analysis of the resource against education goals associated with scientific literacy development and impact analysis pertaining to educational and health/science outcomes (Bay et al., 2016c). Analysis of the former indicates significant potential. Analysis of key aspects of the latter are provided in Part IV of this thesis and similarly promise significant potential.

The role of ‘intermediaries’ who bridge the science/education divide (Bolstad and Bull, 2013) offer potential to facilitate the development of adaptable resourcing that teachers can use to meet the differing needs of student (Bay and Vickers, 2016). This offers the potential to reduce the overall cost of resource development while maintaining quality. Further research and development is required to identify structural and evaluative strategies to enable broader access of reimaged resource evidence for use in schools.
Chapter 5. Facilitating transformative learning

Preface

To facilitate learning that is contextualised in exploration of a socio-scientific issue, teachers require time and resources to support their personal and professional understanding of the issue, and of appropriate pedagogical approaches. Alongside this, they must have access to relevant adaptable student learning resources.

The pedagogical model that we developed at the outset of the Healthy Start to Life Education for Adolescents Project seeks to use collaborative narrative to support capability development within a transformative learning framework. Student learning experiences encourage exploration of personal and other perspectives, and reflection on the meaning of evidence from scientific, social and cultural perspectives.

This chapter presents an analysis of the role of transformative learning in the HSLEAP model. It examines the potential offered by the learning and teaching resources used in the Pacific arm of HSLEAP from 2014-2015, to enable transformative learning for teachers and for students. This enables evidence that could inform the development of similar types of learning programmes within different or related contexts.

The publications associated with this chapter are listed below. Limited extracts from the relevant learning resources are reproduced in Appendix 5A. Copies of all relevant publications are available on request.


5.1. Introduction

The Healthy Start to Life Education for Adolescents Project (HSLEAP) is a multi-sectoral community-based participatory research (CBPR) project involving science, education, and health communities from New Zealand, the Cook Islands and Tonga. The Pacific Island arm of the project is known as the Pacific Science for Health Literacy Project (PSHLP). The project facilitates school-based learning that is contextualised in exploration of the noncommunicable disease (NCD) epidemic, a complex socio-scientific issue (SSI) of relevance to communities globally (Bay et al., 2016a). The aspect of the NCD crisis explored relates to evidence from the field of Developmental origins of Health and Disease (DOHaD) demonstrating associations between adverse environmental exposures in early life (even before birth), and later life NCD vulnerability. This highlights the potential for actions during adolescence to reduce later-life NCD risk for individuals and their potential future offspring (Hanson and Gluckman, 2014). Depending on the implementation strategy developed by each school, learning areas associated with the project may include science, health and physical education (HPE), English, and social sciences. The predominant learning area is science.

The inequities that perpetuate adverse nutritional exposures and associated social, educational, health and economic outcomes in geographically isolated and/or economically disadvantaged communities are preserved by social, cultural, and political norms. Evidence from the sciences (including social and applied sciences), can contribute alongside cultural and social perspectives to challenge factors that perpetuate these inequities. To achieve this, communities contributing to or impacted by inequities, need to examine and consider the implications of evidence from divergent sources. Sense-making (Snowden, 2005) and transformative learning (Mezirow, 2011) are processes supportive of individuals and/or groups examining divergent perspectives relating to complex issues such as the NCD crisis, and potentially making decisions that may disrupt social norms that promote inequities.

The contextual framing of learning in HSLEAP is supportive of both educative and health goals (Bay et al., 2016a). In promoting the development of capabilities associated with scientific literacy and critical citizenship through exploration of the NCD crisis, the programmes aim to provoke students to identify and take actions in their lives resultant of their learning (Bay et al., 2012a; Bay and Vickers, 2016).
The pedagogical model used in HSLEAP is informed by concepts associated with the development of scientific and health literacies via collaborative narrative, inclusive of application of transformative learning theory (Grace and Bay, 2011). Collaborative narrative is the deliberate bringing together of stories from differing perspectives to support learners to construct meaning of experiences (Lauritzen and Jaeger, 1997). The HSLEAP learning and teaching framework (Figure 5.1) illustrates the learning journey facilitated by teachers to enable students to explore personal and other perspectives relating to the issue, and develop capabilities supportive of evidence-based actions (Bay and Mora, 2014). To build and facilitate learning programmes of this genre, teachers need access to context-specific resources and professional learning and development (PLD).

![HSLEAP Learning and Teaching Framework](image)

**Figure 5.1 HSLEAP Learning and Teaching Framework**

### 5.1.1. Purpose

To identify how resources support teachers to use the HSLEAP learning and teaching framework to facilitate the development of collaborative narratives that contribute to capability development, and facilitate opportunities for students to consider scientific, cultural and social perspectives in their analysis of issues pertaining to NCD risk.
5.1.2. Procedure
Qualitative analysis was used to examine examples of HSLEAP resources and their use by teachers in the Cook Islands and Tonga (Bay et al., 2016d; Bay and Yaqona, 2016, In Press). Detailed methods of the overall study are described in Chapters 9 and 10. Contributing evidence for this analysis comes from teacher focus groups, observations of lessons, exemplars of student work, student focus groups and student surveys. Forty-five teachers were variably involved in teaching classes associated with the project over the period 2014-2015 in the Cook Islands and Tonga. This evaluation is limited to a group of 18 science teachers who participated in focus groups and classroom observations. Extensive mixed-methods analysis has examined cohort-wide outcomes for students (Chapters 8 – 10) but does not examine relationships between the learning resource design, the pedagogical model and learning experiences.

The study was approved by the University of Auckland Human Participants Ethics Committee (Ref. 011207), the Cook Islands Research Committee (Ref. 05/14), and National Health Ethics and Research Committee of Tongan (Ref. 040614.2).

5.2. Theoretical and conceptual background
5.2.1. Context-embedded learning
The contextualisation of learning in complex, open-ended and values-laden socio-scientific issues (SSIs) is widely identified as being beneficial for adolescent development. Often labelled as ‘future-focussed learning’, this is supportive of equipping adolescents with the capabilities required to engage in today’s world, and to continue to learn throughout life in order to engage in a future that cannot yet be determined (Hipkins et al., 2014; Perkins, 2014). Context-embedded learning is relevant to the development of actively engaged citizenship (Zaff et al., 2010) and key life-competencies (Rychen and Salganik, 2003), and encompasses learning that integrates knowledge, skills attitudes and values and encourages dispositions associated with acting on learning (Bay et al., 2016c). In science education, learning experiences contextualised in SSIs are known to be supportive of development of understanding of the nature of science (NOS) (Sadler, 2009; Sadler et al., 2004), argumentation skills (Venville and Dawson, 2010), substantive knowledge related to the SSI context, and general scientific content knowledge (Sadler et al., 2016; Yager et al., 2006; Zohar
and Nemeth, 2002). Our work has demonstrated that education of this genre can facilitate students to act on learning beyond the classroom (Bay et al., 2012a).

Complex open-ended issues such as the NCD crisis or climate change are values laden and cannot be dissociated from issues of equity and social justice. Therefore, education that contextualises learning in exploration of socio-scientific issues brings issues of social justice and values discussions into classrooms (Hipkins et al., 2014; Hodson, 2011). Learning of this type aims to enable students to engage in the use of scientific knowledge alongside knowledge from sociological and cultural perspectives, creating the potential for responses that reflect on issues of social justice. Experiences should allow learners to identify and reflect on their personal frame of reference regarding an issue, and examine and consider the perspectives of others before contemplating actions. When this process includes experiences that cause individuals and/or groups to identify and reflect on evidence that challenges status-quo thinking, it represents transformative learning (Mezirow, 2011). Aspects of transformative learning associated with the exploration of multiple perspectives have similarities to sense-making. This is a social process involving exploration of divergent perspectives to enable understanding and inform decision-making relating to issues within complex adaptive systems (Snowden, 2005).

Transformative learning also aligns well with talanoa, a communication medium common across Pacific cultures involving respectful sharing and listening (Halapua, 2008). Within talanoa, conversation, storytelling, and relating of experiences, aspirations and viewpoints facilitates participants to listen to and reflect upon differing perspectives (Vaioleti, 2006). Talanoa creates a safe environment in which critical discussion, reflection and the emergence of new or altered perceptions and informed decisions can emerge.

### 5.2.2. Transformative Learning

Learning is a process of growth and development resultant from experiences and reflection, and encompassing a broad array of capabilities (knowledge, attitudes, values and skills). Transformative learning describes a developmental journey involving critical reflection that leads to increased awareness of personal and other divergent perspectives, Figure 5.2. This can lead to changes in conceptions, points of view, habits of mind and deeply held beliefs (Mezirow, 2011). While developed to inform understanding of adult learning, there is inadequate evidence to claim that it is only applicable to adult learning (Schugurensky,
The theory has expanded to inform adolescent learning in secondary school settings (Larson, 2017; Lawrence and Global, 2014; Taylor and Snyder, 2012; Williams, 2013).

By the time an individual reaches adolescence they have formed habits of mind and deeply entrenched beliefs and conceptions resultant of life experiences. These are strongly influenced by the proximal environment of family, peers, school, community and internet enabled techno-subsystems within the context of the wider social, economic, political and geographic environment (Bronfenbrenner, 2005; Johnson and Puplampu, 2008). Capability development during adolescence will inevitably involve situations that challenge these deeply held beliefs and conceptions.

During adolescence, young people begin to establish a greater sense of self. They expand their being beyond the family unit, and potentially their community and culture, in preparation for the transition into adulthood (Kroth and Cranton, 2014). These characteristics may engender an openness to exploration of divergent frames of reference, particularly if learning experiences create opportunities for non-judgemental exploration, critical analysis, and reflection.

In the school setting, education leaders, teachers and adolescents should all be engaged in learning that has the potential to be transformative. This is not always a comfortable journey as people may encounter cognitive dissonance. This occurs when learning presents evidence that contradicts deeply held understanding or beliefs (Jackson, 2008).
5.2.3. Facilitating Transformative Learning via Collaborative Narrative

To facilitate transformative learning embedded in exploration of a SSI, teachers need access to resources and professional learning and development (PLD) relevant to the SSI, and to the community in which the learning is taking place. Within HSLEAP PLD aims to support teachers to develop knowledge of the NCD epidemic and DOHaD science as well as knowledge of the available learning resources and exploration of the pedagogical model on which the programme is based. This knowledge is integrated into existing pedagogical content knowledge (PCK) to enable teachers to construct, implement and evaluate learning programmes suitable for the variable needs of students in their classrooms, Figure 5.3. This process of integration emphasises the topic specificity of PCK (Hashweh, 2013) and highlights the need for teachers to actively build individual and collective capabilities required to implement future-focussed learning (Hipkins et al., 2014). PLD may deliberately present evidence that is new and/or challenging to participants. This may be associated with the SSI, the community, and/or pedagogy and practice. Such events create opportunities for open and respectful listening and discussion and have been shown to nudge individuals and groups to question strongly held beliefs and firmly entrenched learning and teaching practices (Bay et al., 2016b).

Figure 5.3  Model of pedagogical content knowledge, adapted from Hashweh (2013).
Teaching is more than having a good kit of activities (Loughran et al., 2012). However, without purpose-built resources that support capability development and SSI exploration, teachers will not be able to facilitate the type of learning that we have described. With purpose-built resources and contextual application of PCK within a supportive professional learning community, teachers can facilitate learning that examines SSIs. The HSLEAP learning resource are designed to support the creation of opportunities for students to engage with and explore age-appropriate NCD/DOHaD issues from a range of perspectives; build capabilities required to engage in this process of exploration; and engage in testing out and communicating ideas emerging from learning that may nudge behaviour change. Access to evidence, dialogue, space for reflection, and support for potential action is required, Figure 5.4.

![Figure 5.4 Factors supportive of context-embedded transformative learning](image-url)
5.3. Findings and Discussion

5.3.1. Identification of personal frames of reference

Commonly held perspectives associate NCD susceptibility with a combination of individual behaviours during adulthood and genetic dispositions (Bay, 2015a; Bay et al., 2015; Hanson, 2016; Koloto, 2013). This perpetuates reductionist thinking that assigns blame to individuals. Evidence from the DOHaD field challenges this perspective by demonstrating that nutritional and non-nutritional environmental exposures from early life interact with socio-ecological factors in childhood and later life to impact NCD risk (Hanson and Gluckman, 2014). A key aim of the HSLEAP programmes is to facilitate learning that enables adolescents to explore this evidence and identify why the commonly held belief of individual blame is inaccurate and damaging. To enable learning to disrupt this frame of reference, learners must have the opportunity to identify and reflect on their personal frame of reference regarding the issue. This establishes the opportunity to consider other perspectives and reflect on the meaning of evidence.

NCD risk is a potentially sensitive issue to explore in classroom settings due to the possibility for personal experiences, including premature death of family members, to provoke strong emotions. Therefore, it is not recommended as an introductory focus in HSLEAP programmes. Rather, we recommend consideration of what it means to be healthy and well, and factors that contribute towards a sense of health and wellbeing, as an entry point for exploration of personal perceptions. It is imperative that learning environments encourage participation by all and are non-judgemental, thus allowing students to explore and express personal perspectives. Analysis of an example of this from the Year 9 resources developed for use in the Cook Islands (Appendix 5A), and culturally adapted for use in Tongan and New Zealand schools shows that factors supporting exploration of personal perspectives in a non-judgemental manner include:

- unpacking of technical language e.g. “Oraanga e Pitoenua or health and wellbeing is about all the things that contribute to making us healthy, happy and well”
- connections to prior learning (health and wellbeing)
- use of language that connects to cultural identity
- the emphasis on personal perspectives, promoting the validity of all ideas
- separation of descriptions and explanations; reducing the potential for the requirement for explanation to block the potential for participation
• the use of images representative of the local context; supporting contextualisation
• use of small discussion groups, optimising the potential for participation.

The asset-based salutogenic representation of health and wellbeing used within these resources reflects the definition given within the constitution of the World Health Organization (1948) (World Health Organization, 2017) and is strongly aligned to perspectives of health and wellbeing inclusive of spiritual wellbeing expressed in Pacific and Māori cultures (Cook Islands Ministry of Education, 2004; Durie, 1985). Identification and discussion of the place of culture, spirituality and the socio-ecological environment in health and wellbeing at this stage of the learning journey points strongly towards science being socially and culturally situated. The gradual engagement throughout the programme with concepts that encourage this thinking is designed to encourage the integration of scientific perspectives with social and cultural perspectives in decision-making. This reflects the development of scientific literacy (Vision II) as opposed to science literacy (Vision I) (Douglas and Rodger, 2014). Observations of classes and teacher feedback in focus groups indicated that this task enabled students to explore the concept of health and wellbeing and express their personal views.

Teachers also need experiences where they can consider and reflect on perspectives on NCDs as a SSI. An early exercise within the PLD programme engaged teachers in using the ‘Think-Pair-Share’ strategy (Lyman, 1981) with a trusted colleague to consider how NCDs are connected to their family story (Bay et al., 2016d). Differences in perspectives were recognised. Teachers who could identify with NCD experiences that affected their family or friends tended to reflect deeply about this. Where these teachers were willing to share their experiences with the group the discussion created opportunities to enable those who had expressed reservations around the extent of the issue an opportunity to hear a contrasting perspective. Many of the teachers who had personal experience of NCDs affecting their family became deeply engaged in developing their professional knowledge of the issue as the project evolved. Some used their family experiences to encourage personal experience to enter into the collective narrative evolving in the classroom.

“Growing up in a family with a history of diabetes, many of the personal impacts of diabetes were familiar with me. This was my buy-in to the project. My family life gave me ‘real-life’ experiences that I used to engage my students. We also had a staff member with diabetes who was willing to share his experiences - that was of great value. This knowledge of diabetes drove me to explore the issue further through PLD sessions as well as
professional readings. To help develop my understanding of the issue I sought information from the Ministry of Health who provided me with a wealth of knowledge on the current and historical state of diabetes and nutrition in the Cook Islands. The STEPS report was a great tool that gave me insight into the nutritional issues facing the Cook Islands people.”

Senior teacher, Cook Islands

5.3.2. Exploring differences in thinking

To expose and potentially facilitate reconsideration of frames of reference it is essential that participants can identify that different frames of reference exist, and consider how and why these might differ from their perspectives. We analyse here processes and outcomes from learning resources used to facilitate examination of differences in thinking within the middle school programmes (Years 7-10) in the Cook Islands and Tonga. These offer opportunities for students to engage in research within a scientific framework while exploring differences in thinking (Appendix 5A). This supports curriculum-linked learning outcomes associated with development of understanding of the nature of scientific evidence and the process of scientific research. It also assists students to experience science as a human endeavour.

These resources were developed in response to a workshop in which teachers indicated that most Year 11 students were challenged by requirements to develop and refine research questions. By engaging Year 8-9 students in learning that aims to develop capabilities associated with asking questions and undertaking research, the resources offered support for a key educational goal. Framed by the title “Think like a Researcher” the tasks facilitate students to create their own narrative about doing research ((Bay and Yaqona, 2016), page 10 – 25, Appendix 5A). Experiences of this type support critical reflection within trusted learning relationships, facilitating the development of understanding and the potential for altered perceptions (Taylor, 2011). In this case, learning is assisting students to explore perceptions of what science is and how it is carried out, as well as beliefs about health and wellbeing.

Students were presented with a question that was too large to answer, an issue identified by teachers as very common in work presented by Year 11 students. The question asked “Do people of different ages have similar or different ideas about what makes us happy, healthy and well?” The use of ‘us’ prompts students to identify that they must refine the question to sit within the frame of their context (e.g. school. family. community). Activities
support students to examine why this question is too broad and to design their own question. A series of differentiated worksheets provide variable scaffolding, designed to support all students to engage in the research task (Appendix 5A).

A fictitious story is interwoven between the activities in which the students are designing and undertaking their research. In the story, a boy (Tama in the Cook Islands and Sione in Tonga) is undertaking research to identify whether shirts hanging on the line from the tail or the collar dry faster. Tama and Sione’s story provides scaffolding to support learning. It links to previous learning associated with the design of scientific research, supporting students to review and reconnect with these concepts. The story offers contextual explanation of technical terms such as hypothesis and variable, supporting access to knowledge required to engage in the inquiry.

Some teachers could not see the point of the integration of the Tama/Sione story, suggesting that this should be removed as it distracted from the task. Others used the story to support development of understanding of components of the research process. Several teachers who had previously not used visual stimuli to aid learning strung clotheslines with shirts, and in one case relevant vocabulary, across their classrooms. A group of experienced teachers in Tonga who have not had the opportunity to study science at university identified that the story facilitated discussions between teachers about their understanding of research methods. In some cases, the story had assisted teachers to recognise misconceptions regarding the nature of an hypothesis that they believed they had been passing on to students. The teachers raised these questions in a PLD workshop, facilitating discussion that prompted change in understanding that they then applied in their practice.

The provision of differentiated learning resources created variable outcomes which were broadly associated with differences in teaching experience. Senior teachers with deep and broad PCK, including strong content knowledge, teaching practice knowledge and knowledge of the community in which the school was set, found that the differentiated learning resources encouraged collaborative learning, and through this engagement in discourse about learning.

“The teaching resources had differentiated activities as well as both hands-on and theoretical activities set in an ‘Inquiry Learning’ model. To utilise the potential of these resources, I had to find the best activities to suit the needs of my students. To achieve this I used data such as literacy assessment data. This gave me evidence of the literacy levels of each student and allowed me to provide each student with suitably pitched activities.
This gave rise to the question, “Do I let the students work individually or in groups? And if in groups would they be mixed or similar ability groups?” As a teacher, this left me with a ‘wonderful dilemma’ because despite having to make all these decisions, I was confident that my choices were evidence based! While there was no ‘one size fits all’ scenario, the strategy I used most often was differentiated activities within a mixed ability group. This strategy created a lot of interest among the students as to what the others were doing. Without needing specific instruction, the students began working together to help work through each other’s activities. This gave students a sense of being a part of a solution, especially the lower ability students.”

Senior teacher, Cook Islands

Some early-career teachers identified that while they understood differentiation conceptually, they were tentative about what differentiated learning might look like in a classroom setting. Teachers in this category reflected that the provision of resources enabled them to visualise and trial differentiation.

Other early-career teachers chose not to engage in the use of the resources, either as whole class or differentiated exercises, stating that this would be too time consuming. It was noticeable that in these classrooms students had difficulty in defining a manageable research question, affecting the quality of student outputs. The most common problem identified the questions put forward in these classes was associated with the selection of independent variables that enabled comparisons between two groups.

Discussion within the PLC created opportunities for early-career teachers to hear the stories of other teachers who were using differentiation. In schools where integrated learning approaches were being used this was particularly effective as teachers who taught the same class in a different subject area could share their experiences. These discussions prompted questions for some novice teachers about why the experienced teachers could successfully use differentiation with a class in which they believed students would not cope with such activities. In asking these questions, teachers were demonstrating critical reflection.

A group of experienced teachers in Tonga, who described their usual practice as not involving open-ended learner centred activities, selected from the differentiated activities to create learning episodes that accounted for this lack of prior experience. Recognising the complexities associated with student-centred open-ended learning they decided to work with their classes to define one question, and then allowed each group to undertake their research. This collective planning demonstrated application of multiple aspects of PCK
alongside a very high level of self-awareness of personal teaching practice. The teachers reported very positive experiences of group work in their classrooms. Observation of student responses and analysis of student outputs indicates that these students were engaging in open-ended learning. Their written outputs reflected less depth of analysis compared to those from classes taught by experienced teachers for whom open-ended learner centred activities were the norm. However, the students were able to analyse and discuss their findings when questioned. Observation and teacher reporting of ongoing use of this style of learning indicates that the resources allowed teachers to test out an alternative frame of reference, which to varying degrees they have integrated into their normal practice over a period of two years (La'a'akulu, 2016).

5.3.3. Disrupting thinking

A core element of transformative learning is the concept that exposure to disorienting ideas, experiences or evidence can promote the potential for consideration of alternative perspectives (Mezirow, 2011). Increasingly alarming evidence of the extent of the NCD crisis in the Pacific (Hawley and McGarvey, 2015) has promoted significant efforts from governments to engage communities in awareness and actions (Cook Islands Ministry of Health, 2015; Tonga Health Promotion Foundation, 2016). However, many of these efforts are relatively recent, evolving during the period of the PSHLP project. A relatively high level of denial was expressed amongst teachers in the early stages of professional development regarding the extent of the NCD issue. Thus, we consider the presentation of evidence of the NCD epidemic in Pacific nations to represent a disorienting dilemma for some teachers, as well as for students. Evidence suggests that the NCD epidemic in the Pacific is a crisis (Hawley and McGarvey, 2015), making transformative learning approaches highly appropriate (Sharpe, 2016).

Learning resources designed to expose students to evidence associated with NCD risk were presented to Year 8-9 students in the context of narratives exploring the work of scientists within their communities (e.g. Bay and Yaqona 2016, p 30-39). These included reimaged data for students to examine and interpret. For Year 11 students, evidence was presented in the form of reimaged data exploring incidence and risk factors locally and internationally (Bay et al 2016d, p 64-83). Teachers were provided with workshop experiences, adult learning resources and original research reports to support development of their understanding of the extent of the issue.
As with the previous learning resources, these were all designed to support core curriculum goals as well as engage students in the SSI context. The narratives developed for the Year 8-9 students support the notion that scientific research is a human enterprise conducted by real members of the community and relevant to issues of concern to the community. Used alongside experiences of meeting scientists within the narratives, we observed that learning of this nature challenged perceptions about scientists, e.g.

“We thought scientists are people in white coats and glasses but they are just ordinary people...they are just the same person I’ve always walked past.”

Year 9 Student, Cook Islands

The process of data analysis and reflection supported by the Year 11 resources disrupted the frame of reference commonly held by these students, e.g.

“I was really surprised by how many people there are suffering from diabetes and obesity because it does not seem like much to us. But, when we saw the data it was a lot which was really surprising. I am glad we did the topic because now we know and now we can try and make a difference.”

Student, Year 11, Cook Islands

Students used their newly acquired knowledge to support discussion within families that challenged the predominantly held viewpoint, e.g.

“My family didn’t believe when I said that we were number one [for obesity] because I think my Dad still believes that Cook Islanders are still all fit. So you have to show them the data. They were surprised because they did not know about this because back in their time there were no problems with weight. After like I explained this to them they too agreed because one of my parents said they saw one of their friends from when they kids already has diabetes - and so we were like talking about how it is real and that we all need to change and eat more veges and do more exercise. So we have been talking about that quite a lot in our house and we are eating more vegetables for our dinners.”

Student, Year 11, Cook Islands

For some students, the experience of examining the data created uneasiness. It is important that teachers reflect on the potential for exploration of evidence of this nature to be frightening to adolescents and ensure that they are given appropriate support e.g.
“We were given handouts and were reading through it and first it started with how many people in the Cook Islands had diabetes and from there with the reading and talking we just found out that us the younger generation are at risk of getting diabetes. I am actually scared about that.”

Student, Year 11, Cook Islands

The resources associated with disrupting thinking for Year 8/9 and Year 11 contained differentiation strategies. Literacy demand variability was provided to enable task differentiation. Teachers were encouraged to engage student pairs in taking responsibility for exploring one aspect of the evidence, and sharing their findings within a larger group. This represents students contributing to collaborative narrative about the issue. As with the earlier resources, novice teachers and teachers with less experience of learner-centred practice tended not to use the resources in this way. In some cases, this created issues of excessive work being presented to students, and teachers stating that allowing students to explore the evidence takes too much time. These observations have highlighted areas that require further attention via PLD.

5.3.4. Developing conceptual understanding

The development of understanding of relevant content knowledge is required to enable application of scientific perspectives to critical evaluation and decision-making related to socio-scientific issues (Hodson, 2011). Conceptual understanding is greater than the collection of knowledge of facts (Konicek-Moran and Keeley, 2015), reflecting the ability to integrate knowledge of and about concepts to describe, explain and analyse phenomena. The inclusion of resources supporting the development of relevant contextual understanding is intentionally placed after learning that facilitated engagement with the issue and before the introduction of DOHaD related scientific evidence. For example, having defined personal perceptions of diabetes and its impacts and explored evidence of the prevalence of diabetes locally, regionally and globally, the Year 11 programme enters a phase of conceptual understanding development. This recognises that without understanding of what diabetes is and how it impacts physiological systems, students cannot engage in effective exploration of evidence associated with socio-ecological and biological determinants related to the diabetes epidemic (Bay and Mora, 2016, p 95-111). Analysis of student outputs demonstrated the use of content knowledge in the development of evidence-based discussions.
5.3.5. **Science narratives: Introducing alternative frames of reference**

All people lead storied lives. The use of narratives to engage youth in exploration of data that may present alternative perspectives is underpinned by evidence of the efficacy of narrative-based learning in science communication and education (Dahlstrom, 2014; Hadzigeorgiou, 2016; Lauritzen and Jaeger, 1997; Solomon, 2002). Furthermore, narrative pedagogies create power-sharing opportunities in classrooms through committed, connected participatory relationships known to be supportive of students from indigenous cultures (Bishop and Glynn, 2003). The nature of the narratives used in HSLEAP to explore scientific evidence has been described via an exemplar analysis in Chapter 4.

Quantitative survey data demonstrated that participation in the learning experiences increased awareness of associations between early-life nutritional exposures and later-life NCD risk. Evidence from focus groups indicates that the narratives supported change in understanding; and that students valued the access to data provided, and discussed the evidence presented in the narratives with their families. This sharing with family indicates that the students developed the collaborative narrative about NCDs beyond the classroom.

> “The data made it interesting. It was new data, information on NCDs that we did not previously have access to.” Year 11 Student, Cook Islands

> “I learned that the food that the pregnant mothers eat can be part of the cause of diabetes. I talked to my mum about that. She was kind of shocked at first and so I started explaining it to her and she started understanding.” Year 9 Student, Cook Islands

> “The benefit of this [the narrative] is it was really good for learning. We learnt and we can learn how to teach other people or to make other people aware of what is going on it a cycle - you can talk to your family. Like we were teaching our family and they were surprised because they did not know about it.” Year 11 student, Cook Islands

A common theme arising to questions asking students about improvements that could be made to the programme related to increasing access to evidence via stories. This suggests that the students appreciated this method of learning.
“We need to make everyone else aware of this epidemic. Not just us, but also the primary [students]. Have some little books and stories for them as well”

Year 11 student, Cook Islands.

“The student book, could we have more detail of the rat models and those stories. That would make it easier to understand. Because I understood that you could not make a human to do that - so you need the rats to make the model - but yeah we need lots more around that because it is interesting and we wanted to know more”.

Year 11 Student, Cook Islands

Further discussion with Year 11 students around this issue identified that they had seen, and requested to use the teacher resources because they felt that the level of detail provided for teachers gave them greater potential to understand the issues. This was a small (~ 15 students) Year 11 class in one school. In another school where the Year 11 class was larger, students had become aware of Professor David Barker’s book exploring DOHaD evidence (Barker, 2008) and had requested access to this because they wanted to find out more. These examples of responses from Year 11 students suggest a high level of engagement with the SSI and the evidence. They also indicate that students in this context (Cook Islands) responded well to the narrative genre.

Evidence from teachers indicates that the sharing of stories about NCDs and DOHaD occurred between peers as well as in the families.

“The power of storytelling was clearly evident in the school. Through the sharing of stories amongst the students a lot of interest has been created. Students are coming into the classroom with either some form of prior knowledge or questions about the work which is great! The stories were not only circulating among the students. Staff were beginning to ask questions about the modules as well. These discussions initiated the journey of cross-curricula teaching and assessment using the context of the modules. This led to the Year 11 study of the issue of type 2 diabetes in Science being used in English for formal writing as well oral presentation. This has helped reduce the teaching time in English but more importantly students are using issues in their study of English that they are very familiar with. Once we have the required staff capacity this will be extended to Social Studies where students will be studying a Social Issue.”

Senior teacher, Cook Islands
Initial PLD workshops indicated that while almost all teachers used anecdotes and exemplary stories in their teaching and encouraged students to bring their experiential stories into learning, very few science teachers had previously used narratives such as those presented in “My First 100 Days”. Patterns associated with experience of learner-centred classroom emerged in reflections on the use of resources of this kind. While senior teachers reflected on literacy across the curriculum strategies that they employed in using these resources, less experienced teachers and teachers for whom substantive content was a key driver in learning were less enthusiastic about using the narratives.

“It was important that literacy strategies were used. One such approach to enhance reading for deep understanding is ‘shared reading’ which involves reading with and talking with students. This strategy allows the teacher to model and think aloud about adopting literacy strategies during the reading. While the teacher is reading, the students are following the teachers reading with their text. When the teacher pauses to discuss the text, ask questions and make predictions, the students listen, respond, question and learn how a strategic reader processes information. One of the main benefits of this strategy is that students often get the feel of the important aspects of the reading through the tone of the teacher’s voice. This instigates critical thinking. It is important to provide students with opportunities to discuss and explore the issue being read.”

Senior Teacher, Cook Islands

An experienced teacher in Tonga used role-play extensively to support students to explore the narratives. She then used role-play to enable students to envision different ways of approaching thinking about food choices in their families. Less experienced teachers commonly reflected problems associated with inadequate time for learning and the importance of getting through content in the syllabus. These teachers believed that the use of narratives was too time intensive.

5.3.6. Nudging: From decision making to sustainable actions

HSLEAP aims to support capability development that facilitates participants to act on learning, and nudges small sustainable behaviour changes that are supportive of long-term and intergenerational advancement of health and wellbeing. We emphasise small and sustainable, as sudden large behaviour changes are usually unsustainable and are known to be potentially dangerous (Todd et al., 2015).
Survey data from the Cook Islands cohort shows changes in behaviour associated with junk food consumption, (Chapter 9). Focus group discussions indicate that students who are initiating change relate this to the evidence they have been exploring, and understand that there are challenges associated personal choices when changing nutritional practices.

I have started cutting down on meat and I have started eating the right food at the right time. Also changed some of the eating rules in our house. For breakfast my little niece and nephews used to have chocolates and fizzy drinks, and then now, ever since I started on the survey [research task] I have thought about it and I have actually told my mum there are fruits, there is cereal and there is toast. Before we used to have Nutella chocolate and now that’s changed to Vegemite.”

Year 9, Cook Islands

Food is a big risk factor for diabetes - what we eat now as well as what our mum could have when we were in the womb with her - that affects the risk of the baby. So it is important for us to eat healthy food now and exercise but that is not easy. Eating is hard because we have learnt to love junk food. It is hard to get away from something you have learnt, the fast food is hard to change. I tried eating more fruits but I still want to eat the meat and you try not eating the fast food but you want it; you want the fruit - but the fast food is there and that makes it hard.

Year 11, Cook Islands

Overall, the evidence suggests that transformative learning has been enabled for some students. Phenomenological case study analysis of differences between students for whom learning has and has not nudged actions outside the classroom would be valuable.

5.3.7. Change in teaching practice

Evidence suggests that for some teachers, processes associated with transformative learning have been activated with respect to pedagogy and practice. Resources provided to facilitate exploration of the SSI were used differently by experienced and novice teachers. Teachers from across this spectrum reflected on the value of learning resources providing them with examples of different strategies. Some novice teachers reflected that they felt that seeing experienced teachers in action using the types of strategies that were being explored in PLD would be valuable. Discussions within the clusters in response to these reflections led to the development of short videos where teachers explain the strategies, using footage from classes and short interviews with students to support understanding e.g. (La‘akulu, 2016). Investigation into the use of these narrative-based videos in supporting
teachers to engage in collaborative narrative about learning and explore the potential for change would be valuable.

Evidence of teachers developing and visualising ongoing use and development of the project is indicative of a frame of reference that is inclusive of future-focused learning. Where this was not previously occurring, this suggests that the PLD created the opportunity for new thinking to become embedded in core practice. Examples of the types of actions that have been observed include:

- development of learning modules based on concepts of context-embedded SSI exploration outside of the project context (e.g. sustainable water use)
- development of complementary learning modules building on the learning within the project (e.g. Case Study 1.1)
- development of integrated learning opportunities (e.g. cross-curricula collaborations)
- integration of evidence presented within the project in wider aspects of school life such as food festivals, fundraising events, action associated with school tuck shop foods, catering used in workshops, staff and parent meetings
- increased integration of participation in health promotion activities in the community into learning
- engaging teachers from schools outside of the project in development of the potential for integration of the project in their schools
- planning to continue to formally evaluate the project from both education and health perspectives beyond the initial period of the pilot

These examples of actions by teachers are supportive of long-term sustainability of the project and represent the integration of new thinking into practice.

5.4. Conclusions

The HSLEAP programmes promote the use of collaborative narrative in facilitating personal and professional development for adolescents and their teachers. Humans are storied people who learn from the past, live in the present and visualise the future through stories. Families, schools and communities all possess collaborative narratives built over generations that influence who they are and the journey that they are on. To learn from the journeys of others, people need access to opportunities to explore those journeys and reflect on their meaning. We have shown that when teachers can access stories about SSIs, and
possess the professional capabilities required to use these, stories may facilitate transformative learning experiences.

Transformative learning reflects a learner-centred model within a constructivist framework (Ultanir, 2012) within which dialogue and reflection are considered pivotal in influencing outcomes (Sharpe, 2016). Narrative-based transformative learning also aligns well with the talanoa communication model common across many Pacific cultures. The teachers in the clusters include locals and expatriates. The size of the cluster is not large enough to determine whether being of Pacific cultural heritage influenced responses to narrative-based transformative learning models. However, the PLD model has promoted significant changes in practice amongst teachers of Pacific cultural heritage within the clusters, including those for whom learner-centred practice was not the norm.

Teachers cannot facilitate learning that explores stories from science and the community relating to SSIs if they do not have access to narrative-based resources. We have identified that resources provided within HSLEAP offered opportunities for teachers and PLD leaders to facilitate transformative learning experiences. However, we have also identified that teacher experience is a key factor in enabling effective use of narrative-based learning. Therefore, careful attention to the needs of early career teachers and teachers whose usual practice is not aligned to a learner-centred constructivist approach is required.

If I have a kete (basket) of coconuts but no knowledge or tools with which to open the coconuts, the nutritional goodness contained within the coconut will remain locked inside. Future research should examine in-depth the experience of a range of teachers engaging in context-embedded learning exploring SSIs to better understand how teacher experience impacts learning, and how effective resourcing can support teaching.
Chapter 6. **Questioning in Tongan Science classrooms: A pilot study to identify current practice, barriers and facilitators**

Preface

This case study, published in the *Asia Pacific Forum on Science Learning and Teaching*, examines how the use of participatory action research supported teachers in Tonga to define, challenge and amend their frame of reference with regard to the use of questions in science classrooms. The altered approaches to learning and teaching strategy that emerged are described in videos the teachers produced as professional development resources supportive of communication of the impact of the changes they have made within their schools and the wider education community in Tonga. Two examples of these video-based resources can be viewed on the PSHLP website where the story of this research is presented by members of the professional learning community (PLC). The creation of this web page represents a ‘story’ designed by the PLC to support the development of collaborative narrative with teachers beyond the PLC. Thus, this professional learning community used the process of creating their own narrative to in turn create a resource (story) that they could use with other teachers in the formation of future collaborative narratives. By using video to create the story they have embedded their interpretation of the story into the resource. Thus, the challenge of interpretation by the storyteller is overcome to an extent. Ideally the narrators need to be able to engage in discussion with any new groups of teachers wanting to embark on a professional development journey based on this work.

6.1. Introduction

6.1.1. The role of questioning in the development of scientific literacy

Scientific literacy is identified internationally as a core objective within 21st century school science education (Douglas and Rodger, 2014; Millar, 2008). Definitions of scientific literacy are variable but all relate to the development of capabilities (knowledge, skills, attitudes, and values) that enable the use scientific knowledge and understanding in decision-making at personal, community, and societal levels (Bybee, 1997; Laugksch, 2000; Millar and Osborne, 1998; OECD, 2013). The scientific literacy approach to science curricula arose initially from the need to address the purpose of science education in schools (Douglas and Rodger, 2014). Twentieth century science education was dominated by content-laden curricula. These were designed to train future scientists, and usually delivered using decontextualized didactic approaches (Osborne, 2007). Increasingly complex interactions between science and society in the latter half of the twentieth century demanded review of these approaches. Science education that supported the development of critical consumers of science as well as potential future scientists was required (Bull, 2011; Osborne, 2007). Thus, the past 20 years has seen a gradual shift towards science education that promotes the development of knowledge, skills, attitudes, and values required to engage with and use scientific evidence. When embedded in a contextual approach this contributes to the cross-curricular task of development of critical, informed citizenship; a process enabling adolescents to engage with and act upon evidence relating to complex, open-ended, future-focused issues (Hipkins et al., 2014). Such issues are associated with complex interactions between science, technology, health, the environment, economics, culture, and sociology. Thus, while the focus of this paper is on the role of questioning in the development of scientific literacy (including interactions between science and society), we note that in science classrooms exploration of such issues should be inextricably linked to the development of contributing capabilities such as health and environmental literacies (Grace and Bay, 2011; Zeyer, 2014). Furthermore, exploration of multiple perspectives should evolve within the learning experiences. This enables students to explore and value diverse perspectives that include science (Kahn and Zeidler, 2016).

Development of scientific literacy requires critical thinking. This is associated with dispositions that encourage inquiry alongside questioning linked to observation, evidence-seeking, analysis, and examination of uncertainty, debate, and justification of
decisions/positions/arguments. To cultivate critical thinking, learning environments should encourage students to ask questions, think about their thought processes, and develop habits of mind that enable them to transfer critical thinking skills from the classroom to life situations (Molnar et al., 2011). Therefore, questioning is an essential component of learning environments that promote development of scientific literacy and contribute towards lifelong critical informed citizenship.

6.1.2. Questioning in Tongan Science Classrooms

The Pacific Science for Health Literacy Project (PSHLP) is a multi-sectoral partnership involving education, health, and science communities in Tonga, the Cook Islands, and New Zealand (NZ). The project supports the development of capabilities required for adolescents to explore and take actions relating to the non-communicable disease (NCD) epidemic, a complex, open-ended issue of significance in Pacific Island communities (Bay and MacIntyre, 2013). Health literacy is identified as a core capability alongside scientific literacy required to enable students to negotiate health-related SSIs (Bay et al., 2016a). Health literacy is associated with application of knowledge, skills and self-efficacy enabling evidence-based decision-making and actions related to health and wellbeing (Nutbeam, 2000). As with scientific literacy, this is applied at the level of personal, community, or societal decision-making and is considered critical to empowerment (Nutbeam, 2000; Nutbeam, 2008). Therefore, in the context of the PSHLP project and this study strategies to support the development of health literacy and scientific literacy are examined simultaneously within PLD.

Practicing teacher capability development is a key component of PSHLP. This supports teachers to make evidence-based decisions related to learning and teaching that facilitate improved development and application of scientific and health literacies within the adolescent population. Learning resources contextualized in aspects of the NCD epidemic have been co-constructed by the project team. Narratives supporting students to explore research evidence are central to the pedagogy on which these resources are based (Bay et al., 2012c; Grace and Bay, 2011). Through these stories, students explore factors contributing to the NCD epidemic, develop relevant knowledge and understanding (conceptual, process and epistemic), examine scientific and health data (reimaged to suit the age of the students), and construct evidence-based arguments for actions that they could undertake to support NCD risk reduction in their families and school communities.
During professional learning and development (PLD) workshops examining interactions between and the development of scientific and health literacies, teachers within the PSHLP Tonga team identified a dilemma with regard to the importance of questioning as a capability required for the development and application of scientific literacy. The teachers proposed that questioning, debate and argumentation were not actively encouraged in classrooms within the team, nor in many Tongan families. While the teachers agreed that the development of critical thinking was a stated aim promoted in schools participating in the project, they felt that in practice, a combination of traditional teacher-centred classrooms and cultural factors meant that minimal questioning occurred. The teachers proposed that it was very difficult to support students to use scientific and health evidence in decision making if students had little experience of questioning and argumentation at school or at home. This hypothesis sits well with established literature examining the importance of argumentation in science, and thus in science education (Chin and Osborne, 2010; Lawson, 2003).

This dilemma is not unique to Tonga. Addressing respectful silence in learning within Pacific cultures is well documented (Chu et al., 2013; Lee Hang and Bell, 2015). In Tongan culture, faka’apa’apa (to be respectful, humble and considerate) is an important quality (Vaioleti, 2006). Traditionally, questioning and asking questions is not seen as a process supportive of development of knowledge, clarification, or understanding. Rather it is seen as questioning the authority of the elders, being parents, teachers and all those that are supposed to 'know' and are expected to tell others what to do, or give instructions. While indigenous knowledge and culture is often incorrectly perceived by western-dominated thinking as being timeless, this is not the case (Quanchi, 2004). In Tonga there is a gradual drift from the traditional position on questioning to one that finds questioning acceptable, depending on who is asking the question and for what purpose the answer is going to be used. This is particularly evident in younger generations with acceptance from some that the one who is questioned is expected to 'know' (therefore is being respected) and is ready to share information for learning. Therefore if the question is not challenging the authority of traditional thinking, but is asking for clarification or elaboration, and the respondent is prepared to engage, questioning may occur.

The PSHLP teachers proposed testing of two hypotheses to establish understanding of their current practice with regard to questioning in science classrooms and enable a baseline from which action research could be developed and evaluated.
1. That issues associated with questioning and respect in Tongan culture limit opportunities for questioning and discussion in classrooms, impacting potential for students to develop critical thinking capabilities required for development and application of scientific and health literacies.

2. That while open questions were supportive of development of capabilities associated with critical thinking and scientific inquiry, where questions were used by teachers in science classrooms in Tonga, these tended to be closed questions.

The testing of these hypotheses via participatory action research placed the PSHLP teachers in the role of teacher-researchers (TRs) within this study. They identified this as an important aspect of their professional development within the PSHLP intervention, growing their capacity to support the development of scientific and health literacy in adolescents via learning contextualized in exploration of the NCD epidemic.

6.2. Purpose
To develop a peer-to-peer protocol enabling teacher-researchers to characterize current teacher-led questioning practice and identify barriers and facilitators to the use of questioning in Tongan science classrooms. By utilizing an action-research approach, the study encourages teachers to engage in an ongoing ‘Teaching as Inquiry’ cycle (Ministry of Education, 2007; Weinbaum, 2004).

6.3. Methods

6.3.1. Study Design: Talanoa-based participatory action research
Within PSHLP-Tonga, methodologies grounded in Tongan thought and culture are purposefully used to ensure that study methods are centred within a Tongan epistemology. The study used a talanoa-based qualitative participatory action research (PAR) methodology. Talanoa is a communication medium shared amongst Pacific cultures. It is a process of conversation, storytelling, relating of experiences, aspirations and views and listening to different voices within respectful relationships (Halapua, 2008; Vaioleti, 2006). Talanoa allows authentic ideas to be expressed which may lead to “critical discussions or
knowledge creation that allows rich contextual and inter-related information to surface as co-constructed stories” (Vaioleti, 2006).

The PSHLP professional development workshops within which the dilemma relating to questioning in Tongan science classrooms arose were also based on concepts of talanoa, emphasizing the importance of voices being heard, and most importantly listening purposefully. The depth to which listening occurs is central to talanoa, and from this emerges communication and dialogue where respect and attention is given to all participant voices (Halapua, 2008). Through talanoa, a safe space is created for dynamic processes supporting critique, from which can emerge evidence-based actions that are appropriate for the social and cultural context. In the case of our talanoa pertaining to scientific and health literacy development, through a process of sharing and listening, reflections emerged that developed into a question, from which the action research reported in this paper has arisen.

A summary of the action-research process is presented in Figure 6.1. Details of the setting and each component of the methods are described in the paragraphs that follow. The PSHLP study was approved by the University of Auckland Human Ethics Committee (Ref. 011207), the Tonga National Health Ethics Research Committee (Ref. 040614.2). The study was approved by the Director of Education, Tonga Ministry of Education and Training.

6.3.2. Setting and Participants

Tonga is a middle-income Pacific Island nation, with a population of just over 100,000, 56% of whom are less than 15 years of age. Approximately 73% of the population reside on the main island of Tongatapu (Tonga Department of Statistics, 2011). The study team consisted of 16 practicing science teachers and one deputy principal from three government schools on the island of Tongatapu, and the project leader. Two of the schools conduct lessons in English, supplemented by Tongan, and one uses Tongan exclusively. Teacher-researchers were strongly supported by the principals of each school. The teacher-researchers all teach science in Forms 1–2/Years 7–8, where students are 11 to 13 years old. Most also teach science through to Form 5/Year 11. Other than one, the deputy principal and principals supporting the team were not science teachers. Their role was in linking the project to learning and teaching practice PLD in participating schools, ensuring the teachers felt confident that they could try new ideas within the project. The majority of
teacher-researchers have a diploma in teaching but have not had the opportunity to undertake university level study in science. This is typical of form 1 – 5 science teachers in Tonga where only 3% of the population have a tertiary qualification (Tonga Department of Statistics, 2011). The research was the first experience of action research for the teacher-researchers, but not the principals. Teacher-researchers recorded their written intentions, observations and reflections in English. Discussions occurred in both Tongan and English throughout the research process. The project was overseen by the CEO of Education. This leadership gave permission for teachers and schools to openly explore their practice.

6.3.3. Data Collection

Peer-to-Peer (teacher-to-teacher) observation was used to gather data on typical teaching practice with eight of the sixteen teacher-researchers in the project group participating in data gathering as teachers and eight as observers. This process is described in Figure 6.1. All teacher-researchers were familiar with classroom observation by a principal or deputy principal for appraisal, but peer-to-peer observation was novel. Participating teachers identified a science lesson with a Form 1 or 2 class in which they intended to undertake active questioning with the class-group. Learning intentions were exchanged with a trusted peer who was invited to observe the questioning episode within the lesson and record observations using a standardised observation record sheet. The observer categorized questions used by the teacher as open or closed, recorded the number of students offering to respond to each question, and the number of student questions arising from each teacher question. Student responses and questions were not recorded. Following the teaching episode reflections were recorded by both the teacher and observer independently, prior to meeting to exchange and discuss reflections. Following this meeting final reflections were recorded and development goals set.
### Defining the Research Question
The research question emerged within PSHLP teacher PLD examining scientific and health literacies, and their relevance to science education in Tonga. Consensus was sought from the Ministry of Education and Training (MET), participating schools and teachers to investigate the use of questions by teachers within the PSHLP-Tonga study group via teacher observation, an approved research method in the PSHLP project.

### Co-construction of the study protocol
Workshop A (3 hours): The Study Design Workshop explored concepts associated with types of questions, use of questions in classrooms, and research methods. A protocol based on the approved teacher-observation protocol was co-constructed. This involved formation of trusted-peer partnerships within the teacher-researcher team; invited observation of a teaching episode; data analysis and interpretation via collaborative workshop. The protocol was confirmed by MET & participating schools.

### Data Collection
Classroom observations with a trusted peer. Teacher-researchers (TRs) self-selected into pairs. Within pairs, one member elected to teach and the other to observe. TR pairs agreed on a time and context for the observation focusing on the use of questions by the teacher in a 10-20 minute episode within a science lesson. The observer recorded questions asked by the teacher and the number of student responses. Both TRs conducted written self-reflections and shared these with each other at a mutually agreeable time. Agreed data was submitted to project lead (PL).

### Data Analysis
Workshop B: 4 hours
Facilitated by the PL the workshop introduced TRs to concepts of qualitative data analysis. A consensus coding criteria evolved from sharing of results of small group coding of anonymized data. This process was supported by the development of coding exemplars via discussion & consensus. The group coding process was repeated until consensus was achieved. Six TRs were elected by the group to summarize the findings.

Workshop C: 4 hours
Facilitated by the PL; 6 elected TRs working in pairs summarized and presented the data analysed in Workshop B in written formats in preparation for internal peer review.

### Writing & Peer Review
Workshop D: 2 hours; Facilitated by the PL and attended by all TRs.
The 6TR group presented the findings of Workshops B and C. Peer review discussions involving all TRs were undertaken. These resulted in agreed instructions for the 6TR group to complete development of a research poster and seminar presentation.

Workshop E: 1 ½ hours;
Facilitated by the project leader and attended by the 16 TRs. The 6TR group presented the draft poster and seminar. Peer review occurred via small group and then full-group discussion. The 6TR group undertook to make collectively agreed changes.

### Communication
Seminars presentation:
The 6TR group presented the seminar on behalf of the team. The audience consisted of the CEO of Education, principals and teachers from participating schools. The 30 minute seminar presentation was followed by a response from the CEO and an open discussion. TRs were presented with a certificate of achievement by the CEO of education. A shared meal for the TRs, their families and school/MET leadership provided a culturally appropriate celebration of the achievements of the TR team.

Final adjustments were made to the poster presentation via consensus following comments from CEO and Principals. A0 and A3 copies of the poster were distributed to participating schools for use in school-staff discussions. TRs from each participating school gave seminar-presentations to full staff meetings. These were supported by the PL and the school principal. Departmental discussion and planning for actions based on the evidence presented in the seminar followed.

### Year-end reflections
Annual PSHLP teacher focus groups were used to gather evidence regarding ongoing impact of the action research programme.

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**Figure 6.1** Study flow diagram
6.3.4. Data analysis

A series of workshops described in Figure 6.1 were used to introduce participating teachers to qualitative data analysis methods including coding and inter-researcher consistency, a process that was novel to all participating teacher-researchers. Coding was undertaken in small groups to support research capability development in the teacher-researchers. An inter-researcher coding consensus development process during Workshop B was used to establish codes. Groups of four teachers were given anonymized data from two TR pairs and required to code each teacher question as open or closed. Groups were then required to share and justify their coding, initially with one other group, and then with the entire workshop. This process revealed variation within and between groups arising from inconsistent conceptions of open and closed questions. Through the talanoa process of open and respectful dialogue, the groups were able to collectively agree on perceptions of open and closed questions, and reach consensus on the coding system. During this process, questions were placed along three continuums, initially in a linear manner, and then within a three-dimensional axis (Figure 6.2). Open and closed questions were distinguished by the potential for multiple acceptable answers (open) vs defined answers (closed) and cognitive demand (represented by simple to complex in the axis), being greater for open questions (Kawalkar and Vijapurkar, 2013). Within the cognitive demand axis the terms ‘recall’, ‘explain’ and ‘analyse’ were used to categorize questions. The passive to active axis represents the group’s interest in student-centred learning environments, a significant focus of PLD with the project, and a strategic focus within the Lakalaka Policy Framework being implemented in schools at the time of the project (Ministry of Education and Training, 2012). This was not used in the coding process as all questions in the collected data were passive. However, we have included this as it represents the questioning framework that the teacher-researchers aspired to and can be used in future action-research. In developing this coding frame exemplars were established from the data as well as from recent teaching experiences (Figure 6.3). Notably, once a collection of exemplars was established by the research team, categorization occurred more rapidly.

Coding of reflections was conducted via a constant comparative approach with inductive reasoning (Boyatzis, 1998). A talanoa-based group discussion was used to establish inter-researcher consistency in the manner described above.

All statistical data analyses were performed using SPSS (IBM Corp, 2015). Talanoa followed by peer review were used to support the process of data analysis, writing and
seminar presentation development. Themes emerging from the analysis were used to form three hypotheses for future investigation.

Figure 6.2 Components of questions
Interacting components of teacher-initiated questions identified by teacher-researchers to support coding of questions represented in the data.

Figure 6.3 Exemplification of open and closed questions on a continuum
Used to support teachers in the process of coding of question characterization data.
6.4. Findings and Discussion

6.4.1. Characterization of questions used by teachers

Seven of the eight participating teacher-observer pairs collected quantitative and qualitative data from the observation exercise (Table 6.1). At the point of personal reflection (prior to Workshop B), teacher-researchers categorized the majority of the questions they or their observation partner asked as open (77%). Analysis of these data following the coding consensus development process in Workshop B resulted in only 15% of questions being coded as open. The final collective classification is presented in Table 6.1. This indicates that closed questions (85%) were more likely to be used in the teaching episodes ($\chi^2(1) = 24.923, p<.001$).

Table 6.2 Examples of typical questions used by teachers in these learning episodes

<table>
<thead>
<tr>
<th>Closed Questions</th>
<th>Open Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you call the process that plants use to make</td>
<td>What should the community or government do to assist in</td>
</tr>
<tr>
<td>their food?</td>
<td>prevent this disease?</td>
</tr>
<tr>
<td>Teacher 1</td>
<td>Teacher 2</td>
</tr>
<tr>
<td>Where does photosynthesis take place?</td>
<td>Explain how roots help plants.</td>
</tr>
<tr>
<td>Teacher 6</td>
<td>Teacher 7</td>
</tr>
<tr>
<td>What were the three types of microbes we studied in</td>
<td>In what ways could you help to avoid the spread of</td>
</tr>
<tr>
<td>our last class?</td>
<td>viral infections?</td>
</tr>
<tr>
<td>Teacher 8</td>
<td>Teacher 8</td>
</tr>
</tbody>
</table>

Table 6.2 provides examples of closed and open questions observed in the learning episodes. Closed questions were typically used to examine students’ content knowledge, potentially reviewing prior learning. Teachers reflected that these were intended to be easily answered by students to encourage participation.

“In my introductory activities I start using questioning to check students’ prior knowledge....most of my questions are easily answered correctly by the students.” Teacher 7

“I opened with the easiest questions I could ask...and three students answered correctly all at once. I asked the others [students] to give them a big hand before praising them myself...Students who frequently give positive responses and frequently receive positive reinforcement tend to attempt almost every question, without being asked, with great enthusiasm.” Teacher 8
In contrast, open question used by the teachers targeted exploration of more complex concepts or issues, and provided opportunities for students to engage in explanation and analysis.

The level of cognitive demand in teacher questions was characterized using recall, explanation, and analysis, representing increasing cognitive demand from recall to analysis. Closed questions were more likely to require recall (80%) than explanation (20%) ($\chi^2(1) = 15.356, p<.001$) (Analytical questions were not considered in this analysis). Analysis of the open questions is limited by the small sample size (n=8). However, the trend in the data is towards increased frequency of questions requiring explanation (5) and analysis (2), compared to recall (1).

Observing teachers counted the number of students offering to respond to each question and the number of student questions that arose from a teacher-led question. On average, students were more likely to offer to respond to closed questions ($\chi^2(1) = 9.000, p=.003$). However, the type of teacher-led question (open or closed) had no impact on the likelihood of student-generated questions arising ($\chi^2(1) = 0.818, p=.366$).
<table>
<thead>
<tr>
<th>Participating Teacher</th>
<th>Observation time (min)</th>
<th>Number of teacher questions</th>
<th>Closed Questions Number (% Total)</th>
<th>Categorization of closed questions</th>
<th>Final categorization of questions asked by teachers</th>
<th>Open Questions Number (% Total)</th>
<th>Categorization of open questions</th>
<th>Student responses to teacher questions*</th>
<th>Student questions arising from teacher questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Categorization</td>
<td>Recall</td>
<td>Explain</td>
<td>Analyze</td>
<td>Categorization</td>
<td>Recall</td>
<td>Explain</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>11</td>
<td>11 (100)</td>
<td>8</td>
<td>(72.7)</td>
<td>3</td>
<td>(27.3)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3</td>
<td>2 (66.7)</td>
<td>1</td>
<td>(50.0)</td>
<td>1</td>
<td>(50.0)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>4</td>
<td>3 (75.0)</td>
<td>2</td>
<td>(66.7)</td>
<td>1</td>
<td>(33.3)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>9</td>
<td>8 (88.9)</td>
<td>8</td>
<td>(100)</td>
<td>0</td>
<td>(0.0)</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>4*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Teacher 5 asked four questions in the teaching episode, three of which the observer categorized as open. The observer did not record the questions. Therefore, analysis was not possible and these questions were not counted in the total.

During analysis it was confirmed that observers recorded the total number of students offering to respond/question (indicated by hand-up). Reflection within the group recommended for future use of the protocol that both the number of students indicating willingness to respond, and the number of students that teachers allowed to respond should be recorded.

Expecting students to respond to questions en masse was common practice for participating teachers. This explains data such as 98 students responding to 5 questions (Teacher 8)
6.4.2. Barriers and Facilitators

In examining the data two key themes emerged, that of barriers and facilitators. Following the collective coding process, each group went back to the data and examined the reflections to identify common barriers and facilitators. The frequency with which these occurred in self or peer reflections was recorded in Tables 6.3 and 6.4.

That there is a need to increase student interaction and reduce the presence of silence in classrooms was not denied by the teacher-researcher team.

“I really need my students to break the silence.” Teacher 7

As hypothesised, the peer observation evidence suggests that factors associated with socio-cultural context contribute to barriers that potentially reduce the use of questioning. These include respect for teachers as elders, who because of their position should be respected and potentially may be seen by some students as people who should not be questioned (Table 6.3).

The highly structured environment typical of classrooms in the participating schools, as well as a strong desire by all (teachers and students) not to be incorrect, are identified as barriers that can be addressed, and link back to the wider socio-cultural context of the school communities.

“Maybe that [students answering questions all at the same time] is the reason why my students are usually quiet. They always wait for my orders to throw it to them to answer it together at the same time.” Teacher 7

“Most of the students respond by sitting up straight….some look at their books before looking at the teacher.” Observer of Teacher 3

“You were very effective. Students were very attentive. A very loud and demanding voice captured students’ attention.” Observer of Teacher 6

“Another barrier... was the frequent wrong answers given by some students. Actually I wanted to ask them more questions but because I knew they will be discouraged if they continue to give wrong answers, I was reluctant to ask those students more.” Teacher 8
### Table 6.3 Barriers to the use of questions by teachers, identified from self-reflection and peer observation.

<table>
<thead>
<tr>
<th>BARRIERS</th>
<th>Examples from the Peer-to-Peer Questioning Reflections</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students worried about giving wrong answer.</td>
<td>“In our Tongan classrooms, some of the students do not respond to the questions because once their answers are not correct some of their peers might laugh or mock them.”</td>
<td>4</td>
</tr>
<tr>
<td>Time Limitations</td>
<td>“I had found out from my colleague that I did not allow some of the students to respond to my questions but they were willing to answer the questions.”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>“I did not give adequate thinking time for students about certain questions.”</td>
<td></td>
</tr>
<tr>
<td>Personal past experience of students</td>
<td>“I almost asked one of the students to explain the harmful effect of virus on our bodies, but then I remembered that the child [had] lost a loved one because of AIDS, I refrained myself from asking the question to that particular student.”</td>
<td>1</td>
</tr>
<tr>
<td>Lack of visual resources to support students to understand the question</td>
<td>“I should have got pictures of real animals to help my questioning”</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>“I should have shown students the process of osmosis by bringing tapioca and a container of water and do the activity.”</td>
<td></td>
</tr>
<tr>
<td>The impact of cultural norms</td>
<td>“Culture is another barrier. In our school some of the students really respect the teachers and avoid - the students do not come close to the teacher and build a barrier between the teacher and the student. When we ask the questions the students are afraid to respond to the questions, and this makes the students keep silence all of the time.”</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>“Students cannot openly discuss this as it is a taboo subject according to tradition and customs ... and there are cousins and close relatives in the same class.”</td>
<td></td>
</tr>
<tr>
<td>Literacy Barriers</td>
<td>“Difficult scientific terms that may be too complicated for students and hard to express.”</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>“Last but not least - my English and language skills.”</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.4 Facilitators to the use of questions by teachers, identified from self-reflection and peer observation.

<table>
<thead>
<tr>
<th>FACILITATORS</th>
<th>Examples from the Peer-to-Peer Questioning Reflections</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using questions to encourage participation.</td>
<td>“Students who are involved and participate in discussion and questions [build] self-confidence to bring out their views and ideas.” Teacher 1&lt;br&gt;“... formulate questions based on their wrong responses [to] guide questioning [towards] the correct answer.” Teacher 8</td>
<td>7</td>
</tr>
<tr>
<td>Knowing your students; recognising and addressing needs.</td>
<td>“...but then I remembered that the child has lost a loved one to AIDS. So I refrained from asking the question to that particular student. Instead of asking that particular question [in class] I used it as a homework question... to be [completed] in pairs. I assigned one student in each pair to [answer] the question, and the other students to do the task...” Teacher 8</td>
<td>2</td>
</tr>
<tr>
<td>Positive reinforcement</td>
<td>“Instead of myself reinforcing their positive responses directly I asked others to give them a big hand before I praised them myself” Teacher 8</td>
<td>6</td>
</tr>
<tr>
<td>Using differentiation to meet the variable needs of students</td>
<td>“I rephrase the wording of the questions to make it clearer to students...” Teacher 1&lt;br&gt;“...attention should be given to the wording of the questions to ensure coherency between levels of difficulties of the words used...” Observer of Teacher 8&lt;br&gt;“The questions uses needed to be worded with simpler phrases or words ...” Teacher 8</td>
<td>6</td>
</tr>
<tr>
<td>Using visual, hands-on or experiential resources to encourage engagement</td>
<td>“...[you could] provide a health talk from an organization...” Observer of Teacher 2&lt;br&gt;“A fieldtrip would be helpful....” Teacher 3</td>
<td>4</td>
</tr>
</tbody>
</table>
6.4.3. The impact of teachers as researchers

The study placed teachers in the role of researchers, supporting empowerment of teachers to become adaptive experts, who are “engaged in ongoing cycles of inquiry and knowledge building to develop their expertise in response to specific challenges students face.” (Timperley H., 2011). Because of this resultant empowerment, the process through which these outcomes were established is potentially more important than the baseline characterization itself. McIntyre defines four principles that are core to PAR methodologies, each of which we identified in the process that led to the development and undertaking of this study. These are “(a) a collective commitment to investigate an issue or problem; (b) a desire to engage in self- and collective reflection to gain clarity about the issue under investigation; (c) a joint decision to engage in individual and/or collective action that leads to a useful solution that benefits the people involved; and (d) the building of alliances between researchers and participants in the planning, implementation, and dissemination of the research process.” (McIntyre, 2008, p.1).

These principles fit well with a talanoa methodology. The PAR process has established a model that can be applied by this research group in ongoing analysis and development relating to the issue of questioning, or to other challenges they identify.

Analysis of the process also indicates that it represents the work of a professional learning community (PLC) promoting teaching as inquiry, and the role of teachers as researchers engaged in analysing and addressing issues critical to supporting student learning. Core to this classification is the notion that in contrast to one-off workshops known to be ineffective in facilitating change, the PLD workshops in the model were part of a series that provided a foundation for ongoing critical reflection and analysis, supported by internal and external leadership over an extended period (Lumpe, 2007). This is reflected in a focus group discussion held with teacher-researchers at the end of the academic year in which the work was initiated.

“It was different [to prior PLD] because you [external project leaders] kept coming back to us - we kept coming back together – that made us do something, we could not just go - I’m too busy...”

Participating teacher-researcher, School A; focus group

“We talked together – it was not just being talked at.”

Participating teacher-researcher, School B; focus group
“Also the [PLD] programme had real examples – we were hands on learners, so that works for us as well as the kids!”

Participating teacher-researcher, School C; focus group

PLCs are characterised by shared values and vision, collective responsibility, reflective inquiry, collaboration, and group as well as individual learning (Stoll et al., 2006). These characteristics can be identified in the focus groups comments as well as within the process and outcomes of the study. Shared values and vision, while established earlier in the project at a high level (Bay & MacIntyre, 2013), were co-constructed by the PLC within Workshop B. This involved defining the research process that was required in order to address the question of interest, which sat within the overarching shared project goals relating to scientific and health literacy development.

The PAR process enabled the team to critically examine and reflect on their practice, and the frames of reference supporting that practice with regard to the use of questions in learning and teaching. The emerging evidence supported the hypothesis that questioning, when used, was more likely to be closed. The significant shift from initial to final coding with regard to what constituted open or closed questions demonstrates that participants engaged in a transformative learning process. Key elements of transformative learning seen within the process include identification of prior experience and critical reflection within a community of learners (Taylor, 2011). This supported the questioning of assumptions, promoted awareness of the presence of alternative perceptions and led to changed perceptions that were in turn examined in greater depth.

While exploring concepts associated with the use of questioning in learning the team were aware that they in turn would be facilitating the process of examination of the role of questioning in science learning with other teachers. They reflected that identification of exemplars had been useful to them in refining their perceptions of categorisation of questions (Figure 6.3), and hypothesised that such exemplars could support other teachers to analyse the types of questions being used in classrooms. In order to develop the continuum exemplars represented in Figure 6.3, the team had to imagine learner centred activities that represented the far right of the continuum as they identified that such questions were not as a common part of their current practice. The associated PLD programme had introduced learner-centred discovery activities, so these were not unfamiliar in theory. The PLD had enabled teachers to experiment as a group with these,
but the team was yet to apply these ideas in practice. That learner centred activities could be imagined for learning contexts and topics beyond the project represents the potential offered by talanoa to facilitate active engagement and learning in this professional community.

“There were actual learning resources that we could trial to use these ideas - in the past we just get told - do this, do that - there are never any examples of how we could change things in our classrooms.”  Participating teacher-researcher, School A; focus group

The evidence suggests that the process of participating in action research created opportunities for participating teacher-researchers to question assumptions with respect to the use of questions in science learning, test out the use of questioning, and reflect *on how students responded to this different approach to learning and teaching.*

“During my questioning session, I can feel how the learning environment changed in this time. Once I start asking questions, some of my students [were] eager to respond to the questions and some do not. For the students who involve and participate in the discussions of the questions, they build self-confidence which brings out their ideas and view about the questions. At this time, some of the students [are] against the opinion and view of some other students and even my ideas but this builds up some new questions for me to ask the students. At this stage, it shows me that some of my students can critically analyse some of the answers to the questions.”  Teacher 1

Furthermore for some teachers it provided an important opportunity for identification of potential changes in their practice that could enhance the ability of students to engage in open-ended dialogue, through which learning could occur.

“From my colleague’s reflections, the wording of some of my questions were a bit advanced for my students and needs improvement. The students failures in their first attempts to answer some of the questions correctly was not due to unknowing, but rather misunderstanding of the questions. Another weakness……was that I did not give adequate thinking time for students …mostly with questions that required an explanation.”  Teacher 8

These reflections indicate that teachers are testing, or proposing to test perspectives or activities different to those typical of their practice. This is a hallmark of transformative learning.
Overall, the reflections indicate teacher-researcher awareness of cognitive and social needs of students within the classroom and a strong desire to support student learning. The PAR process utilising collective critique and analysis offered the opportunity for teachers to identify potential actions that could be tested to understand how to enhance learning. This resulted in the development of an action research question relating to strategies that may enhance the use of questions in Form 1 – 5 Science classrooms in Tongan schools. Specifically from the evidence it was identified that the following three hypotheses should be investigated:

- That engaging in hands-on learning activities will support increased student participation in questioning.
- That engaging in learning experiences supported by visual stimuli will increase student participation in questioning.
- That placing questions within a Tongan cultural framework will increase active and effective student participation in learning.

These hypotheses offer teacher-researchers potential actions that could be evaluated using the methods established in this pilot study.

6.5. Limitations

The potential for participation in research to impact the behaviours of the participants should be acknowledged as a limitation of this study. This is highlighted by the lesson intentions and reflections from participants, examples of which are indicated below.

“Questioning is a key part of the teaching-learning process in any classrooms of any level. All strategies used to impart a teaching concept in the classrooms to the students will surely fail to bring out the desirable learning outcome if questioning is not or less used while the lesson is undertaken. Thus, I will ask more number of questions in this period than I have ever used before in my science classes.”

Lesson intentions, Teacher 8

“The purpose of this lesson is for all learners to identify and label these two plant systems - shoot system & root system and also to describe the function of each part of the two systems. I was planning to spend most of my questions in open questions because I really need my students to break the silence and come out from their shells. They are all capable but they need to be more curious.”

Lesson intentions, Teacher 7
“From this teaching episode, I have found out how the use of open-ended questions in teaching is really effective. Not only [does] it engage students to participate and express their ideas and opinion about the questions but it also make other students criticized the ideas of others.”

Lesson analysis, Teacher 1

These records indicate that the learning episodes selected for observation by these teachers may not have been typical of their practice. The statements indicate towards usual learning environments where interaction via questioning may be more limited than that observed in this action research setting. This reflects research participation effect, an extensively documented phenomena in human behaviour research, but one that is not fully understood in terms of research design to minimise impact (McCambridge et al., 2014).

The number of observations could also be considered as a limitation. However, this is a pilot study limited to three schools collaborating in the project and defined by the teacher-researcher team as the extent to which they could enable data collection. Potentially a larger research team or observations outside of the team could have exposed further factors, however the limitation of observation and analysis to the active research team was an intentional act within the design, identified as being important as trust was established within and between the teachers in this group and the group leaders.

This study only examined the content of questions asked by teachers. Once teachers are confident in the use of this method it should be extended to include analysis of the content of student responses and student questions.

6.6. Conclusions

This study evolved from identification of a dilemma within the project team with respect of the absence of questioning and argumentation within many Tongan science classrooms. The objective of developing a methodology to identify evidence of the extent of this issue from which it could be examined and potentially addressed has been enabled by the study. The use of peer-to-peer observation and reflection with anonymized data being analysed within a respectful group setting enabled an environment in which teacher-researchers could confidently participate in analysis and critique of classroom practices. This identified that where questions were being used they were likely to be closed, thus limiting opportunities for discussion and argumentation. It supported the development of
pedagogical content knowledge pertaining to questioning as a tool for the development of engaged learning.

Key factors identified as barriers to the use of questions in Tongan science classrooms were linked to the socio-cultural factors that teachers hypothesised to be barriers to the use of questions in learning.

Factors relating to supporting and scaffolding students were identified by participating teachers as positive facilitators that were or could be put in place to increase the confidence and ability of students to ask and answer questions, thereby developing understanding and capabilities.

The PLD process imposed expectations of action on participating teachers. This included taking responsibility for analysis of research findings, communicating these formally within the project collective and their school, and making resultant evidence-based decisions about practice. This is a highly action-oriented PLD process, which we propose led to increased pedagogical content knowledge and its implementation in practice. We will report on the next stage of this work in due course, identifying how the teacher-researchers implemented actions in their practice, and their roles as leaders within their professional communities.
Chapter 7. Adolescent education: An opportunity to create a DOHaD circuit breaker

Preface

This chapter presents a paper published in the Journal of Developmental Origins of Health and Disease. It outlines for scientists from within this community the potential of schools as a setting for DOHaD translation. The narrative presents a frame of reference that encourages scientists to consider their perceptions of what schooling is, what curriculum is, how learning to support engaged citizenship is organised and how this may be used to support DOHaD translation. The paper is designed as a resource to support the DOHaD community to consider engaging with the education sector as a partner in DOHaD translation. Conferences present an essential opportunity for dialogue, supporting the ongoing need to engage this community in participation in a collaborative narrative that includes education and youth.

7.1. Adolescence: A life stage for translation of DOHaD evidence into action

The field of developmental origins of health and disease (DOHaD) has provided epidemiological and experimental evidence indicating that nutritional and non-nutritional exposures, during preconception and developmental periods, contribute towards later-life vulnerability to obesity and chronic diseases such as type 2 diabetes mellitus and coronary heart disease (Newnham and Ross, 2009). This evidence has been successfully communicated to the science and health research sectors, now reaching a point where population-wide application is being promoted by organizations of global significance (Chestnov et al., 2013). This heralds a growth phase for the DOHaD Society, requiring increased breadth of scope and capabilities to enable knowledge exchange with governmental and community organizations that have the potential to facilitate population level application of DOHaD evidence.

To date attention on DOHaD intervention opportunities has largely focused on mothers and children. However, application of DOHaD evidence in conjunction with evidence surrounding adolescent development (cognitive and psychosocial) points strongly towards the validity of adolescence as a DOHaD intervention stage (Todd et al., 2015). In presenting this argument, it is important to appreciate that behaviour patterns exhibited during adolescence, including those associated with diet, physical activity and cognitive development, track through to adulthood, (Craigie et al., 2011; Steinberg, 2005) and are associated with future health (Todd et al., 2015). Thus, even when adolescence is significantly distanced from pregnancy, capabilities and behaviours that evolve during this period will influence preconception and periconceptional health and environmental exposures, thus contributing to the prospect of improved long-term health potential for offspring.

Schooling is a core social structure providing in-depth engagement with adolescents up to the age of 11-18 years (variably by context). Within this often relatively well-resourced social structure exists opportunities for empowerment-based learning interventions supporting adolescents to engage with, understand, contextually interpret, and act upon life course NCD risk evidence. Such interventions must not be additional to the core business of the school. They should be integrated into existing curriculum, assessment and pastoral care objectives and have relevance to the socio-ecological context of the school community.
Intervention design, facilitation and evaluation requires understanding of education, DOHaD and public health, alongside professional capabilities associated with the design, delivery and assessment of adolescent education. Therefore, this activity requires collaboration between education, science and health. Collaborations must enable teachers and education leaders to examine relevant evidence and determine where and how DOHaD-informed interventions may exist so as to support the objective of positive adolescent health-behaviour development, while simultaneously contributing towards core educational objectives of schools. Thus, if the work of the DOHaD Society is to include interventions that “promote healthy early development, beginning even before conception, as well as interventions aimed at sustaining health in children, adolescents and adults” (International Society for Developmental Origins of Health and Disease, 2015), it is important that expertise from the education sector is incorporated into the Society to support child and adolescent aspects of this work.

A growing number of DOHaD translation programmes addressing the potential of school-based education to empower action competence leading to behaviour change in adolescents have been developed, and in some cases, evaluated and shown to have potential for population-level integration (Bay et al., 2012a; Bay, 2015b, c; Grace et al., 2012). As primary to secondary (K-12) education is not the core work of most within the DOHaD Society, we believe that this short commentary outlining how the education sector can engage with DOHaD communities to develop and facilitate interventions may be of assistance to scientists interested in exploring the potential of collaboration with education to “...promote the health of the current generation... [and] ...ensure a healthy life course for future children and grandchildren.”(International Society for Developmental Origins of Health and Disease., 2015)

7.2. Schooling: Where and how could DOHaD-informed community partnership actions fit?

Capturing the potential of school-based DOHaD-interventions requires the development of partnerships between DOHaD research and education communities. Such partnerships should be jointly informed by scientific evidence and understanding of the nature of pedagogy, curriculum and practice in modern schooling. When presenting evidence of impact of the Liggins Institute’s Healthy Start to Life Education for Adolescents Project, (Bay et al., 2012a) we are frequently asked by scientists how we “got DOHaD into the school
curriculum?" The answer is, we didn’t. Modern curricula almost universally specify the development of capabilities, but do not specify the context in which this may occur. Therefore, we identified where and how it would be appropriate to integrate DOHaD and life course NCD risk as contexts of relevance to adolescents, through which teachers may develop and facilitate learning programmes supportive of curricula goals and the learning needs of students (Bay et al., 2012c).

The focus of education has moved considerably in the past 20 years. No longer is education primarily concerned with the mastery of content knowledge. Rather, in response to the rapid pace of societal development, modern education systems are designed to prepare young people to participate as critically engaged citizens and life-long learners able to negotiate present realities as well as futures that we cannot predict. Curricula focus on the development of capabilities (knowledge, understanding, skills, attitudes and values) that enable critical and active participation in all aspects of society. Often referred to as twenty-first-century skills and dispositions these capabilities cultivate “critical and creative thinking, collaborative skills and dispositions, leadership, entrepreneurship, and related skills and dispositions that speak strongly to living and thriving in our era” (Perkins, 2014).

While in the past knowledge acquisition was commonly dissociated from context within schooling, learning in modern education systems is contextual. This enables young people to develop, refine and apply capabilities within contexts of local and global relevance, and is supportive of the development of action-competencies, a precursor to evidence-based decision-making (Bruun Jensen, 2000). Learning areas (disciplines) that lend themselves to the use of DOHaD as a context of relevance include sciences, health, social sciences, languages, technology and physical education. While this may seem diverse, and science and health will take a leading role, the diversity reflects the breadth of capabilities required for critical citizenship and the importance of interdisciplinary learning to enable adolescents to develop competencies relevant to diverse and complex issues that require application of systems thinking (Hipkins et al., 2014). For example in the Cook Islands the national college is utilizing DOHaD/NCDs as a cross-disciplinary learning context in science, social science, health and physical education at Year 9, while in Year 11 it is being...

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2 The term curriculum in education refers to a policy document created nationally and adapted locally to define high-level objectives that guide learning and teaching in schools. From these documents, teachers create annual work plans, composed of learning modules/units/programmes that collectively support the objectives of the curriculum. We make this point because the term curriculum is often used differently in science and health sectors where it can describe a discrete series of lessons, which in the education sector would be called a learning programme or module. This sectoral difference in the use of terminology can cause considerable confusion if it is not understood.
used solely in science. A neighbouring school is utilizing the context in an integrated programme crossing science and languages at Year 11, whereas at Year 9 they are currently only using the context in science while they build appropriate staff capacity to enable inclusion of the context in cross-disciplinary learning. These examples reflect the breadth of opportunity for learning that teachers identify in DOHaD/NCD contexts. They also reveal the importance of context and the centrality of school-level autonomy in education. While these schools are part of a cluster developing the use of DOHaD/NCD contexts to support national education and health strategy, their programmes are differentiated in accordance with contextual variance in each school community.

Learning programmes should always be flexible so that teachers can adapt objectives and resources to meet individual and collective learning needs of the students in their classroom. Educators share and use programmes that provide adaptable resources enabling teachers to develop appropriately differentiated programmes. Using approaches such as the action research informed ‘teaching as inquiry cycle’, (Weinbaum, 2004) teachers continuously analyse student engagement and performance, and accordingly adjust programme design to inform ongoing learning within the current cohort, and programme design for future cohorts. Thus, school learning environments and the programmes within them are dynamic. DOHaD-informed school-based interventions need to be designed to empower teachers to analyse and adjust programmes, ideally in professional clusters within or between schools that are connected to a DOHaD community and the local health community, and therefore offer both educational and DOHaD engagement in the process of analysis and contextual refinement.

7.3. Health literacy: A component of the capabilities required to engage in and act upon DOHaD evidence

The promotion of health literacy development in adolescence is identified as an aim by the DOHaD Society (International Society for Developmental Origins of Health and Disease., 2015). However, to achieve transformative empowerment enabling adolescents as decision makers, health literacy development must be seen as a component within a matrix of interrelated capabilities that enable application of knowledge, understanding and critical thinking skills to support evidence-based actions supportive of life course and intergenerational health and wellbeing. These capabilities include: health, scientific and environmental literacies; knowledge of and about the impact of social, cultural and
economic and political factors on wellbeing (individual and societal); and metacognitive and critical thinking (identified as central to transformative learning (Mezirow, 2003) and integral to competencies required for citizenship). Therefore, development leading to empowerment is a complex educational task requiring considerable time. The potential for and nature of transformative action emerging from interventions supporting empowerment will be determined by interactions between capability development, access to evidence, opportunities for discourse, and the socio-ecological context of the individual and community. While challenging, this task fits extremely well with the development of twenty-first century capabilities promoted in the education sector. Therefore, it is important not to approach adolescent interventions with a narrow focus on health, but rather to ensure that teachers across the spectrum of relevant learning areas are provided with the opportunity to engage with DOHaD evidence and its application as a context of educational relevance.

7.4. Intermediaries: Enablers working between DOHaD and education communities

While scientists should be involved in aspects of the intervention partnership, it is an unusual scientist who has capabilities and expertise in communication and learning required to facilitate adolescent education interactions of the nature we have described. Therefore, connections are required between DOHaD and in the case of school-based adolescent interventions, education communities. These can be facilitated by intermediaries, “people with the knowledge, experience and dispositions that enable them to effectively liaise between the education and science communities.” (Bolstad and Bull, 2013, p 54). While Bolsted & Bull focus on the need for intermediaries to have “a sophisticated level of understanding of the multiple purposes of science learning, and familiarity with the operational characteristics of school science teaching and learning, including curriculum and assessment frameworks, and whose work often involves building and maintaining relationships, seeking and managing funding and resourcing, and identifying areas where research or evaluation is needed to contribute to the development or refinement of programmes”[ibid], we suggest that intermediaries also need to develop in-depth understanding of DOHaD science and public health.

Significant roles for intermediaries enabling school-DOHaD partnerships include: building engagement and relationships between DOHaD and education communities that facilitate
awareness of intervention potential; re-imaging of research data for use in adaptable learning resources; (Bay et al., 2012c) facilitation of professional learning and development communities and related resources (Bay and Mora, 2014) that empower teachers to engage in and develop the use of DOHaD research as contexts for learning; and research evaluating intervention impact and informing development.

The process of data re-imaging is collaborative, requiring scientists and educators to examine how data can be presented in meaningful formats for students of different ages. We have found that for K-12 education settings, presenting data within narratives about scientists and the process of science, accompanied by narratives that participating communities provide about their experiences of NCDs, (Bay and Yaqona, 2016) is an enabler of interaction in classrooms. Additionally, via these stories, young people can take DOHaD evidence into their homes and facilitate evidence-based behaviour change at the family level (Bay et al., 2012a).

In addition to resources, transactional engagement is required between stakeholders from communities who have developed or fully understand the evidence, and teachers in communities for whom the evidence may have application. This engagement should enable exchange of ideas, issues and evidence, leading to synthesis of the relevance and potential of DOHaD evidence within the particular context. Transformative learning theory examines the processes of critical reflection that leads learners to examine, assess and potentially alter their frame of reference with regard to a particular issue (Mezirow, 2003). It is known to lead to active decision-making and action taking. While the objective of interventions is to achieve this goal for students, transformative learning is also required to support teachers to identify with the value of the DOHaD context, and to engage personally with the evidence. Transformative learning is often, stimulated by a disorienting dilemma. In the case of DOHaD informed interventions this may be engagement that leads participants to examine for example the extent to which obesity is impacting people/communities/societies. Via critical assessment and examination of assumptions, frames of reference are exposed and can be challenged. When learners are exposed to alternative frames of reference, via critical analysis they are able to evaluate and potentially alter their viewpoint. This leads to exploration of options, identification of alternative actions, active experimentation and eventually new frames of reference which in the case of understanding of the role of early life exposures in vulnerability to NCD risk, could lead to behaviour change. Teachers need to experience this process of critical reflection with
regard to frames of reference related to NCD risk before they can facilitate educational programmes that will enable adolescents to examine and make-meaning of DOHaD evidence. Therefore creating opportunity for learning such as this is a key purpose of professional learning communities that engage DOHaD and education together.

7.5. Conclusions

To unlock the potential of DOHaD evidence to improve health and social wellbeing requires society to be given the opportunity to learn about this evidence, examine its relevance, and make decisions about how it is used, thus facilitating community-led actions. This requires knowledge exchange between the DOHaD community, and all communities where families desire their children to grow and contribute as healthy adults within society. Health and education professionals in regular contact with families and young people during developmental periods from pre-conception through childhood and adolescence are in the best position to implement programmes supporting and empowering families to engage in health-promoting behaviours (Gillman and Ludwig 2013; Gluckman et al., 2011). These sectors have expertise in communication, learning, community engagement and behaviour required to support sustained interactive intervention programmes within existing social settings. However, they also require opportunities to develop understanding of relevant scientific evidence. For the education sector, NCD risk reduction is not core business, therefore it is important to create opportunities to engage this sector and identify shared value that can emerge from their participation in DOHaD-informed adolescent interventions. The DOHaD Society has confirmed the potential of adolescent interventions in the Cape Town Manifesto. Achieving positive action with regard to the goals relevant to adolescent education could be significantly enhanced by increased educational input into the work of the Society and consideration of strategies that may enhance the availability of DOHaD relevant resources to the education sector.
This section presents evaluative evidence examining the effect of participation in Healthy Start to Life Education for Adolescents Project (HSLEAP) programmes for adolescent cohorts from New Zealand and the Cook Islands. Each chapter represents work that I lead in collaborations that encompass education, science and public health, set within the context of diverse school communities across Auckland and Rarotonga. A group of three schools in Tongatapu is also part of this collaboration, and will add data to this evidence in the near future.

This evidence examines the potential for education to work in collaboration with science and health to support World Health Organization (WHO) goals associated with adolescent health and wellbeing, and the reduction of NCD risk and incidence in current and future generations. The recent work of the WHO relating to addressing the growing issue of child and adolescent obesity has highlighted the need for core curriculum subjects including STEM to play a role in multi-sectoral efforts to address child and youth obesity. For STEM education, this opportunity fits very well with the potential of learning contextualised in exploration of socio-scientific issues to support the development of scientific literacy.

In 2015, members of the WHO Commission on Ending Childhood Obesity requested to meet with students and teachers from schools that have participated in HSLEAP. The Commissioners were interested in understanding how learning designed around STEM educational goals was supporting health goals as they recognise that school-based health-promotion has often not been linked well to the core mission of schools.

Chapters 8 and 9 present papers examining evidence from the New Zealand and the Cook Islands individually. Chapter 10 examines and compares differences that were applied to the programmes in each country to enable understanding of the potential for contextual adaptation.
Chapter 8. The Noncommunicable Disease Epidemic: Adolescents as Agents of Change through Scientific Literacy Development in New Zealand

Preface

This chapter presents evaluative evidence from application of the HSLEAP model in ten schools in the Auckland region. Data from the early phase of this work has been published previously. The work represented in this chapter reflects efforts in the period 2012-2013 that supported the extension of this cohort to enable examination of associations between gender and programme response. The paper is currently under review.

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8.1. Introduction

The development of scientific literacy is a key goal of science education (Hodson, 2011), contributing to the capabilities required for engaged citizenship. Scientific literacy enables use of science knowledge in decision-making relating to everyday occurrences as well as complex open-ended socio-scientific issues (SSIs). Understanding of the epistemology of science as a way of knowing, (the nature of science (NOS)), is central to scientific literacy. However, knowledge and understanding of relevant scientific concepts is also required, alongside competencies associated with critical thinking, problem solving, communicating, acting autonomously (Rychen and Salganik, 2003), and attending to moral and ethical ramifications (Sadler et al., 2004).

Development of scientific literacy and associated competencies is enhanced when learning is contextualized in real-world issues (Hipkins et al., 2014). The noncommunicable disease (NCD) epidemic is one such issue. Considered one of the most pressing SSIs of our time NCDs are responsible for considerable and growing social and economic burden (Bloom et al., 2011). Dominated by overweight, obesity, cardiovascular disease (CVD), cancers, and type 2 diabetes mellitus (T2DM), these slow developing chronic conditions account for 64% of deaths globally. The burden of long-term morbidity and premature death associated with NCDs is disproportionately high in populations with limited resources (World Health Organization, 2015b). NCD risk is impacted by a matrix of biological and socio-ecological factors that create rich contexts for learning associated with the development of scientific literacy (Bay et al., 2016a). Because the NCD epidemic is a health-related SSI, when scientific literacy development is contextualized in NCD related issues this should be integrated with health literacy development (Grace and Bay, 2011). Similar to scientific literacy, health literacy enables the use of evidence in health-related decision-making (Nutbeam, 2008).

Increasing understanding of the complexity of overweight, obesity and NCD vulnerability has led to calls for multi-sectoral approaches to NCD risk reduction (Chestnov et al., 2013). These include primary prevention strategies prior to the onset of risk. Primary prevention is informed by evidence from the field of Developmental Origins of Health and Disease (DOHaD) demonstrating that early-life exposures, even before birth, as well as health status and nutritional exposures of either parent prior to conception, influence the vulnerability of an individual to later-life obesity and NCDs (Hanson and Gluckman, 2014).
Adolescence, a life stage where cognitive and lifestyle behaviours that track into adulthood are established (Craigie et al., 2011; Hu et al., 2016; Steinberg, 2005) offers significant opportunity for primary NCD risk prevention for the adolescent and their potential future offspring (Todd et al., 2015). Overweight and obesity in adolescence is known to persist into adulthood and impact future health (Alberga et al., 2012). Even if adolescence is significantly distanced from pregnancy, adolescent behaviours that track into adulthood will influence nutrition in the periconceptional period and pregnancy, consequently influencing offspring vulnerability to obesity and related NCDs in later life (Bay et al., 2016c). Thus, establishing positive nutritional and related lifestyle behaviours in the teenage years offers significant long-term health and social benefits for adolescents and their future offspring.

Life-long behaviours that develop during adolescence are strongly influenced by educational, biological, cognitive, and socio-ecological factors. Therefore, schools are recognized by the World Health Organization (WHO) as having a key role in enabling primary NCD risk reduction (World Health Organization, 2016b). However, school-based health interventions often have not been particularly successful (Khabaliali et al., 2012) due to lack of connection to the core mission of schools (Waters et al., 2011). We have argued that this could be resolved by ensuring that school-based interventions: are designed by educators working in partnership with health/science communities; integrate educational and health goals; utilize opportunities within existing curriculum objectives; are adaptable to enable differentiation; and involve educational as well as health-based evaluation (Bay et al., 2016c; Bay and Vickers, 2016). Science is a key learning area where opportunities for contextual learning supportive of scientific and health literacy development and primary NCD risk reduction exist. Such learning can support educational and health goals and offer adolescents the potential to apply scientific perspectives to decision-making that will influence their future NCD risk, and assist them to understand the complexity of the NCD epidemic as a significant global issue.

New Zealand (NZ) has a devolved curriculum centred on key competencies developed across all learning areas. High-level achievement aims grouped by strands are defined for each learning area. In science the core strand, ‘Nature of Science’, is divided into four themes: understanding about science, investigating in science, communicating in science, and participating and contributing (bringing a scientific perspective to actions). Contextual strands (living-world, physical-world, material-world and planet earth and beyond) support
achievement aims defined in the NOS strand alongside aims associated with understanding of scientific concepts (Ministry of Education, 2007).

Representative of many settings, New Zealand is experiencing increasing overweight and obesity in children and adolescents as well as in adults (Ministry of Health, 2012; Rajput et al., 2015; Utter et al., 2015). Considered together with information on the decreasing age of onset of T2DM in youth (Jefferies et al., 2012) and the increasing rates of pre-diabetes and diabetes in adults (Coppell et al., 2013) these data signal a growing future NCD burden for New Zealand. Thus, the NCD epidemic offers a highly relevant learning context for schools.

The Healthy Start to Life Education for Adolescents Project (HSLEAP) is a multi-sectoral science-education partnership involving the Liggins Institute and schools (Liggins Institute, 2016b). Based on our ‘science for health literacy’ pedagogical model (Grace and Bay, 2011) programmes facilitate learning within a narrative pedagogy, supporting scientific and health literacy development by enabling adolescents to examine the potential of primary NCD risk reduction to support improved long-term health and wellbeing. Programmes support NOS learning objectives at levels 4 and 5 of the New Zealand Curriculum, Figure 8.1, ensuring validity for schools.

<table>
<thead>
<tr>
<th>Nature of Science</th>
<th>Curriculum Level 4 (Years 7-9)</th>
<th>Curriculum Level 5 (Years 9-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding about Science</td>
<td>Appreciate that science is a way of explaining the world and that science knowledge changes over time. Identify ways in which scientists work together and provide evidence to support their ideas.</td>
<td>Understand that scientists’ investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument.</td>
</tr>
<tr>
<td>Investigating in science</td>
<td>Build on prior experiences, working together to share and examine their own and others’ knowledge. Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.</td>
<td>Develop and carry out more complex investigations, including using models. Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables. Begin to evaluate the suitability of the investigative methods chosen.</td>
</tr>
<tr>
<td>Communicating in science</td>
<td>Begin to use a range of scientific symbols, conventions, and vocabulary. Engage with a range of science texts and begin to question the purposes for which these texts are constructed.</td>
<td>Use a wider range of science vocabulary, symbols, and conventions. Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).</td>
</tr>
<tr>
<td>Participating and contributing</td>
<td>Use their growing science knowledge when considering issues of concern to them. Explore various aspects of an issue and make decisions about possible actions.</td>
<td>Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.</td>
</tr>
</tbody>
</table>

Figure 8.1  New Zealand Curriculum, Nature of Science Learning Objectives, Levels 4 and 5 (Ministry of Education, 2007)
This study aimed to assess the potential of HSLEAP programmes undertaken in Year 7 – 10 science classrooms in New Zealand to contribute towards development of science and health literacies, and simultaneously empower adolescents to engage in evidence-based decision-making in relation to lifestyle factors associated with nutrition. We have shown previously that exposure of Year 7-10 students in New Zealand to HSLEAP programmes stimulated evidence-based decision-making related to health-promoting behaviours at 3-months post-intervention (Bay et al., 2012a). This paper reports on educational and health-related impacts of this programme exposure 12-months post-intervention.

8.2. Methods
The study utilized a mixed-methods approach within an individually-matched repeated time-series design (Biglan et al., 2000), Figure 8.2, approved by the University of Auckland Human Participants Ethics Committee (Ref. 2009/426).

Self-matched questionnaire data collected at baseline (T0), 3-months, (T2) and 12-months post-intervention (T4) assessed the potential for programme participation to support scientific and health literacy development, and for this to impact health and science-related knowledge, attitudes and behaviours (KAB). Use of an explanatory mixed methods design (Punch, 2009) enabled examination of the potential of qualitative data to corroborate quantitative data (Bryman, 2008) and contributed evidence relating to why change did or did not occur. Matching of individual participant data enabled reporting of cohort-wide KAB trends at time-points, and change patterns based on aggregation of individual differences between time-points. Analysis of individual change is important within community-based interventions as impacts will vary dependent on participant circumstances (Biglan et al., 2000).

8.2.1. Context
The study was conducted in 30 classrooms ranging from Years 7-10 across 10 Auckland schools. In New Zealand, curriculum levels span year levels. Curriculum levels 4 and 5 span Years 7-10. Teachers design learning programmes enabling students to progress through appropriate curriculum levels in mixed-ability classrooms. Hence, the diversity of year levels and schools in the study is appropriate and contributes towards addressing issues related to the impact of heterogeneity and complexity in school settings. Participating
schools elected when to undertake the study to ensure integration into their science learning programmes. The resulting data collection period spanned from 2010 to 2013.

**Figure 8.2 Study flow diagram**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T0</strong></td>
<td>Principal and Lead Teacher meetings&lt;br&gt;Students with parental consent and participant assent undertake baseline</td>
</tr>
<tr>
<td><strong>T1</strong></td>
<td>HSLEAP program implementation in school science classes over a period of 4 - 6 weeks</td>
</tr>
<tr>
<td><strong>T2</strong></td>
<td>Observation of planning; classes; student work</td>
</tr>
<tr>
<td><strong>T3</strong></td>
<td>12-week post intervention questionnaire (data available for matched analysis)</td>
</tr>
<tr>
<td><strong>T4</strong></td>
<td>6 month post intervention interviews:</td>
</tr>
</tbody>
</table>
8.2.2. **Recruitment**

Schools were selected from a group of 46 participating in the Liggins Institute’s schools partnerships programmes in 2009 (Bay et al., 2012b). Inclusion criteria described in Figure 2 generated a sample of 20 schools. Using purposive sampling 13 schools were invited, aiming to create a sample representative of schools in the region. Nine schools accepted, three of which were single-sex girls’ schools. On completion of the T0 data collection a combination of two single-sex girls’ schools with high rates of participation and three co-educational schools from the lowest socioeconomic setting (SES) with low rates of participation had created a significant gender imbalance. To address this a single-sex boys’ school joined the study. Published evidence at 6-months post-intervention included nine schools (Bay et al., 2012a). Impacts to 12-months post-intervention reported here are from all ten schools.

Consent/assent to participate was obtained from principals, teachers, parents and students. Irrespective of participation in evaluation, all students were exposed to HSLEAP learning modules. Learning resources and professional development were provided for each school.

8.2.3. **Intervention Tools**

Intervention tools were developed by a multi-sectoral team led by science educators working as ‘intermediaries’ (Bolstad and Bull, 2013) capable of crossing science, education and health. Tools consisted of adaptable learning modules based on the HSLEAP learning and teaching framework (Figure 8.3) and contextualized in exploration of aspects of the NCD epidemic (Bay and Mora, 2009a; Bay and Mora, 2009b). The contexts were (a) nutrition (including early-life) and later-life obesity and CVD vulnerability or (b) early-life nutrition, early puberty and later life obesity and NCD risk. Opportunities for students to explore scientific evidence are central to the framework. This is achieved via narrative-based learning resources containing scientific evidence, reimaged to enable age-appropriate access (Bay et al., 2012c). This enables students to traverse into the culture of science, encounter scientists, their stories, and scientific evidence and explore similarities and differences between scientists’ ideas and ways of thinking and their own. Combined with experiences of NCDs from families and/or communities these narratives enable adolescents to construct and potentially act upon contextual understanding of evidence relating to life course approaches to NCD risk reduction. Each school developed a 4-6 week learning-module (12-18 classroom hours) based on the framework and appropriate for their setting.
During the module classes were exposed to ‘LENScience Face-to-Face’, a one-day hands-on learning programme exploring DOHaD research evidence at the Liggins Institute (Liggins Institute, 2016a).

8.2.4. Data Collection

Questionnaires enabling quantitative KAB analysis utilized Likert attitude scales and closed items. Parent questionnaires also included open items (available on request). Student questionnaires were completed in class under the guidance of a teacher who ensured students understood the nature of the questions and could seek clarification. Interviews were conducted within the school environment using semi-structured open-ended questions. Review meetings with teachers and classroom observations confirmed that delivery of the intervention module was representative of the HSLEAP framework.

8.2.5. Data Analysis

Publically available school demographic data (Ministry of Education, 2009) provided information on the range of communities represented within the study. Quantitative data was analysed using SPSS, (IBM Corp, 2015). Descriptive statistics were used to identify frequencies. Comparison of response frequencies between groups was evaluated with Chi-square, Fisher’s exact and Mann-Whitney U tests as appropriate. Distribution of responses of self-matched ordinal data at T0, T2 and T4 was analysed using the Friedman test.
followed by post-hoc assessment using the Wilcoxon Signed-Rank test. Matched binomial data were analysed using Cochran’s Q test. Ordinal logistic regression was used to ascertain the effects of gender on cohort-wide response patterns. Bonferroni-Holm’s correction for multiple comparisons was applied (Aickin and Gensler, 1996). Interviews were transcribed and anonymized prior to theme sorting using a constant comparative approach and inductive coding (Boyatzis, 1998) in line with the relativist ontological and subjective epistemological approach (Levers, 2013). Coding was conducted independently by two researchers and checked for inter-observer variability. Qualitative responses from parent questionnaires were treated similarly.

8.2.6. Participants

Table 8.1 describes demographic characteristics and response rates for students. The students who participated in evaluation (n=349) may not be representative of the intervention cohort (n=844). Without access to school records this could not be assessed. However, comparison of baseline data for those who did or did not complete all questionnaires demonstrated that the students who completed all questionnaires had a similar demographic and baseline response profile to those who responded to T0 and/or T0-T2 only, Appendix 8A. Where differences were found the T0-T2-T4 matched group demonstrated attitudes and behaviours that are slightly less health-aware than the T0 and/or T0-T2 group. Parental evidence was received from 32% of the cohort at baseline with matched T0-T2 data available from 165 parents (Figure 8.2), more than 50% of whom were linked to schools in the highest SES category.

The schools, nine of which were described in detail in Bay et.al. 2012a, represented a cross-section of communities from low to high SES. Parents from schools in the lowest SES category were least likely to consent to students participating in the study (Bay et al., 2012a). Discussion with teachers and parents suggested that this was associated with the requirement for written consent. Evaluation retention of students from this group was 1.2-fold greater than overall retention rates, Table 8.1. However, at only 20% of the total cohort this was inadequate to enable analysis of SES impacts on programme response. Despite the female bias in the cohort noted earlier as a limitation of the study, T0-T2-T4 matched sample was 38% male, enabling limited evaluation of the impact of gender on programme response.
Table 8.1. Cohort characteristics

<table>
<thead>
<tr>
<th>School Community SES¹</th>
<th>Schools in Auckland Region²</th>
<th>Intervention participation &amp; Invitation to participate in evaluation</th>
<th>Matched pre- and post-intervention responses (students)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School</td>
<td>Classes</td>
<td>Students &amp; T0³</td>
</tr>
<tr>
<td></td>
<td>Decile 1-4</td>
<td>39 (33.9)</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>Decile 5-7</td>
<td>20 (17.4)</td>
<td>1 (10)</td>
</tr>
<tr>
<td></td>
<td>Decile 8-10</td>
<td>56 (48.7)</td>
<td>5 (50)</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>290 (34.4)</td>
<td>123 (38.0)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>554 (65.6)</td>
<td>226 (36.6)</td>
</tr>
<tr>
<td>School Year Level</td>
<td>Year 7-8</td>
<td>227 (26.9)</td>
<td>140 (61.7)</td>
</tr>
<tr>
<td></td>
<td>Year 9-10</td>
<td>617 (73.1)</td>
<td>209 (33.9)</td>
</tr>
<tr>
<td>Median age at intervention [Inter-quartile range]</td>
<td>13y1m</td>
<td>12y1m – 14y1m</td>
<td>13y1m</td>
</tr>
<tr>
<td>Ethnicity [Multiple responses accepted]</td>
<td>Māori</td>
<td>45 (12.9)</td>
<td>35 (11.7)</td>
</tr>
<tr>
<td></td>
<td>Pacific</td>
<td>47 (13.5)</td>
<td>40 (13.4)</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>50 (14.3)</td>
<td>40 (13.4)</td>
</tr>
<tr>
<td></td>
<td>Indian</td>
<td>14 (4.0)</td>
<td>12 (4.0)</td>
</tr>
<tr>
<td></td>
<td>NZ European</td>
<td>222 (63.6)</td>
<td>197 (66.1)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>36 (10.3)</td>
<td>31 (10.4)</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>

Values are numbers; (percentage by column); (percentage by row)
¹ SES categorization for NZ schools is based on the SES of families within the school’s catchment area, calculated by census data relating to household income, educational qualifications, and occupation of adults within the household, household crowding, and income support provided to the household. Decile 10 includes the 10% of schools with the lowest proportion of low SES families within the catchment.
² Decile 1 includes the 10% of schools with the highest proportion of low SES families within the catchment (Ministry of Education, 2011). Data from NZ Ministry of Education (Ministry of Education, 2009), based on schools in the Auckland region comprising Years 7-13, 9-13, 7-10 or 11-13.
³ Parents were encouraged to make the consent decision in consultation with their children. Where parents gave consent for children to participate, 96% of adolescents gave assent.
8.3. Results

If sustained actions are to emerge from programme participation it should be possible to identify behavioural and emotional engagement during and beyond the intervention period.

Teachers from diverse settings identified positive behavioural engagement during the intervention.

“I have observed full engagement from students who often opt out.” Teacher, Decile 1-4

“Students are seeing a different side of science. They are very positive about learning more about their health and wellbeing.” Teacher, Decile 8-10

“It got the students working and engaged.” Teacher, Decile 5-7

Emotional engagement was indicated by factors such as enjoyment, interest and identification of relevance of the programme to personal situations.

“It is all relevant. That enables the students to stay engaged.” Teacher, Decile 8-10

“I am interested that they appear so receptive. Great to see the kids’ enthusiasm in delivering their findings and information at the conference” Parent, Decile 8-10, T2 interview

“All the time he is talking about it. Before [the project] most of the time he didn’t talk about school but since this project started he has really started talking about this – about Health, Science and PE. He has been going on the computer and he has done a lot of research. To be honest I am amazed he has stepped out of the school space and is doing work on his own at home. He is motivated.” Parent, Decile 1-4 school; T2 interview

Further examples of emotional engagement were reported previously (Bay et al., 2012a). When behavioural and emotional engagement leads to cognitive engagement the potential exists for development and application of capabilities resultant in action-taking. We present evidence relating to attitudes and understanding followed by evidence associated with actions emerging from cognitive engagement.
8.3.1. Awareness of and engagement with science

Questions examining NOS understanding (Table 8.2, Figure 8.4) indicate that pre-intervention the cohort generally understood science as an activity that seeks to understand the natural world via observation and inquiry. A common misconception relating to NOS is that which associates science with a lack of creativity (Lederman et al., 2013). Pleasingly at T0 64.7% of adolescents associated creativity and imagination with scientists. While overall cohort change is not significant, of the 69 students who responded Disagree (D), Strongly Disagree (SD) or Don’t Know (DK) at T0, 45% changed to a position of Agree (A) or Strongly Agree (SA) post-intervention and retained this to T4, p<.001. In contrast, only 18% of the 126 students who initially responded SA/A changed to an uncertain or negative position at T4.

Certainty of knowledge is a common NOS misconception (Lederman et al., 2013), promoted by content-laden science curricula alongside misrepresentation of the certainty of science by the media (Sinatra et al., 2014). Application of epistemic beliefs about the nature of scientific knowledge will influence the way individuals or groups respond to SSIs (Engdahl and Lidskog, 2014). Therefore, it is important to support adolescents to acknowledge and negotiate concepts associated with the inherent uncertainty of scientific evidence if they are going to negotiate issues associated with primary NCD prevention. Pleasingly, at T0 over 50% of students disagreed with the statement “Science is always about being sure of the answer.” Overall proportions of students taking this view did not alter significantly. However, 43% of the 75 students who pre-intervention responded SA/A moved to SD/D while only 22% of the 110 students who pre-intervention responded SD/D moved to SA/A. The odds of boys associating science with certainty was 2.638 times that of girls at T0, p<.001. At T2 this rose to 2.950 times that of girls, p<.001; while at T4 it reduced to 2.010 times that of girls, p=.008. These data should be of interest in boys’ schools as they suggest that unless teachers actively provoke discussions it may be less likely that this frame of reference will be challenged.

Public distrust of science is common. It is associated with use of science in regulatory capacities (Engdahl and Lidskog, 2014) and risk analysis (Retzbach et al., 2016). Asked if science could be trusted 74% of students responded SA/A at T0, with a small significant shift towards SA at T4. Of the 149 students responding SA/A at T0 only 18% moved to a negative response by T4 whereas 57% of the 51 students responding DK/D/SD at T0 moved to SA/A at T4. No significant gender difference was seen at T0. By T2 the odds of boys
agreeing that science could be trusted was 2.773 times that of girls, \( p=.001 \), dropping to 2.002 at T4, \( p=.013 \). The relatively high level of trust in science exhibited may be supportive of engagement in exploration of NCD risk. The gender difference post-intervention warrants further investigation. Combined with the gender difference regarding the tentative nature of evidence this should be a point of discussion for teacher planning.

Doing science is associated with contributing towards NOS understanding when combined with explicit instruction and opportunities for reflection (Kahana and Tal, 2014). At baseline 13.8\%/41.5\% of students respond SA/A to the statement “I have done proper scientific investigations at school” At T2 this shifts to 23.6\%/46.2\%, rising slightly at T4, 25.5\%/53.8\%, \( p<.001 \). Contributors to this shift could include changes in understanding of the process of science and thus appreciation of prior experiences, changes in teaching practice reflected in student experience, or a combination of both. It is likely that most students had undertaken open-ended investigations prior to the intervention as this is a component of the New Zealand curriculum. During the intervention, all classes experienced learning exploring the process of science and carried out some form of open investigation. This suggests that the use of science narratives within the intervention may increase understanding of what science is and allow students to recognize science more readily.

Meeting scientists (actually and through narratives) enables students to explore epistemologies that may be different to their own. This supports the potential for frames of reference to be adapted to include evidence-based scientific perspectives in addition to perspectives arising from personal contexts. Most adolescents had little or no contact with scientists outside of their school environment, Table 8.3. Pre-intervention, 37\% of students identify with having met a scientist. Of this group, 63.5\% identify either a teacher or a person they have met via a school event. Students did not identify all teachers as scientists. E.g. in a school with six participating teachers, 39\% of students identified having met a scientist at T0 and 68\% of these qualified their answer by naming one or other of two teachers, both of whom had prior work experience in science. Post-intervention the proportion of students identifying as having met scientists increases to greater than 70\%, \( p<.001 \). While school-related encounters still dominate, there is a significant shift towards school-events linked to the programme.
Table 8.2. Perceptions of science, matched pre-post responses, n = 201

<table>
<thead>
<tr>
<th>Statement</th>
<th>4. Science is about understanding the world</th>
<th>5. Scientists do experiments</th>
<th>6. Scientists are creative and imaginative people</th>
<th>7. Science is always about being sure of the answer</th>
<th>8. You can trust science</th>
<th>9. I have done proper scientific investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched Responses</td>
<td>n=198</td>
<td>n=201</td>
<td>n=195</td>
<td>n=199</td>
<td>n=200</td>
<td>n=195</td>
</tr>
<tr>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
</tr>
<tr>
<td>% Strongly Agree</td>
<td>39.9</td>
<td>33.8</td>
<td>42.9</td>
<td>64.7</td>
<td>66.2</td>
<td>64.7</td>
</tr>
<tr>
<td>% Agree</td>
<td>44.4</td>
<td>52.0</td>
<td>47.0</td>
<td>31.8</td>
<td>32.3</td>
<td>34.3</td>
</tr>
<tr>
<td>% Don’t know</td>
<td>1.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>% Disagree</td>
<td>8.6</td>
<td>9.6</td>
<td>7.1</td>
<td>1.5</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>% Strongly Disagree</td>
<td>6.1</td>
<td>205</td>
<td>2.5</td>
<td>1.5</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Friedman test</td>
<td>χ²(2)=4.678, p=.096</td>
<td>χ²(2)=0.788, p=.674</td>
<td>χ²(2)=1.219, p=.544</td>
<td>χ²(2)=0.287, p=.866</td>
<td>χ²(2)=9.115, p=.010*</td>
<td>χ²(2)=42.213, p&lt;.001*</td>
</tr>
<tr>
<td>Pairwise comparison</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
</tr>
<tr>
<td>z</td>
<td>0.215</td>
<td>1.821</td>
<td>1.762</td>
<td>0.215</td>
<td>1.821</td>
<td>1.762</td>
</tr>
<tr>
<td>Adj p</td>
<td>.832</td>
<td>.069</td>
<td>.078</td>
<td>.832</td>
<td>.069</td>
<td>.078</td>
</tr>
</tbody>
</table>

| OR (Male cf. Female) | 0.825 | 1.702 | 1.303 | 1.318 | 1.377 | 0.729 | 1.947 | 1.731 | 2.431 | 2.638 | 2.950 | 2.010 | 1.430 | 2.773 | 2.002 | 1.392 | 1.043 | 1.771 |
| 95% CI | -0.482 - 0.983 | -0.754 - 1.411 | 0.724 - 2.947 | 0.372 - 2.533 | 1.136 - 3.337 | 0.404 - 2.397 | 1.020 - 2.940 | 1.400 - 4.221 | 1.554 - 4.479 | -1.817 - 5.605 | -1.558 - 9.911 | -1.197 - 3.375 | -0.372 - 2.601 | 1.157 - 4.937 | 0.872 - 3.462 | 2.355 - 1.760 | 3.078 - 3.078 |
| χ²(2) | 0.493 | 3.601 | 0.901 | 0.817 | 1.061 | 1.106 | 5.872 | 4.133 | 9.947 | 12.896 | 16.256 | 6.966 | 1.571 | 12.013 | 2.811 | 1.519 | 0.025 | 4.102 |
| p | .483 | .058 | .342 | .366 | .303 | .293 | .015* | .042* | .002* | <.001* | <.001* | .008* | .210 | .001* | .013* | .218 | .875 | .043* |

Variance in distribution of matched responses at T0, T2 and T4 was measured using the Friedman test. Post hoc pairwise comparisons were conducted using Wilcoxon Signed-Rank test. The effect of gender on responses was assessed using ordinal logistic regression with proportional odds. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; p = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons.
Figure 8.4. Awareness of & engagement with science: T0-T4 Individually matched change, n=201
Table 8.3. Experiences of meeting scientists. Matched pre-post responses n = 201.

<table>
<thead>
<tr>
<th>Matched Responses:</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Yes</td>
<td>37.0</td>
<td>76.0</td>
<td>71.0</td>
</tr>
<tr>
<td>% No</td>
<td>63.0</td>
<td>24.0</td>
<td>29.0</td>
</tr>
<tr>
<td><strong>Cochran’s Q</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q=98.255,  p&lt;0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Odds Ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male cf. Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.683 (95%CI 0.374-1.247)</td>
<td>0.817 (95%CI 0.421-1.583)</td>
<td>0.605 (95%CI 0.325-1.126)</td>
</tr>
<tr>
<td>Pair-wise comparison</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
</tr>
<tr>
<td><strong>McNemar</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>χ²(1)=64.446,  p&lt;.001*</td>
<td>χ²(1)=51.011,  p&lt;.001*</td>
<td>χ²(1)=2.025,  p=.155</td>
</tr>
</tbody>
</table>

Variance in distribution of matched responses at T0, T2 and T4 was measured using the Cochran’s Q test. Post hoc pairwise comparisons were conducted using McNemar’s test. The effect of gender on responses was measured using binomial logistic regression. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; p’= Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons.

8.3.2. Perceptions of the importance of health and lifestyle

Matched pre-post comparisons of responses to statements exploring perceptions of the importance of health and lifestyle provide indications of impact on engagement with health as an issue of relevance to adolescents. We reported previously that students considered health as a concept that encapsulated physical, social, and emotional factors and correctly interpreted concepts of healthy and unhealthy foods (Bay et al., 2012a). Pre-intervention students rated highly (‘quite a lot’ or ‘a lot’) the importance of ‘being healthy’ (94.5%), ‘what you eat’ (88.5%) and ‘daily exercise’ (87.9%), Table 8.4. At baseline, students were less likely to rate ‘what you eat’ as mattering ‘a lot’ (39.0%) compared to being healthy (55.1%) and exercising daily (51.0%), assessed via Cochran’s Q test to be significant χ²(2) = 18.143, p<.001. Post-hoc analysis reveals that the difference is between ‘what you eat’ vs ‘being healthy’, p<.001, and ‘what you eat’ vs ‘daily exercise’, p=.006. At 3- and 12-months post-intervention there was a significant increase in students identifying ‘being
healthy’ $\chi^2(2) = 9.297$, $p=.010$ and ‘what you eat’ as mattering ‘a lot’ $\chi^2(2) = 6.889$, $p=.032$, indicating that engagement led to positive attitudinal change. Conversely, there was no change in students’ perceptions of the importance of daily physical activity, a concept not explored within the programme.

Table 8.4. The importance of health and lifestyle: matched pre-post responses $n = 201$

<table>
<thead>
<tr>
<th>Statement:</th>
<th>9. How much does it matter whether or not you are healthy?</th>
<th>10. How much does it matter what you eat?</th>
<th>11. How much does it matter whether or not you are active or exercise every day?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched Responses:</td>
<td>$n=197$</td>
<td>$n=197$</td>
<td>$n=196$</td>
</tr>
<tr>
<td></td>
<td>T0</td>
<td>T2</td>
<td>T4</td>
</tr>
<tr>
<td>A lot (AL)</td>
<td>55.1</td>
<td>68.2</td>
<td>59.5</td>
</tr>
<tr>
<td>Quite a lot</td>
<td>39.4</td>
<td>27.4</td>
<td>36.5</td>
</tr>
<tr>
<td>Not very much</td>
<td>5.6</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Not at all</td>
<td>0.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Cochran’s $Q$ (AL vs < AL) $\chi^2(2)=9.297$ $p=.010^*$ $\chi^2(2)=6.889$ $p=.032^*$ $\chi^2(2)=1.604$ $p=.448$

Pair-wise comparison: T0-T2 | T0-T4 | T2-T4 | T0-T2 | T0-T4 | T2-T4
Adj Sig                     | .003* | .490  | .189  | .113  | .018* | .925

Odds Ratio: Male cf. female, selecting ‘A lot’

<table>
<thead>
<tr>
<th>OR</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.043</td>
<td>1.254</td>
<td>0.660</td>
<td>0.762</td>
<td>0.475</td>
<td>1.163</td>
<td>0.782</td>
<td>0.849</td>
<td>0.810</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.593-1.835</td>
<td>0.676-2.327</td>
<td>0.372-1.172</td>
<td>0.440-1.320</td>
<td>0.272-0.829</td>
<td>0.672-2.015</td>
<td>0.453-1.350</td>
<td>0.491-1.470</td>
<td>0.468-1.402</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.021</td>
<td>0.515</td>
<td>2.011</td>
<td>0.943</td>
<td>6.874</td>
<td>0.291</td>
<td>0.777</td>
<td>0.340</td>
<td>0.566</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.884</td>
<td>0.473</td>
<td>0.156</td>
<td>0.332</td>
<td>0.009*</td>
<td>0.589</td>
<td>0.378</td>
<td>0.560</td>
<td>0.452</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Variance in proportion of responses confirming ‘A lot’ vs less than ‘A lot’ was assessed via Related Samples Cochran’s Q test with post-hoc pairwise comparisons where the variance in proportional distribution between T0-T2-T4 was significant. The effect of gender on responses was measured using a cumulative odds ordinal logistic regression with proportional odds. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; Adj.Sig = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons. OR = Odds Ratio; CI = Confidence Interval.

8.3.3. Awareness of associations between nutrition and health

Responses to statements exploring awareness of associations between nutrition in early life and adolescence and health assessed the potential for narrative-based exploration of DOHaD evidence to support development of awareness of this evidence as a component of NCD vulnerability, (Table 8.5, Figure 8.5).
### Table 8.5. Awareness of associations between nutrition and health across the life course, n = 201

<table>
<thead>
<tr>
<th>Matched Responses</th>
<th>Statement 12. The food a woman eats when she is pregnant affects the health of her baby</th>
<th>Statement 13. The food a woman eats when she is pregnant affects the health of her baby when it is grown up</th>
<th>Statement 14. The food a father eats will affect the health of his children when they are babies</th>
<th>Statement 15. The food a father eats will affect the health of his children when they grow up</th>
<th>Statement 16. It is important for me to eat healthy food now</th>
<th>Statement 17. The food I eat now will affect my health in the future</th>
<th>Statement 18. The food I eat now will affect the health of any children I have in the future</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
</tr>
<tr>
<td>% Strongly Agree (SA)</td>
<td>53.1</td>
<td>62.8</td>
<td>61.2</td>
<td>41.2</td>
<td>5.6</td>
<td>7.7</td>
<td>62.1</td>
</tr>
<tr>
<td>% Agree (A)</td>
<td>40.8</td>
<td>35.7</td>
<td>36.2</td>
<td>25.2</td>
<td>34.4</td>
<td>33.3</td>
<td>22.8</td>
</tr>
<tr>
<td>% Don’t Know (DK)</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
<td>6.8</td>
<td>2.1</td>
<td>2.1</td>
<td>12.8</td>
</tr>
<tr>
<td>% Strongly Disagree (SD)</td>
<td>4.1</td>
<td>1.5</td>
<td>2.1</td>
<td>25.7</td>
<td>11.5</td>
<td>19.9</td>
<td>25.1</td>
</tr>
<tr>
<td>Friedman test</td>
<td>$\chi^2(2)=8.313$, p=$.016^*$</td>
<td>$\chi^2(2)=40.671$, p$&lt;.001^*$</td>
<td>$\chi^2(2)=7.121$, p=$.003^*$</td>
<td>$\chi^2(2)=2.409$, p=$.122$</td>
<td>$\chi^2(2)=2.714$, p$=.122$</td>
<td>$\chi^2(2)=9.552$, p$=.008^*$</td>
<td>$\chi^2(2)=3.850$, p$=.146$</td>
</tr>
<tr>
<td>Pairwise comparison</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
<td>T0-T2</td>
</tr>
<tr>
<td>z</td>
<td>3.010</td>
<td>2.409</td>
<td>-0.625</td>
<td>5.704</td>
<td>3.985</td>
<td>2.589</td>
<td>1.381</td>
</tr>
<tr>
<td>Adj p</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.030^*$</td>
<td>$.023^*$</td>
<td>$.008^*$</td>
<td>1.000</td>
<td>$.390$</td>
</tr>
<tr>
<td>Odds Stat / Odds Female Responding Strongly Agree</td>
<td>OR</td>
<td>0.615</td>
<td>0.699</td>
<td>0.629</td>
<td>2.234</td>
<td>1.344</td>
<td>2.224</td>
</tr>
<tr>
<td>95% CI</td>
<td>0.351 - 0.584</td>
<td>0.388 - 0.781</td>
<td>1.296 - 3.816</td>
<td>1.792 - 1.299 - 1.677 - 5.202</td>
<td>0.217 - 3.711</td>
<td>4.870</td>
<td>1.555 - 0.188 - 1.611 - 0.846</td>
</tr>
<tr>
<td>$\chi^2(2)$</td>
<td>2.908</td>
<td>1.421</td>
<td>2.421</td>
<td>8.834</td>
<td>1.139</td>
<td>8.417</td>
<td>16.865</td>
</tr>
<tr>
<td>p</td>
<td>.088</td>
<td>.699</td>
<td>.629</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
</tr>
</tbody>
</table>

Variance in distribution of matched responses at T0, T2 and T4 was measured using the Friedman test. Post hoc pairwise comparisons were conducted using Wilcoxon Signed-Rank test. The effect of gender on responses was assessed using ordinal logistic regression with proportional odds. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6–12 weeks post-intervention; T4 = 24-months post-intervention; n = number; p’ = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons, OR = Odds Ratio.
Figure 8.5  Awareness of associations between nutrition & health: T0-T4 Individually matched change, n=201
Pre-intervention SA/A responses to Statement 12 “The food a woman eats when she is pregnant affects the health of her baby” are high (53.1/40.8%). Significant positive shift towards SA occurs at T2 (62.8/35.7%) and is sustained to T4, (61.2%/36.2%), indicating that the programme increased awareness of this concept, p=.016. Gender difference in T0 response indicating that boys were less likely than girls to respond positively (p=.088) did not alter markedly post-intervention.

The concept of association between the nutritional environment of the mother during pregnancy and later life health (Statement 13) elicited a wide range of pre-intervention responses. The odds of boys responding positively at T0 was 2.234 times that for girls p=.003. Strong positive change in awareness was observed at T2 and sustained to T4, p<.001. Of the 47.2% of participants who pre-intervention did not demonstrate awareness of this concept, 73.3% demonstrated awareness at 12-weeks post-intervention, 81.8% of whom continued to demonstrate this awareness at 12-months post-intervention. Awareness in girls increased markedly between T0 and T2, with the odds of boys responding positively at T2 lowering to 1.344 compared to that of girls p=.286. Retention of SA/A response was higher in boys (92%) compared to girls (83%) at T4. Correspondingly the odds of boys responding positively at T4 increased to 2.224 that of girls, p=.004.

The learning resources did not explore associations between paternal nutritional environment prior to conception and offspring health. However, this concept was attracting increasing attention within the DOHaD community at the time of the intervention (Ng et al., 2010). It was raised as a question in teacher professional development, as well as by students in the one-day Liggins Institute programme in the years prior to this intervention. Therefore, the concept was included as a point of emerging interest without exploration of evidence in the one-day Liggins Institute sessions attended by all participants. A small change in awareness is detected in responses to Statement 14, suggesting that information sharing without examination of evidence has limited impact. When compared to the significant positive change in awareness of associations between maternal nutritional environment and later life offspring health this confirms that for students to develop understanding of research evidence they need to explore data rather than be told of findings. Clear evidence of associations between paternal environmental exposures and later-life health outcomes is now available (Bale, 2014; McPherson et al., 2014). Relevant adolescent learning resources should be created.
Most adolescents receive signals from home, school, and community indicating the importance of healthy eating. Therefore, unsurprisingly 61.0%/36.4% of students responded SA/A to **Statement 16** exploring the importance of eating healthy food. While not statistically significant, the change upwards to 69.2%/27.7% at 12-months post-intervention is promising. Gender based differences were statistically significant at T0 and T4. At T0 the odds of boys responding positively to this statement were 0.467 that of girls, p=.011. Responses of boys shifted markedly at T2, bringing responses in line with those of girls. Girls responses at SA/A level continued to move upwards between T0 (69%/28.4%) and T4 (75.2%/22.2%). However, boys dropped back to 59.5%/36.5% at T4, still somewhat higher that their T0 rates of 50.0%/47.3%. Thus, the odds of boys responding positively at T4 lowers back to 0.507 that of girls, p=.030.

Positive (SA/A) responses to **Statement 17** “The food I eat now will affect my health in the future” were lower than those for Statement 16 at T0, (40.2/51.5%). Post-intervention responses shifted significantly upwards and were sustained at 52.6/41.2% 12-months, p=.008.

**Statement 18** “The food I eat now will affect the health of any children I have in the future” tested the potential for students to engage with DOHaD concepts in relation to their potential future offspring. Given their age (11-14 years), this was conceptually challenging as it related to events in their adult future. Responses at T0 were mixed, potentially reflecting this challenge. While overall there was a positive shift in responses, significant moves occurred in both directions. This suggests that applying these concepts to their future as adults is challenging and should be explored further.

### 8.3.4. Cognitive engagement and actions

Recognition of relevance, when followed by action signals investment in learning and is indicative of emotional and cognitive engagement, e.g.

“I had thought about it but I had never really done healthy eating before. Now I pay more attention to healthy eating and exercise. In P.E. I participate more. Like I used to just stand there but now I take part and it is really fun. [Before] I was ashamed, but now I enjoy it and I really take part and I eat healthy too. I eat vegetables.”

Year 9 female, Decile 1-4, 6 months post-intervention
The potential of programme participation to facilitate nutritional behaviour change was assessed using matched self-reported evidence relating to eight key food categories, Tables 8.6a and 8.6b. Not all adolescents need to make nutritional behaviour changes. Therefore, we divided the assessment of behaviour change into two categories based on the risk-level represented by baseline patterns. We reported at 12-weeks post-intervention indicators of positive change in students whose pre-intervention nutritional behaviours could increase later risk of overweight/obesity and NCD. This was triangulated with interview evidence indicating that change was determined by adolescents in response to evidence they had explored in the HSLEAP programmes (Bay et al., 2012a). Matched analysis demonstrates statistically significant sustained behaviour change from T0 to T2 and T4 for all food categories for students in the ‘at-risk’ group, Table 8.6a. Consistent with our reported 12-weeks post-intervention evidence, some negative behaviour changes were observed at 12-months post-intervention in the group for whom pre-intervention behaviour was not in the ‘at risk’ category Table 8.6b. Exploration of whether the programme has greater impact for those who recognize NCD risk in their families or identify with behaviours that they learn are associated with increased NCD risk would be valuable. However, conclusions relating to this cannot be drawn from the data presented. Overall, the nutritional change data shows that the odds of positive behaviour change for students in the ‘at risk’ group were significantly higher than the odds of students in the ‘low/no risk’ group making negative changes.
### Table 8.6a. Change in self-reported diet behaviours indicated by individually matched pre & post intervention responses, n=167*

<table>
<thead>
<tr>
<th>Food item</th>
<th>T0 responses in ‘at risk’ category</th>
<th>T0 – T2 – T4</th>
<th>Pre-to 12-weeks post intervention (T0-T2)</th>
<th>Pre-to 12-months post-intervention (T0-T4)</th>
<th>Oddsratio/Odds&lt;sub&gt;premale&lt;/sub&gt; T0 to T4 Positive Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-reported consumption pattern defined as indicating risk</td>
<td>n</td>
<td>%</td>
<td>Odds&lt;sub&gt;male&lt;/sub&gt;/Odds&lt;sub&gt;female&lt;/sub&gt;</td>
<td>Positive change (%)</td>
<td>Negative change (%)</td>
</tr>
<tr>
<td>Potato crisps (snack food)</td>
<td>&gt; once per week 69 42.3</td>
<td>1.352 (95%CI 0.719 to 2.542), χ²(1)=0.878, p=.349</td>
<td>30.516 &lt;.001*</td>
<td>39.1 1.5 &lt;.001*</td>
<td>42.9 5.7 &lt;.001*</td>
</tr>
<tr>
<td>Fried food (e.g. hot chips, fried chicken, burgers)</td>
<td>≥ once per week 93 58.5</td>
<td>1.289 (95%CI 0.680 to 2.442), χ²(1)=0.606, p=.436</td>
<td>17.857 &lt;.001*</td>
<td>43.0 16.1 &lt;.001*</td>
<td>36.6 9.7 &lt;.001*</td>
</tr>
<tr>
<td>Soft drinks [fizzy, cordials, sports drinks]</td>
<td>≥ 2-4 times per week 41 24.5</td>
<td>2.100 (95%CI 1.027 to 4.296), χ²(1)=4.129, p=.042*</td>
<td>13.904 &lt;.001*</td>
<td>36.6 7.3 &lt;.01*</td>
<td>43.9 7.3 &lt;.01*</td>
</tr>
<tr>
<td>Sweet snacks (e.g. biscuit, muesli bar, sweet [candy])</td>
<td>&gt; 2-4 times per week 28 17.8</td>
<td>1.035 (95%CI 0.504 to 2.124), χ²(1)=0.925</td>
<td>18.764 &lt;.001*</td>
<td>42.9 N/A .001</td>
<td>50.0 N/A &lt;.001*</td>
</tr>
<tr>
<td>Green vegetables (e.g. spinach, beans, lettuce)</td>
<td>&lt; Daily 58 36.5</td>
<td>1.224 (95%CI 0.641 to 3.339), χ²(1)=0.925</td>
<td>20.520 &lt;.001*</td>
<td>46.6 5.2 &lt;.01*</td>
<td>39.7 10.3 &lt;.01*</td>
</tr>
<tr>
<td>Starchy vegetables (e.g. sweet potato, potato, pumpkin)</td>
<td>≤ once per week 26 16.4</td>
<td>1.496 (95%CI 0.643 to 3.480), χ²(1)=0.874, p=.350</td>
<td>26.275 &lt;.001*</td>
<td>73.1 0.0 &lt;.001*</td>
<td>73.1 3.8 &lt;.001*</td>
</tr>
<tr>
<td>Fruit (e.g. apples, pears, bananas)</td>
<td>&lt; Daily 57 35.0</td>
<td>1.875 (95%CI 0.975 to 3.608), χ²(1)=3.545, p=.060</td>
<td>16.528 &lt;.001*</td>
<td>38.6 5.3 &lt;.001*</td>
<td>45.6 14.0 &lt;.01*</td>
</tr>
<tr>
<td>Raw fruits and vegetables</td>
<td>&lt; Daily 88 54.3</td>
<td>1.136 (95%CI 0.607 to 2.128), χ²(1)=0.159, p=.690</td>
<td>23.452 &lt;.001*</td>
<td>48.9 11.4 &lt;.001*</td>
<td>52.3 19.3 &lt;.002*</td>
</tr>
</tbody>
</table>

*An administrative error in data collection at one site reduced the number of valid responses to food frequency questions at T0. Hence n=167 rather than 201.

T0, Pre-intervention; T2, 6-12 weeks post-intervention; T4, 12-months post-intervention; n, number; p* Bold: significant (α=0.05). Adj.Sig = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons. The Friedman test was used to measure variance in distribution at T0, T2 and T4. Post hoc pairwise comparisons were conducted using Wilcoxon Signed-Rank test.
Table 8.6b  Comparative behaviour change patterns (at risk vs no/low risk), n=167

<table>
<thead>
<tr>
<th>Food item</th>
<th>Pre-intervention to 12-months post-intervention behaviour change</th>
<th>Odds Ratio</th>
<th>T0-Risk / T0-No/low Risk T0-T4 change towards opposite category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Negative change towards greater risk</td>
<td>% No change</td>
<td>% Negative change into at risk category</td>
</tr>
<tr>
<td>Potato chips [crisps]</td>
<td>&gt; once/week</td>
<td>5.8</td>
<td>52.2</td>
</tr>
<tr>
<td>Fried food (e.g. hot chips, fried chicken, burgers)</td>
<td>≥ once per week</td>
<td>9.7</td>
<td>53.8</td>
</tr>
<tr>
<td>Soft drinks [fizzy, cordials, sports drinks]</td>
<td>≥ 2-4 times per week</td>
<td>7.3</td>
<td>48.8</td>
</tr>
<tr>
<td>Sweet snacks (e.g. biscuit, muesli bar, sweet [candy])</td>
<td>&gt; 2-4 times per week</td>
<td>N/A</td>
<td>50.0</td>
</tr>
<tr>
<td>Green vegetables (e.g. spinach, beans, lettuce)</td>
<td>&lt; Daily</td>
<td>10.3</td>
<td>50.0</td>
</tr>
<tr>
<td>Starchy vegetables (e.g. sweet potato, potato, pumpkin)</td>
<td>≤ once per week</td>
<td>3.8</td>
<td>23.1</td>
</tr>
<tr>
<td>Fruit (e.g. apples, pears, bananas)</td>
<td>&lt; Daily</td>
<td>14.0</td>
<td>40.4</td>
</tr>
<tr>
<td>Raw fruits and vegetables</td>
<td>&lt; Daily</td>
<td>19.3</td>
<td>28.4</td>
</tr>
</tbody>
</table>

T0, Pre-intervention; T2, 6-12 weeks post-intervention; T4, 12-months post-intervention; n, number; p* Bold: significant (α=0.05). The effect of T0 response group (‘at risk’ vs ‘low/no risk’) on change response was measured using ordinal logistic regression with proportional odds.
8.3.5. **Cognitive engagement and communication**

Evidence indicating that students became science storytellers is a sign of cognitive engagement that offers important potential for school-based interventions to reach into families. At T2, positive changes in parental awareness of DOHaD-related concepts were identified (Bay et al., 2012a) and 73% of parents responding to a request to comment on the programme (n=55) indicated interest in learning about aspects of science explored within the programme. Additionally 37 of the 40 adolescents interviewed at 6-months post-intervention talked about engaging their family in learning from the programme and 19 discussed application of their learning in evidence-based actions, examples of which we reported previously (Bay et al., 2012a). These data indicate that students became science communicators in their families. In addition to supporting family-level behaviour change reported in Bay et al., 2012a, this has supported parents to develop an understanding of science as a human endeavour of relevance in their community.

“Back in my day science at school was not so relevant to the children’s world. Soana* is telling me about what she is doing. She is really interested and they are looking at how things work. That has changed my mind on what science is so I can see there are branches of it in everyday things and I can see the value of science for her. When I came to the parent’s night I was interested and wanting to know more about what Soana* was learning at school and I went away learning something, and I enjoyed the evening. I wanted to come to this meeting because she has been talking about science ever since this programme started and she has said that she likes science so I thought well I should come and support her.”

Parent, Decile 1-4 school; 6-months post-intervention, *name altered

This type of impact is valued by schools as it promotes the worth of science education within communities.

“The value of the programme for parents in our community is that they have begun to see what science is a little more. The students are taking back ideas to their families and their communities. We are getting a lot more understanding about how science is impacting the community. We are getting more students wanting to take science – they can see the relevance of it. There is a strong link to their lives.”

HOD Science, Decile 1-4 school
8.4. Discussion

This study tested the potential of narrative-based science learning contextualized in NCD related issues to support scientific and health literacy development and facilitate health-promoting actions. Participation was strongly associated with engagement, known to be a prerequisite to the development of capabilities associated with critical citizenship, and associated with higher levels of scientific literacy (Caygill and Sok, 2008). This led to increased understanding of the culture, nature and process of science as well as research evidence associated with life course understanding of NCD risk. Greater knowledge change was associated with exposure to learning resources enabling students to explore evidence compared to questions relating to evidence not presented in this manner. Assessment of nutritional behaviour change demonstrated that the positive change in the ‘at-risk’ group was significantly higher than negative change in the ‘no/low-risk’ group for all but one food item (fried foods). Combined with the significant qualitative evidence from the 6-month post-intervention interview data demonstrating that the observed positive behaviour changes were associated with application of evidence-based thinking (Bay et al., 2012a) these data indicate that students in the ‘at-risk’ group made and sustained evidence-based decisions in relation to learning associated with the intervention. The high level of communication into the family by students is encouraging as it supports evidence linked to the importance of family-engagement in achieving positive adolescent health promotion (Todd et al., 2015).

In some aspects of the evaluation we identified small increases in understanding and capability development between 3- and 12-months post-intervention, indicative of ongoing development beyond the intervention period. This reflects the notion that each learning module in a programme contributes to overarching educative goals. Therefore, ideas explored will be linked into learning beyond the module, supporting ongoing capability development.

The impacts of this study sit in contrast to the questionable value of school-based health-interventions expressed in the literature (Khamalia et al., 2012). Unusually for school-based health-interventions, experienced science educators embedded in a health-research setting led the intervention design. This enabled a programme supportive of educational as well as health/science goals (Bay et al., 2016a) and set within a core curriculum area (World Health Organization, 2016b), addressing issues relating to connection to the core mission of schools (Waters et al., 2011). Ensuring that the intervention resources supported teachers to develop
locally relevant programmes addressed issues associated with the impact of school diversity on intervention impacts (Keshavarz Mohammadi et al., 2010).

Evaluation recognized that for education to impact health, assessment must look at whether learning took place before asking whether this learning influenced health. Ideally, the programme should also support measurement of long-term health impacts, an issue that we hope to address in the future.

8.5. Limitations

The study is limited by several factors, including lack of matched control schools. However, factors within the study design address internal validity. Individually matched analysis has been used throughout the study, addressing issues of individual variance and fixed confounding variables. The use of 30 classrooms across 10 schools contributed to addressing factors associated with heterogeneity in school settings. Biglan et al, argue that time-series studies should be considered as experimental, rather than quasi-experimental (Biglan et al., 2000). However, in this study we were limited to a single pre-intervention baseline where to be considered experimental the baseline questionnaires should be repeated to determine stability prior to intervention (Biglan et al., 2000). When conducting research in schools the use of curriculum time for evaluation must be carefully considered. Most New Zealand schools timetable 3-hours per week for science learning in Years 7-10. The evaluation processes required 5-hours of this time. The addition of a further hour to collect a second baseline was rejected by participating schools. This was addressed by comparing baseline evidence with known evidence relating to NOS understanding and nutritional behaviours in New Zealand adolescents. The high level of NOS understanding at baseline was reflective of international assessment of NOS in New Zealand 15 year-olds (Ministry of Education). Food frequency data was comparative to patterns in the New Zealand National Youth Nutrition Survey (Clinical Trials Research Unit Synovate, 2010). Awareness of associations between nutrition in early-life and later life health was consistently low across all 10 schools at baseline, measured over a period of 2 years as each school timed the study to suit their own needs. This is parallel to data we have from 900 adults in the Auckland region (Bay, 2015a), indicating reliability of the baseline. Furthermore, change data was triangulated with interview data from parents and students. Collectively this indicates that it is highly likely that changes found in individually matched pre-post assessments can be attributed to intervention participation.
As noted the study cohort presented limitations in terms of the potential to explore the impact of gender, age and SES. Gender differences observed should be treated cautiously as we were not able to assess differences in SES and age due to the mid-SES group being from single-sex girls’ schools and the Year 7-8 cohort being from mid- and high-decile schools only. Further research is underway to address these questions.

8.6. Conclusions

The World Health Organization (WHO) is promoting the importance of curriculum-embedded school-based partnerships to support primary NCD risk reduction. This study examined whether addressing known shortcomings relating to school-based health-promotion such as shared vision, and understanding of pedagogy and practice could demonstrate the value of combining educative and health goals in support of DOHaD translation in the adolescent life stage. Our study suggests that use of a narrative-based pedagogy centred on development of scientific literacy is effective in promoting evidence-based actions by adolescents that are supportive of long-term health. Utilization of mixed-methods enabled student-, teacher- and parent-voices to identify associations between observed KAB changes and programme participation. Strong links to the goals of the national curriculum combined with evidence of positive change in NOS understanding validated the use of science learning time and offers strong potential for sustainability and future development. Further development and testing of tools and contexts associated with primary NCD risk reduction linked to learning objectives in science, as well as other core learning areas should be explored. Understanding of impacts associated with teacher diversity, student age, gender, and socio-ecological setting are required, along with assessment of relative sustainability and contextual transferability of scientific literacy capabilities developed in this manner.
Chapter 9. Cook Islands Adolescents as Agents of Change in the Face of the NCD Crisis

Preface

This chapter presents evaluative evidence from application of the HSLEAP model in three schools in Rarotonga. It represents the work of a community-based participatory research programme involving the Ministries of Education and Health in the Cook Islands, the Liggins Institute, and the participating school communities. The contextual adaptation of the HSLEAP model for use in developing nations in the Pacific region is contributing to the urgent need to address the NCD crisis in the Pacific. The work represented in this chapter is in final preparation for submission to an academic journal with a focus on the role of education in development. Authors will include the lead collaborators from the partnership.
9.1. Introduction

The prevalence of adult and childhood obesity and associated noncommunicable diseases (NCDs) continues to rise globally, causing great concern (World Health Organization, 2015b, 2016b). NCDs primarily include cardiovascular diseases (CVD), type 2 diabetes mellitus (T2DM), cancers, and chronic respiratory diseases. They are responsible for 68% of global deaths, 40% of which occur prematurely (prior to age 70-years). Low- and middle-income countries (LMICs) carry a disproportionate high NCD burden accounting for 75% of all, and 82% of premature NCD deaths (World Health Organization, 2015b). The prohibitive cost of treatment (Beaglehole et al., 2011a) combined with the social and economic loss resultant of NCD morbidity and mortality is significantly curbing development in LMICs (Bloom et al., 2011; World Health Organization, 2011). The United Nations (UN) and the World Health Organization (WHO) have called for multifaceted approaches to address the issue (Chestnov et al., 2013). Amongst the wide range of political, economic and public health strategies is a call for school-based education to contribute to intergenerational NCD risk reduction (World Health Organization, 2016b).

9.1.1. Why involve school-based education in NCD risk reduction?

Traditionally, NCD risk was thought to be associated with a combination of genetic predisposition and unhealthy adult lifestyle (Hanson, 2016). Risk reduction strategies targeted adults with risk factors such as hypertension, or requiring treatment to curb progression of diseases such as diabetes. Despite extensive investigation, no strong genetic links have been found that account for obesity risk (Manolio et al., 2009). Improved understanding of the biology of obesity has shown that once established it is extremely difficult to reverse due to biological factors that support the ongoing condition in the individual (Blackstone, 2016). However, a field of research known as Developmental Origins of Health and Disease (DOHaD) has shown that vulnerability to NCD risk is strongly influenced by environmental exposures from early life through to adolescence that affect our epigenome, changing the way in which cells use instructions contained within DNA. Adverse nutritional exposures (undernutrition &/or obesogenic environments) experienced by either parent prior to conception, the mother during pregnancy, and the infant and child, contribute towards vulnerability to obesity and NCDs in later life (Hanson and Gluckman, 2014). This knowledge has driven the development of programmes supporting positive nutritional and lifestyle behaviours prior to and during pregnancy, and during childhood.
However, parents find it very difficult to change nutritional behaviours during pregnancy (Crozier et al., 2009; Morton et al., 2014). Furthermore, maternal overweight or obesity prior to conception and excessive weight gain during pregnancy are associated with adverse maternal and offspring impacts, including increased vulnerability to obesity and later-life NCDs for the offspring (Patel and Poston, 2016). Thus, while it is important to persevere with interventions during pregnancy, opportunities for change during childhood and adolescence that address behaviours and obesity risk prior to adulthood may be more likely to succeed. This is particularly relevant given that overweight established during childhood and/or adolescence persists into adulthood (Alberga et al., 2012). Additionally, cognitive and psychosocial behaviours established during adolescence (including those associated with nutrition and lifestyle) persist into adulthood (Craigie et al., 2011; Steinberg, 2005). Therefore, this key developmental phase offers an important opportunity to support adolescents as decision-makers engaged in their current and future health and wellbeing.

9.1.2. Is this a realistic demand on schools?
Multiple demands on curriculum and pastoral care time in schools create an understandable reluctance to add programmes addressing societal issues. In identifying the potential of schools to contribute towards primary NCD risk reduction the WHO noted that traditionally school-based health interventions have faced issues of sustainability associated with lack of connection to the core mission of the school (World Health Organization, 2016b). UN agencies have spoken very clearly of establishing multi-sectoral programmes to address NCD risk (World Health Organization, 2013a; United Nations General Assembly, 2011). To be successful, multi-sectoral programmes must value, and address goals from all contributing sectors (Wildridge et al., 2004). Achieving this overcomes the issue of lack of connection to the core mission of the school as interventions that simultaneously support educational and health outcomes can be embedded in core learning programmes (Bay et al., 2016a). The shift in schooling towards future-focused learning centred on the development of capabilities equipping youth to participate as critically engaged citizens opens up this opportunity (Hipkins et al., 2014). The NCD epidemic with its links to multiple biological, social, economic and cultural factors offers good opportunities for contextual future-focused learning within single subject or integrated learning programmes (Bay et al., 2016a). This has been demonstrated within school science programmes in New Zealand (NZ) via the Healthy Start to Life Education for Adolescents Project (HSLEAP). Participating 11-14 year olds developed improved understanding of the Nature of Science (NOS),
communicated scientific evidence about NCD risk across the life-course within their families, and made evidence-based decisions that led to sustained actions associated with improving their nutritional environment (Bay et al., 2012a; Bay, 2015b). HSLEAP is based on a narrative pedagogical model informed by transformational learning theory (Kroth and Cranton, 2014) and designed to develop capabilities associated with scientific and health literacies and key life competencies (Grace and Bay, 2011). Programmes enable adolescents to explore and interpret evidence from science, health and the community, supporting examination of new frames of reference that may be used in decision-making and action taking.

9.1.3.  The Cook Islands: Living with the most challenging NCD statistics in the world.

The Cook Islands is a Small Island Developing State (SIDS) in the Oceania consisting of 15 islands comprising 240 square kilometres of land spread widely within an exclusive economic zone covering 2.2 million square kilometres of ocean. The main island of Rarotonga is 32km in circumference and home to 74% of the resident population of 14,874 (Cook Islands Statistics Office, 2012). The Cook Islands ranks highest in the world for age standardised statistics relating to obesity (50.8%), insufficient physical activity (65%) and diabetes (29.1%) (World Health Organization, 2015b). The measured prevalence levels from which these data are calculated are frighteningly high, Table 9.1.

Table 9.1  Cook Islands adult NCD risk 2004-2015

<table>
<thead>
<tr>
<th>NCD Risk Factor</th>
<th>%Adults aged 25-64 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004 (n=2,629)</td>
</tr>
<tr>
<td>Overweight (BMI≥25.0)/Obesity (BMI≥30.0)</td>
<td>88.5/61.4</td>
</tr>
<tr>
<td>Hypertension (SBP≥140 &amp;/or DBP≥90mmHg or medicated for elevated BP)</td>
<td>33.2</td>
</tr>
<tr>
<td>Elevated blood glucose (≥6.1mmol/L)</td>
<td>23.6</td>
</tr>
<tr>
<td>Elevated blood cholesterol (≥5.0mmol/L)</td>
<td>75.2</td>
</tr>
<tr>
<td>Fruit (F) and vegetable (V) consumption &lt;2F&amp;3V/day</td>
<td>81.8</td>
</tr>
<tr>
<td>Low daily physical activity (&lt;600 MET-minutes/week)</td>
<td>75.3</td>
</tr>
</tbody>
</table>

(Ministry of Health Cook Islands, 2011, 2016)
BMI, Body Mass Index; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; F&V, Fruit and Vegetable, MET, Metabolic Equivalent

Despite achieving significant reductions in the prevalence of insufficient daily activity between 2004 and 2015, levels of overweight/obesity continue to rise. Childhood and adolescent overweight increased 1.5-fold between 2003 and 2015 (Cook Islands Ministry of Health, 2003-2015) and rates of overweight double between adolescence (43%) and early
adulthood (87%) (Ministry of Health Cook Islands, 2016). NCDs account for 74% of all deaths in the Cook Islands, with 36% of these occurring prior to age 60. This loss during the period of greatest social and economic contribution at a rate 1.25-fold higher than the global average for LMICs (World Health Organization, 2016a) is indicative of the enormity of the NCD burden in the Cook Islands. It has been established that primary NCD risk reduction should be a component of the matrix of programmes that comprise the Cook Islands National NCD Strategy (Cook Islands Ministry of Health, 2015).

9.1.4. Educational development in support of health development

The Pacific Science for Health Literacy Project (PSHLP) is a community-based participatory research (CBPR) programme established via collaboration between education and health sectors in the Cook Islands and Tonga, and the University of Auckland’s Liggins Institute. It is examining the potential for education-based interventions to support NCD risk reduction alongside educational development. Initiated by the NZ Ministry of Foreign Affairs and Trade’s New Zealand Aid Programme (NZAid), the invitation to collaborate stemmed from NZAid identifying potential shared interests between the Liggins Institute’s established school-based programme to support primary NCD risk reduction in New Zealand, and educational and health development goals in Pacific SIDS. For the purposes of this paper, we will deal only with the portion of the project set in the Cook Islands.

The Cook Islands has a devolved national curriculum that emphasizes the development of capabilities associated with engaged citizenship. It aims to ensure that through “relevant learning and relevant application of learning…[young people]…develop as individuals and become responsible and informed members of the community.” Across core subjects learning objectives support “the development of knowledge, skills, attitudes, and values to enable people to put their capabilities to best use in all areas of their lives.” (Cook Islands Ministry of Education, 2002) This capability-centric curriculum lends itself to contextual learning, thus offering potential to adapt HSLEAP programmes to support educational development alongside primary NCD risk reduction. Phase one of PSHLP involved the development and testing of culturally appropriate learning resources. This aims to identify whether in the context of the Cook Islands, contextual learning programmes supporting educational goals can enable youth to understand and take positive actions regarding nutritional exposures and NCD risk.
9.2. Design and Methods

9.2.1. Research aim
This study evaluated outcomes related to learning and health behaviours for Year 9 (Y9) and 11 (Y11) Rarotongan students participating in PSHLP programmes during the intervention development phase (2014 - 2015). Evaluation informed the potential for investment in education programmes to contribute to development relating to education and NCD risk reduction. Comparison of the Y9 and Y11 cohorts enabled consideration of the placement of programmes within schooling.

9.2.2. Research design
The study was co-constructed by project leaders in consultation with the three participating school communities, the Cook Islands Ministry of Education (CIMoE) and the Cook Islands Ministry of Health (CIMoH). The design needed to meet objectives presented by participating ministries, schools and the funding agency, and be acceptable to the community of Rarotonga. The agreed plan utilized an individually matched repeated time-series design supporting quantitative and qualitative data collection and recognizing the importance of individual change analysis within community-based interventions (Biglan et al., 2000). CBPR based research is a partnership sharing process. It involves translational action-research that examines an issue with those affected by the issue, for the purpose of education and action to effect change (Wallerstein and Duran, 2010). The partnership begins at the point of research conceptualisation and continues throughout the research process (Rhodes, 2014). Because of the CBPR nature of the study, implementation strategies evolved in each school community over the period of the project as decisions about where the project should develop to best support strategic initiatives within the school were made, Figure 9.1. The study was approved by the Cook Islands Research Committee (Ref. 05/14) and the University of Auckland Human Participants Ethics Committee (Ref. 011207).

Matched survey data was collected at pre-intervention (T0), 6 to 12-weeks post-intervention (T2), and 12-months post-intervention (T4). Examples of student work were collected during the intervention (T1). Interviews and focus groups with students were conducted approximately 6-months post-intervention (T3) and with key stakeholders at T2 and T4. Classroom observations were conducted at key points throughout the study. Measures relating to participating adolescents enabled analysis of engagement in learning
and changes in health and science related knowledge, attitudes, and behaviours (KAB). As well as reporting on cohort-wide trends at each time-point, via analysis of individually matched data we can report aggregated change patterns based on individual differences between time-points. Comparison of T0 data in 2014 and 2015 found the baseline to be stable across this period. Data from the Cook Islands Global School-Based Health Survey (GSHS) (Cook Islands Ministry of Health, 2014) was used to assess the reliability of the food frequency questionnaire at baseline.

The survey instrument examined demographic factors, health attitudes, awareness and knowledge, and food behaviours (available on request). Surveys were self-completed by students in class. Supervising teachers or researchers ensured that students understood the questions. Focus groups used semi-structured questions. Lesson observations occurred during each phase of teaching and included discussion meetings to ensure agreed interpretation of the events observed. Other data sources included planning documentation, and school demographic and assessment data.

9.2.3. Setting

The study was conducted in Y9 and Y11 classes in the three secondary schools on Rarotonga, an island with a population of 11,000 occupying 67 square kilometres of land. The town and the villages are located along the coast. One main road encircles the island and the population is highly mobile. The three pilot schools represent >95% of secondary education students on the island. They range in roll size from 75 to 650. Only the national college offers Year 12-13 classes. Families elect to send their children to any of the three schools. Some households have children at more than one secondary school.

Schools nominated subject areas and classes to be included in the trial (Figure 9.1). All schools used science as the main learning area associated with the project. The variation in approaches reflected current strategic objectives within each school. This heterogeneity in approach is typical of educational settings and must be respected if the needs of students are to be met (Haque, 2015) and research is to reflect the reality of school-based settings. A further level of heterogeneity should be observable between and within classrooms in each school as teachers adapt programmes to suit the diverse needs of students. Differentiated learning resources were provided to enable this.
9.2.4. Intervention tools

The intervention tools consisted of core learning and teaching resources within adaptable learning modules accompanied by professional learning development (PLD) workshops for teachers. Modules were based on the HSLEAP learning and teaching framework supporting context-embedded learning through a narrative pedagogy, Figure 9.1.

The Y9 resource “Me, Myself, My Environment; Nutrition” (Bay and Yaqona, 2016) evolved from one of the HSLEAP-NZ programmes exploring the role of early-life nutrition in later life heart health (Bay and Mora, 2009a). It was adapted and developed to ensure cultural relevance and build on evidence from evaluation of the New Zealand programme. The resultant resources allowed teachers to develop programmes that enabled students to:

- investigate community perceptions regarding health and wellbeing;
- explore who scientists are and how they work locally and internationally;
- examine and interpret NCD risk-monitoring evidence;
- develop understanding of concepts associated with nutrition, circulation, and relationships between organisms and their environment;
- explore the work of DOHaD scientists, including appropriately reimaged data;
- conduct open-ended investigations related to the learning programme;
- and participate in evidence-based decision-making and communication

In 2014 teachers within the national college identified the potential for students to examine the role of globalisation and social change on the nutritional environment over the past 200 years. Learning resources were developed to enable extension of the project into social studies classrooms (Barrett-Watson, In Press).

The Y11 resource “Exploring type 2 diabetes: A socio-scientific issue for my community” (Bay et al., 2016d) was adapted from a New Zealand resource designed to support contextual learning prior to assessment of a national achievement standard in New Zealand (Bay and Mora, 2014). This programme also utilizes the HSLEAP learning and teaching framework. It culminates in an assessment task requiring students to prepare a comprehensive report on an aspect of the type 2 diabetes epidemic in their community. The resources were adapted for the Cook Islands via addition of culturally relevant narratives and data, and contextual adaptation in relation to food sources and the socio-ecological environment. As had occurred in New Zealand, one school identified the potential for the integration of this learning module with learning in English associated with oral presentation skills. Students in this school presented both written and oral reports for assessment purposes.
Pacific Science for Health Literacy Cook Islands Partnership
Liggins Institute | Cook Islands Ministry of Education + Partner Schools | Cook Islands Ministry of Health

Leadership Team
Representing all partner institutions

School A
Years 7-11
Roll approx. 150
Church School

School B
Years 9-13
Roll approx. 650
National College

School C
Years 7-11
Roll approx. 75
Rural Community

CBPR Partnership Formation (6 months)
Development of shared understanding of each partner institution
[purpose, philosophy, community, culture & strategic vision]

Funding Confirmation (10 months)
Development of the Stage 2 funding application
Funding negotiations | Contract negotiations

Planning Phase (6 months)
Ongoing planning & development | Building of initial learning and PLD resources
Consent processes at institutional and lead teacher level

Intervention Development and Trial Phase (2 Years)
Professional Learning and Development across all partner institutions
Communication to parents & the wider community via school newsletters, meetings & media
Consent and Assent Process - teachers, parents, students | Baseline data collection

Review of 2014 trials | Refinement of the learning programs | Year 2 planning

Review of 2015 trials | Refinement of the learning programs | Year 3 planning

Explore the context/socio-scientific issue
Learning experiences support exploration:
- What do I know about the issue?
- How does it impact me, my family, my community, my country, the world?
- Making frames of reference visible:
  - How do I view this issue?
  - How do other people view this issue?
  - What does research tell us about this issue?
  - What would I like to know?
  - What possible actions could be taken in society, my community, my school, my family?

Develop capabilities (knowledge, attitudes, skills and values)
Learning experiences support development of capabilities required to engage in exploration of the context/SSI:
- Knowledge of & about science, health & society:
  - Attitudes towards science, health & society;
  - Competencies (e.g. the ability to interpret, evaluate, explain, consider differing viewpoints, jointly consider values, culture and research in evidence-based decision-making, deal with uncertainty).

Inquire/investigate and make decisions
Learning experiences support students to:
- Take responsibility for inquiry into a specific question;
- Use evidence to make decisions about actions that they, their family, or their community may take in response to the issue;
- At senior levels (ages 15+), consider & propose potential government, regional, global actions relating to the issue.

Communicate
Learning experiences support students to communicate with their family, peers and their community about:
- Learning they have undertaken;
- Actions that they would like to take, have taken, believe could make an impact at a particular level (family, community, society).

Figure 9.1 CBPR partnership development and study flow diagram
9.2.5. Recruitment and Participants

The participating schools were part of the CBPR team, established during the partnership formation phase (Bay and MacIntyre, 2013), Figure 9.2. Consent to participate was obtained from heads of institutions and participating education and health professionals. Research team members in these institutions completed a confirmation of confidentiality process.

A combined professional development workshop held in February 2014 introduced the programme to all school staff. The closure of the schools for this event created community interest and via media coverage supported the introduction of this phase of the programme to parents and the wider community. This supported the relationship building process between the research team and the community. School assemblies and parent-teacher association meetings were used to explain the programme to students and parents. Information inviting participation in the evaluation was sent to the families of students in participating classes and followed up by phone. Television, newspaper, and radio advertisements alongside school newsletters were used to encourage parents to consent to children participating in the evaluation. Parental/legal guardian consent was collected and student assent was collected from all students under the age of 16. Students 16-years and over could consent independently.

Table 9.2 describes the demographic characteristics and response rates for the combined cohort. Seventy-five percent of the intervention cohort (n=492) participated in evaluation, with 66% completing evaluation from pre-intervention to 12-months post-intervention. Analysis by year demonstrates that as the project evolved the participation rates improved from 53% in 2014 to 95% in 2015. During sense-making workshops held to support interpretation of data in late 2014, schools identified value in the data and initiated changes in their approach to encouraging participation in the evaluation process for 2015. This reflects increasing ownership of the project by school communities, an important factor in ensuring sustainability. Analysis of participation by year is available in Appendix 9A.

9.2.6. Data Analysis

Quantitative data was analysed using SPSS. Descriptive statistics generated frequencies that were compared between groups using appropriate parametric and non-parametric tests. Distribution of responses of self-matched ordinal data at T0, T2 and T4 was analysed using the Friedman test followed by post-hoc assessment using the Wilcoxon Signed-Rank test. Matched binomial data were analysed using Cochran’s Q test. Ordinal logistic regression
was used to investigate the impact of gender and age on cohort-wide response patterns. Bonferroni-Holm’s corrections for multiple comparisons were applied (Aickin and Gensler, 1996).

Data for Y9 and Y11 was retrieved from the most recent Cook Islands GSHS data set and compared to key nutritional behaviours in the baseline survey.

Qualitative data was transcribed prior to thematic analysis using a constant comparative approach and inductive coding (Boyatzis, 1998) in line with the relativist ontological and subjective epistemological approach (Levers, 2013).

9.2.7. Limitations

Key limitations associated with the research setting were factored into the design. This is not a fully experimental study as limitations associated with the size and nature of the population precluded the use of control groups. The CIMoH reported that when control trials had been attempted in Rarotonga using village-based groups they had failed due to contamination of the control group within the small, mobile, and close-knit community. The common occurrence of families having children at more than one secondary school along with the integration of young people from different schools and villages within church, service, sporting and social groups would compound this issue. The potential to use schools from outer islands as controls was rejected due to significant differences in context between the outer islands (many with populations <500) and Rarotonga.

Variance in the size and nature of the three schools described in Figure 9.1 adds both value and challenge. Analysis of the different approaches would be extremely valuable, but is limited by the variation in size and composition of the schools.

To examine the potential for learning to impact health, assessment should ideally analyse engagement, capability development, and impacts on behaviours, anthropometric and metabolic factors associated with NCD risk (Bay et al., 2016c). In a CBPR programme it is important that all parties agree to assessment measures, are comfortable that they can be implemented safely, and in the case of school-based projects, that measures will not disrupt learning. The opportunity to measure anthropometric and metabolic factors was considered and accepted with some reservations by schools, but rejected by the funding agency. The concerns for schools related to disruption to learning and the resources required to support adolescents to understand the data. Teachers were somewhat relieved when the funding
agency identified this area of evaluation in a request to reduce the budget. Therefore, we do not have anthropometric or metabolic measures in this study. However, at the end of 2015 (2 years into the intervention) the project teachers, some of whom had questioned the inclusion of health-measures in the original plan, presented a request for inclusion of anthropometric and metabolic measures in the third year of intervention (2016). This proposal included the development of a learning resource to support teachers, students, and parents to understand and use these data. The rationale for this request was associated with increased understanding of the value of this type of evidence, alongside discussion with students. These discussions revealed a desire by students to know more about their own health data after investigating national and global health data. This is not without controversy as some view this type of engagement by adolescents in health-related evidence as dangerous (Fitzpatrick and Tinning, 2014; Nihiser et al., 2009). However, it is important to respond to student and teacher voices. Furthermore, the PSHLP programmes examine the impacts on NCD risk of complex socio-ecological factors within and between generations, contesting commonly held perceptions of individual blame and supporting engagement in health promotion at an intergenerational, socio-ecological level. This means that adolescents are learning that health statistics reflect a complex matrix of factors and are not simply resultant of individual choices. Research is underway to identify the perspectives of students and key stakeholders regarding participation in health assessment as part of the integrated learning programme in 2016.

We are aware that the potential exists for change in data from pre- to post-intervention to reflect regression to the mean (RTM) (Barnett et al., 2005). Ideally, two baseline data collections should have been made with the same group of students prior to each intervention to enable assessment of stability and assess the impact of RTM (Biglan et al., 2000). However, this was not realistic given the limited time available for learning. The use of two parallel baseline surveys across 2014 and 2015 proved stability at cohort level. We considered using one-way analysis of covariance (ANCOVA) to assess the potential for RTM to influence the validity of food behaviour score changes measured at three time points within the study (Barnett et al., 2005; Huijtema, 2011). The distribution of data was not appropriate to meet the assumptions of ANCOVA rendering this an invalid option (Laerd Statistics, 2015).
Table 9.2 | Cohort characteristics (Number and Percentage)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes</td>
<td>Students</td>
</tr>
<tr>
<td>Year 9</td>
<td>11</td>
</tr>
<tr>
<td>Year 11</td>
<td>10</td>
</tr>
<tr>
<td>All</td>
<td>21</td>
</tr>
</tbody>
</table>

School A [Year 7-11]

| Year 9 | 2 | 66 | 21.9 | 50 | 75.8 | 43 | 21.2 | 86.0 | 40 | 23.3 | 80.0 | 39 | 23.9 | 78.0 |
| Year 11 | 2 | 40 | 27.1 | 30 | 75.0 | 24 | 20.2 | 80.0 | 18 | 20.5 | 60.0 | 16 | 19.3 | 53.3 |

School B [Year 9 – 13]

| Year 9 | 8 | 223 | 73.8 | 179 | 80.3 | 151 | 74.4 | 84.4 | 123 | 71.5 | 68.7 | 115 | 70.6 | 64.2 |
| Year 11 | 6 | 130 | 68.4 | 82 | 63.1 | 78 | 65.5 | 95.1 | 60 | 68.2 | 73.2 | 57 | 68.7 | 69.5 |

School C [Year 7 - 11]

| Year 9 | 1 | 13 | 4.3 | 11 | 84.6 | 9 | 4.4 | 81.8 | 9 | 5.2 | 81.8 | 9 | 5.5 | 81.8 |
| Year 11 | 2 | 20 | 10.5 | 19 | 95.0 | 17 | 14.3 | 89.5 | 10 | 11.4 | 52.6 | 10 | 12.0 | 52.6 |

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>243</td>
<td>49.0</td>
</tr>
<tr>
<td>Female</td>
<td>253</td>
<td>51.0</td>
</tr>
<tr>
<td>Male</td>
<td>151</td>
<td>50.0</td>
</tr>
<tr>
<td>Female</td>
<td>151</td>
<td>50.0</td>
</tr>
<tr>
<td>Male</td>
<td>91</td>
<td>47.9</td>
</tr>
<tr>
<td>Female</td>
<td>99</td>
<td>52.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median age at intervention [Inter-quartile range]</th>
<th>Evaluating Participants 2014-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 9</td>
<td>14y2m [13y8m to 15y4m]</td>
</tr>
<tr>
<td>Year 11</td>
<td>30</td>
</tr>
<tr>
<td>Year 9</td>
<td>13y9m [13y5m to 14y1m]</td>
</tr>
<tr>
<td>Year 11</td>
<td>15y6m [15y2m to 15y10m]</td>
</tr>
<tr>
<td>Year 11</td>
<td>143</td>
</tr>
<tr>
<td>Year 11</td>
<td>15</td>
</tr>
<tr>
<td>Year 11</td>
<td>12</td>
</tr>
<tr>
<td>Year 11</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 9</td>
<td>Cook Islands Māori</td>
</tr>
<tr>
<td>Year 9</td>
<td>284</td>
</tr>
<tr>
<td>Year 9</td>
<td>11</td>
</tr>
<tr>
<td>Year 9</td>
<td>5</td>
</tr>
<tr>
<td>Year 11</td>
<td>1</td>
</tr>
<tr>
<td>Year 11</td>
<td>173</td>
</tr>
<tr>
<td>Year 11</td>
<td>4</td>
</tr>
<tr>
<td>Year 11</td>
<td>7</td>
</tr>
<tr>
<td>Year 11</td>
<td>5</td>
</tr>
</tbody>
</table>

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Part IV | Adolescents as Agents of Change
9.3. Results

Planning documentation, lesson observations, student work, and assessment tasks confirmed that all classes followed a programme using the HSLEAP learning and teaching framework. This enabled students to examine and interpret evidence relating to NCD risk and burden in the Cook Islands and evidence of the impact of nutritional environment in early-life on NCD vulnerability in later life.

School leaders identified a high level of engagement in learning from students and interest in the programme from the parent community. They identified that experienced teachers transitioned to context-embedded and integrated learning more easily than newly qualified teachers. Generally, local teachers or teachers with significant personal connection to the Cook Islands and/or NCDs had a stronger connection to the context.

“Growing up in a family a history of diabetes, many of the personal impacts of diabetes were familiar with me. This was my buy-in to the project. My family life gave me ‘real-life’ experiences that I used to engage my students. We also had a staff member with diabetes who was willing to share his experiences - that was of great value.” Teacher

“It [NCD] is so relevant to us because of the high levels of incidence. But, people are not aware. Raising awareness through education across all subject areas is contributing to community needs.” Teacher

9.3.1. Attitudes to Health and Wellbeing

Baseline evidence indicates that Rarotongan adolescents place a high value on being healthy (Table 9.3). Students rated the importance being healthy higher than the importance of what you eat, p<.001, and higher than daily physical activity, p<.001. ‘What you eat’ was rated as significantly less important than daily physical activity, p=.002.

The high value placed on being healthy suggests that education, public health messaging and social norms encourage positive attitudes towards the value of health and wellbeing. The CIMoH have active public health messaging programmes relating to NCD risk factors including physical activity and nutrition. Pre-intervention, awareness of advertising relating to healthy eating (76%) and physical activity (82%) was high. In open-ended questions asking students to identify the benefits of a) healthy eating and b) regular physical
activity, the most common themes emerging related to feeling better about oneself, a) 52%, b) 38%, and being physically fitter or having more energy, a) 28%, b) 53%.

At baseline the odds of Y9 students rating being healthy as mattering a lot was almost twice that of Y11 students, p=.025. The Cook Islands national curriculum has a strong emphasis on a holistic understanding of health and wellbeing (Cook Islands Ministry of Education, 2004). Therefore, it is unlikely that this age-based difference represents a lack of exposure to the importance of health and wellbeing. It may reflect age-based developmental differences. If so, this suggests that programmes supporting exploration of the value of wellbeing are important at all stages of secondary education.

Pre-post comparisons indicate positive changes in attitudes towards the importance of healthy eating and physical activity. However, these rating remained lower than the value placed on being healthy. The difference between ratings for healthy eating and physical activity observed at baseline was non-significant at T2 and T4. This reflects a greater increase in positive attitudes towards nutrition between pre and post-intervention.

### Table 9.3 Attitudes to health and wellbeing, Year 9 and 11 students

<table>
<thead>
<tr>
<th>Question</th>
<th>1. How much does it matter whether or not you are healthy?</th>
<th>2. How much does it matter what you eat?</th>
<th>3. How much does it matter whether or not you are active or exercise every day?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched Responses</td>
<td>n=246</td>
<td>n=246</td>
<td>n=239</td>
</tr>
<tr>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
</tr>
<tr>
<td>% A Lot (AL)</td>
<td>66.94</td>
<td>61.98</td>
<td>69.01</td>
</tr>
<tr>
<td>% Some</td>
<td>28.93</td>
<td>33.88</td>
<td>26.86</td>
</tr>
<tr>
<td>% Not very much</td>
<td>4.13</td>
<td>3.72</td>
<td>3.31</td>
</tr>
<tr>
<td>% Not at all</td>
<td>0.00</td>
<td>0.41</td>
<td>0.83</td>
</tr>
<tr>
<td>Cochran’s Q (AL vs &lt; AL)</td>
<td>$\chi^2(2) = 3.664$</td>
<td>$p = .160$</td>
<td>$\chi^2(2) = 8.122$</td>
</tr>
<tr>
<td>Pairwise comparison</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
</tr>
<tr>
<td>McNemar’s Test Adj p</td>
<td>0.236</td>
<td>1.000</td>
<td>0.195</td>
</tr>
<tr>
<td>OR (Male cf. Female)</td>
<td>1.022</td>
<td>0.819</td>
<td>0.682</td>
</tr>
<tr>
<td>95% CI</td>
<td>0.593-</td>
<td>0.484-</td>
<td>0.393-</td>
</tr>
<tr>
<td>$\chi^2(2)$</td>
<td>1.761</td>
<td>1.387</td>
<td>1.185</td>
</tr>
<tr>
<td>p</td>
<td>0.006</td>
<td>0.055</td>
<td>1.841</td>
</tr>
<tr>
<td>OR (Y9 cf. Y11)</td>
<td>1.899</td>
<td>1.729</td>
<td>1.532</td>
</tr>
<tr>
<td>95% CI</td>
<td>1.086-</td>
<td>1.000-</td>
<td>0.865-</td>
</tr>
<tr>
<td>$\chi^2(2)$</td>
<td>3.322</td>
<td>2.988</td>
<td>2.714</td>
</tr>
<tr>
<td>p</td>
<td>0.025*</td>
<td>0.050*</td>
<td>0.144</td>
</tr>
</tbody>
</table>

Variance in proportion of responses confirming ‘A lot’ vs less than ‘A lot’ was assessed via Related Samples Cochran’s Q test with post-hoc pairwise comparisons where the variance in proportional distribution between T0-T2-T4 was significant. The effect of gender and school year level at intervention on responses was measured using binomial logistic regression. *Bold: significant ($\alpha=0.05$). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; Adj.Sig = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons. OR = Odds Ratio; CI = Confidence Interval.
### Table 9.4  
Awareness of associations between nutrition & health across the life course

<table>
<thead>
<tr>
<th>Statement</th>
<th>Yes (n=245)</th>
<th>Yes (n=239)</th>
<th>No (n=245)</th>
<th>No (n=239)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. The food a woman eats when she is pregnant affects the health of her baby</td>
<td>T0</td>
<td>T2</td>
<td>T4</td>
<td>T0</td>
</tr>
<tr>
<td>% Strongly Agree</td>
<td>48.57</td>
<td>70.20</td>
<td>68.16</td>
<td>20.25</td>
</tr>
<tr>
<td>% Agree</td>
<td>33.88</td>
<td>24.08</td>
<td>26.94</td>
<td>41.32</td>
</tr>
<tr>
<td>% Don't know</td>
<td>13.06</td>
<td>2.04</td>
<td>3.27</td>
<td>23.14</td>
</tr>
<tr>
<td>% Disagree</td>
<td>3.67</td>
<td>3.27</td>
<td>1.22</td>
<td>10.74</td>
</tr>
<tr>
<td>% Strongly Disagree</td>
<td>0.82</td>
<td>n</td>
<td>0.41</td>
<td>4.55</td>
</tr>
<tr>
<td>Friedman test</td>
<td>$\chi^2(2) = 54.633$</td>
<td>$p&lt;.001^*$</td>
<td>$\chi^2(2) = 15.137$</td>
<td>$p=.001^*$</td>
</tr>
<tr>
<td>Pairwise comparison</td>
<td>T0-T2</td>
<td>T0-T4</td>
<td>T2-T4</td>
<td>T0-T2</td>
</tr>
<tr>
<td>Adj p</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
<td>1.00</td>
<td>$&lt;.001^*$</td>
</tr>
<tr>
<td>OR (Male cf. Female)</td>
<td>0.905</td>
<td>0.766</td>
<td>0.74</td>
<td>0.88</td>
</tr>
<tr>
<td>95% CI</td>
<td>0.55-1.4727</td>
<td>0.436-1.343</td>
<td>.0432-1.269</td>
<td>0.555-1.396</td>
</tr>
<tr>
<td>$\chi^2(2)$</td>
<td>0.162</td>
<td>0.867</td>
<td>1.196</td>
<td>0.295</td>
</tr>
<tr>
<td>p</td>
<td>0.687</td>
<td>0.352</td>
<td>0.274</td>
<td>0.587</td>
</tr>
<tr>
<td>OR (Y9 vs Y11)</td>
<td>0.267</td>
<td>0.249</td>
<td>0.596</td>
<td>0.668</td>
</tr>
<tr>
<td>95% CI</td>
<td>0.153-0.464</td>
<td>0.123-0.507</td>
<td>0.331-1.072</td>
<td>0.407-1.098</td>
</tr>
<tr>
<td>$\chi^2(2)$</td>
<td>21.801</td>
<td>14.729</td>
<td>2.982</td>
<td>2.535</td>
</tr>
<tr>
<td>p</td>
<td>$&lt;.001^*$</td>
<td>$&lt;.001^*$</td>
<td>0.084</td>
<td>0.111</td>
</tr>
</tbody>
</table>

*Cont’d…..*
Table 9.4 cont’d  Awareness of associations between nutrition and health across the life course, n = 246

<table>
<thead>
<tr>
<th>Matched Responses</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>% Strongly Agree</strong></td>
<td>61.76</td>
<td>73.11</td>
<td>73.95</td>
<td>43.39</td>
<td>54.55</td>
<td>61.98</td>
<td>17.36</td>
<td>19.01</td>
<td>28.51</td>
</tr>
<tr>
<td><strong>% Agree</strong></td>
<td>27.73</td>
<td>22.69</td>
<td>25.63</td>
<td>39.67</td>
<td>31.82</td>
<td>29.34</td>
<td>31.82</td>
<td>35.95</td>
<td>33.47</td>
</tr>
<tr>
<td><strong>% Don’t know</strong></td>
<td>3.78</td>
<td>2.52</td>
<td>0.42</td>
<td>5.79</td>
<td>4.96</td>
<td>2.48</td>
<td>25.21</td>
<td>24.38</td>
<td>18.18</td>
</tr>
<tr>
<td><strong>% Disagree</strong></td>
<td>5.46</td>
<td>1.68</td>
<td>0.00</td>
<td>9.09</td>
<td>7.85</td>
<td>5.37</td>
<td>22.31</td>
<td>16.53</td>
<td>16.12</td>
</tr>
<tr>
<td><strong>% Strongly Disagree</strong></td>
<td>1.26</td>
<td>0.00</td>
<td>0.00</td>
<td>2.07</td>
<td>0.83</td>
<td>0.83</td>
<td>3.31</td>
<td>4.13</td>
<td>3.72</td>
</tr>
</tbody>
</table>

Friedman test

<table>
<thead>
<tr>
<th><strong>χ^2(2)</strong></th>
<th><strong>p</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>T0-T2</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>T2-T4</td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td></td>
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</table>

Pairwise comparison

<table>
<thead>
<tr>
<th><strong>z</strong></th>
<th><strong>Adj p</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>&lt;.001*</td>
</tr>
</tbody>
</table>

OR (Male cf. Female)

<table>
<thead>
<tr>
<th>95% CI</th>
<th>χ^2(2)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.683-1.072</td>
<td>0.563-0.925</td>
<td>0.6969-1.014</td>
</tr>
<tr>
<td>0.880-1.199</td>
<td>0.698-1.107</td>
<td>0.010*</td>
</tr>
<tr>
<td>0.817-1.026</td>
<td>0.696-1.014</td>
<td>0.823</td>
</tr>
<tr>
<td>0.663</td>
<td>0.373</td>
<td>0.494</td>
</tr>
<tr>
<td>0.419-1.047</td>
<td>0.233-0.598</td>
<td>0.312-0.785</td>
</tr>
<tr>
<td>0.312-0.785</td>
<td>0.078</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>0.571</td>
<td>0.855</td>
<td>0.885</td>
</tr>
<tr>
<td>0.351-0.928</td>
<td>0.539-1.383</td>
<td>0.545-1.437</td>
</tr>
<tr>
<td>0.545-1.437</td>
<td>0.024</td>
<td>0.524</td>
</tr>
<tr>
<td>0.524</td>
<td>0.622</td>
<td></td>
</tr>
</tbody>
</table>

OR (Y9 vs Y11)

<table>
<thead>
<tr>
<th>95% CI</th>
<th>χ^2(2)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.005-1.622</td>
<td>0.527-0.890</td>
<td>0.554-0.860</td>
</tr>
<tr>
<td>0.932-1.296</td>
<td>0.498-0.841</td>
<td>0.351-0.928</td>
</tr>
<tr>
<td>0.877-1.118</td>
<td>0.554-0.860</td>
<td>0.545-1.437</td>
</tr>
<tr>
<td>0.045*</td>
<td>&lt;.001*</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>0.26</td>
<td>0.875</td>
<td></td>
</tr>
<tr>
<td>0.005*</td>
<td>&lt;.001*</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>0.622</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Variance in distribution of matched responses at T0, T2 and T4 was measured using the Friedman test. Post hoc pairwise comparisons were conducted using Wilcoxon Signed-Rank test. The effect of gender and age on responses was assessed using ordinal logistic regression with proportional odds. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; Adj p = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons, OR = Odds Ratio
Chapter 9 | Cook Islands Adolescents as Agents of Change in the Face of the NCD Crisis

Figure 9.2  Awareness of associations between nutrition and health  
T0-T4 Individually matched change, n=246

A. Statement 12:  
*The food a woman eats when she is pregnant affects the health of her baby*

B. Statement 13:  
*The food a woman eats when she is pregnant affects the health of her baby when it is grown up*

C. Statement 14:  
*The food a father eats will affect the health of his children when they are babies*

D. Statement 15:  
*The food a father eats will affect the health of his children when they grow up*

E. Statement 16:  
*It is important for me to eat healthy food now*

F. Statement 17:  
*The food I eat now will affect my health in the future*

E. Statement 18:  
*The food I eat now will affect my health of any children I have in the future*

SD = Strongly Disagree; D = Disagree; DK = Don’t Know;  
A = Agree; SA = Strongly Agree  
T0 = pre-intervention; T4 = 12-months post-intervention

<table>
<thead>
<tr>
<th>Response remains positive</th>
<th>Positive change into or within the positive category</th>
<th>Negative change but remains within positive category</th>
<th>Response remains negative</th>
<th>Positive change but still within negative category</th>
<th>Negative change into or within negative category</th>
</tr>
</thead>
</table>

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9.3.2. 

**Awareness of associations between nutrition and NCD risk**

Knowledge does not necessarily lead to behaviour change (Bruun Jensen, 2000). However, knowledge is necessary, but is not the sole factor required to facilitate behaviour change (Worsley, 2002) and to enable the use of scientific evidence in decision-making (Hodson, 2011). The programme engages students in exploration of evidence that disrupts traditional thinking around NCD risk. We report here on knowledge change regarding evidence of associations between nutritional environment in early-life and adolescence that was, or was not, explored within the programmes. Cohort-level change presented in Table 9.4 is shown at the level of individually matched data in Figure 9.2.

**9.3.2.1. Intergenerational factors**

Pre-intervention Agree/Strongly-Agree (A/SA) responses indicated high levels of awareness of associations between maternal nutrition during pregnancy and the health of the baby. Awareness was significantly lower in Y9 students (39.5%/37.7%) compared to Y11 students (22.9%/69.9%), $p<.001$. Post-intervention both groups demonstrated a significant rise in the proportion of SA responses, retained at 12-months, $p<.001$. No gender-related differences were observed at baseline. Post-intervention the positive shift by Y11 girls (retained at 12-months) was significantly higher than for Y11 boys, $p=.036$.

At baseline, awareness of associations between maternal nutritional exposures during pregnancy and later-life health outcomes for the offspring was very low. Post-intervention through to 12-months, a significant positive change was observed, $p=.001$. This was reflected in most focus group discussions. Differences between the complexity of thinking of Y9 and Y11 students was observed. Y9 students presented simple statements reporting awareness, e.g. Table 9.5, Example 3.1. In contrast, Y11 students tended to discuss whether or not a mother could access a healthy diet, e.g. Table 9.5, Example 3.3. This demonstrates appreciation of the influence of socio-ecological factors on health and wellbeing, a concept explored in greater depth within the Y11 programme.

Emergent evidence of associations between paternal nutritional environmental exposures and later-life vulnerability to overweight/obesity and NCD risk was discussed briefly in teacher PLD, but resources examining these associations were not provided. At baseline, 26% of students responded “don’t know” to statements exploring these associations, with a bell-curve towards agree and disagree. No significant change was observed post-intervention.
9.3.2.2. Personal factors

Pre-intervention most students responded SA to Statement 16, “It is important for me to eat healthy food now.” SA rates were higher for Y9 (67.9%) than Y11 (49.4%), p=.045. No gender-based differences were observed. Post-intervention responses moved significantly towards SA in both age groups, p<.001. The increase for the Y11 cohort was larger, matching the Y9 responses by T4. At 12-months post-intervention, the proportion of Y11 girls selecting SA (84.4%) was higher than boys (64.7%), p=.054.

At baseline, agreement with Statement 17 “The food I eat now will affect my health in the future” was significantly lower than for Statement 16, \( \chi^2(4)=19.603, p=.005 \). Gender- and age-based differences were observed. Y11 females were more likely to respond SA (74.5%) than Y11 males (34.4%), Y9 males (34.9%) and females (36.3%), p=.001. A significant positive shift occurred post-intervention, Y9, p<.001, Y11 p=.007. Y11 girls retained a higher proportion of SA responses at 12-months (80.9%). Although not significant SA rates for Y9 girls (62.3%) increased further than for boys (49.4%), p=.373.

Focus group discussions demonstrated that students were aware of associations between nutritional environments during adolescence and later life health and wellbeing (Table 9.5). Students also discussed challenges associated with the impact of the environment they live in on their potential to improve their vulnerability to health issues in later-life. e.g. Table 9.5, Example 8.1.

Exploration of the concept that nutritional exposures during adolescence may influence the health of future offspring showed gender-based differences at baseline and post-intervention. At baseline, Y11 girls were more likely to respond SA (31.3%) than boys (14.4%), p=.017, whose responses were similar to Y9 girls (13.0%) and boys (14.6%). No significant change in response was observed for boys post-intervention. However, a large positive shift was observed for females (\( \chi^2(2)=3.840, p=.004 \)). Post-hoc analysis demonstrated that this was significant from T0-T2 (p’=.020) and T0-T4 (p’=.002). Final SA/A response rates for Y11 girls (47.9%/31.3%) were higher than those of Y9 girls, (27.3%/36.4%). As the learning resources explored evidence of the associations between maternal nutrition during pregnancy and later-life outcomes for offspring these gender-based differences in response are positive. The difference between Y9 and Y11 girls may reflect differences in developmental maturity.
Table 9.5  Major themes emerging from student focus groups conducted between 3 and 6 months post-intervention, n = number of students;

<table>
<thead>
<tr>
<th>Theme</th>
<th>Frequency</th>
<th>Examples from student focus group discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Valuing health and wellbeing</td>
<td>79%</td>
<td>1. Being healthy is important because you want to live long. It’s also important because you want to start a family. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2. Being healthy is about keeping positive inside. It’s important. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3. Being healthy is important - yes, because if you are not healthy like you don’t actually live a longer life and you could have diseases that can affect you as you get older. If you are healthy, you can participate more in the community and you can be more active. Year 11 Student</td>
</tr>
<tr>
<td>2. Associations between adolescent nutrition and adult health</td>
<td>89%</td>
<td>2.1. It depends on what we’re eating now. Because it doesn’t really happen as we are adults. Mostly it is what we are now, like what we are eating. That will affect your health. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2. People live up to 60. If you want to live longer, you eat healthier at the beginning. Year 9 Student</td>
</tr>
<tr>
<td>3. Awareness of the intergenerational nature of NCD risk</td>
<td>89%</td>
<td>3.1. Children tend to be obese because their mother didn’t have a good diet, or because they do less exercise while they grow up depending on the environment they are in. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2. If a mother has a poor diet it goes the same with the baby, baby also grows big. Even if baby is slim baby will grow big later. So mums need to be able to eat healthy food. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3. Obesity comes from eating too much and not enough activity. Sometimes it’s just you but it’s also about your family - the way they eat and the way they ate when the mum was pregnant with you. If mums could not get a good diet, then that will affect the baby when it is older and they might be at more risk of heart disease. But if the mother could get a good diet then the baby grows up with a lower risk of heart disease and diabetes. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4. We need to eat more healthy food for when we are mums. I really don’t eat too healthily at the moment! I need to eat more veges and less fatty foods. I am good on fruits – papaw, star fruit and bananas. Year 11 Student</td>
</tr>
<tr>
<td>4. Awareness of the impact of the environment on the potential to engage in healthful practices</td>
<td>63%</td>
<td>4.1. We need to drop the prices for fruit and for shoes - you need them if you are going to be active. Like shoes are a thing that are really expensive – probably $175. Because locals these days - if they only have jandals they would not go for a walk because they would get teased. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2. People around us influence the food we eat – our parents and shops. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3. My pa said they ate less when they were younger and all the kids were outside exercising. Our generation are inside watching TV. I am an example – always at home on facebook and movies. Our future will be affected. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.4. My nana - all they had was local food and if they did have corned beef they would have it for Sunday meals which is a big feast. And now she is actually really healthy. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5. I have learnt that we are always communicating with one another with what we eat. Year 9 Student</td>
</tr>
</tbody>
</table>

Cont’d…
<table>
<thead>
<tr>
<th>Theme</th>
<th>Frequency</th>
<th>Examples from student focus group discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. Communication in support of exploration of ideas and change</strong></td>
<td></td>
<td>Cont’d….</td>
</tr>
<tr>
<td></td>
<td>53%</td>
<td>5.1. My family didn’t believe me when I said that we were number one [for obesity] because I think my Dad still believes that Cook Islanders are still all fit. So you have to show them the data. They were surprised because they did not know about this. Back in their time there were no problems with weight. After I explained this to them they too agreed because one of my parents said they saw one of their friends from when they were kids already has diabetes. So we were talking about how it is real and that we all need to change and eat more veggies and do more exercise. We have been talking about that quite a lot in our house and we are eating more vegetables for our dinners. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td>68%</td>
<td>5.2. I talked to my mum and now she is starting to go to ula fitness cos I encouraged her. Sometimes I go with her but most of the time she goes by herself. I am really happy she is starting to be active again and she is also coming home from work a bit earlier so she can go. I think I have made a difference. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3. When I talked to my mum about it she thought that when babies come out real big they are good. But it is actually not good to have really big babies. But people think that is cute. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.4. What I enjoyed is that we were in groups and we got to discuss what we feel instead of putting it on our shoulder and making it like a burden. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.5. We learnt and we can learn how to teach other people or make other people aware of what is going on. Its a cycle - you can talk to your family. Like we were teaching our family and they were surprised because they did not know about it because for like mum and dad back in their day there was not these problems. Year 11 Student</td>
</tr>
<tr>
<td><strong>6. Valuing access to evidence</strong></td>
<td>53%</td>
<td>6.1. It was shocking to see that we are the most obese in the world. Like we never really observed it before and now since we heard this we see it. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td>82%</td>
<td>6.2. I didn’t notice how serious it was until I saw the data. Now we have learnt about why and about things we can do to prevent diabetes, we can make decisions. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.3. Like really glad to see the data - it was really important. If we did not study that topic we would not know about the issue that has been happening in plain sight but we don’t really see it. If we had not seen this data we would not know about how diabetes is affecting our population. Year 11 Student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.4. I enjoyed that we got lots of pamphlets for us to store away and we could read them and go back on them if we ever needed. I took them home to my mum and dad and you could keep them. Year 9 Student</td>
</tr>
<tr>
<td><strong>7. Efforts to make change.</strong></td>
<td>68%</td>
<td>7.1. I have started cutting down on meat and I am eating the right food at the right time, and we changed some of the eating rules in our house. For breakfast my little niece and nephews used to have chocolates and fizzy drinks, and then now ever since I started on the survey I have thought about it and I have actually told my mum there’s fruits, there’s cereal and there’s toast. Before we used to have Nutella chocolate and now we’ve changed it to Vegemite. My mum, she was amazed, she was shocked. Because it’s been years she had been eating junk food and fizzy drink. Now everything in the house is starting to get changed, eating healthy and doing exercise. Year 9 Student</td>
</tr>
<tr>
<td></td>
<td>73%</td>
<td></td>
</tr>
<tr>
<td>Theme</td>
<td>Frequency</td>
<td>Examples from student focus group discussions</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Y9 n=19</td>
<td>Y11 n=29</td>
</tr>
<tr>
<td>7.2.</td>
<td></td>
<td>I ask my mum whether she can buy more salads. She says yes, it’s a really good idea. My little sister doesn’t really understand. My grandma says yes, it is a good idea. And dad is in Australia. Year 9 Student</td>
</tr>
<tr>
<td>7.3.</td>
<td></td>
<td>I am eating more healthily and I have told my family. They still like their food but I will always try and encourage them. I am encouraging my family to have balanced meals. On Sunday I cooked and everyone liked it. Year 9 Student</td>
</tr>
<tr>
<td>7.4.</td>
<td></td>
<td>I have cut down on my eating and I am trying to do exercise - just walking for the time being. Sometimes I walk to school. It takes about 15 minutes. Year 9 Student</td>
</tr>
<tr>
<td>8.</td>
<td>53%</td>
<td>The challenge of making change</td>
</tr>
<tr>
<td>8.1.</td>
<td></td>
<td>Food is a big risk factor for diabetes - what we eat now as well as what our mum could have when we were in the womb with her - that affects the risk for the baby. So it is important for us to eat healthy food now and exercise but that is not easy. Eating is hard because we have learnt to love junk food - so it is hard to get away from something you have learnt - the fast food is hard to change. I tried eating more fruits but I still want to eat the meat and you try not eating the fast food but you want it. You eat the fruit - but the fast food is there and that makes it hard. Year 11 Student</td>
</tr>
<tr>
<td>8.2.</td>
<td></td>
<td>I talked to my grandma - she is trying to go out for walks but my grandpa doesn’t want to and like she does not want to go by herself. I work at a job at Crown Beach in the morning so I can’t go with her and night times I am dancing at Highland Paradise so I can’t go with her then. Year 11 Student</td>
</tr>
<tr>
<td>8.3.</td>
<td></td>
<td>We know we should make change but we need more support to make that happen. Year 9 Student</td>
</tr>
<tr>
<td>9.</td>
<td>0%</td>
<td>Access to fruit and vegetables</td>
</tr>
<tr>
<td>9.1.</td>
<td></td>
<td>My family cannot grow because we live in a hotel*. They [fruit and vegetables] are expensive. Year 11 Student, *Some hotel employees live in on-site accommodation</td>
</tr>
<tr>
<td>9.2.</td>
<td></td>
<td>My parents have to buy veges because we only have a taro patch plantation so we have to buy our veges like maybe five times a week. Year 11 Student</td>
</tr>
<tr>
<td>9.3.</td>
<td></td>
<td>We grow for the family but we also sell to the hotels. It costs a lot of money [to grow] but sometimes we don’t get hotels wanting to buy the vegetables we plant so we just keep it for ourselves. There are a lot of locals to buy from here. They [vegetables] are expensive for the local people to buy but for the hotels it is cheap to buy. Year 11 Student</td>
</tr>
<tr>
<td>9.4.</td>
<td></td>
<td>I get fruit and veges every day because I live on a plantation. Year 11 Student</td>
</tr>
<tr>
<td>9.5.</td>
<td></td>
<td>Nothing actually stops us from eating fruit - it is available, sometimes you don’t even have to pay for it. But we don’t eat it. I think we just get sick of eating the same food every day - there is not much variety - you want a change. I like banana and pawpaw ok [local] but I prefer apples - I just LOVE eating apples [imported]. Year 11 Student</td>
</tr>
<tr>
<td>9.6.</td>
<td></td>
<td>So my aunty bought 4 oranges and that cost $16 – so like $4 each! Imagine what you can buy? How much corned beef [canned] can you buy for $16. That is why people don’t eat fruit and veges – it’s very expensive compared to things like corned beef. If they could swap the prices around people would stop eating the unhealthy foods like corned beef. Year 11 Student</td>
</tr>
</tbody>
</table>
9.3.3.  Food behaviours

Food consumption patterns were measured at two levels: days per week and servings per day. Meal patterns were measured in days per week.

9.3.3.1.  Comparison of baseline data to existing NCD surveys

The potential to compare key consumption patterns with data from the 2010 Cook Islands GSHS was limited by differences in question structure. However, via recoding of data into similar groups we identified consistency in patterns related to consumption of fruit ($\chi^2=2.879$, p=.237), vegetables ($\chi^2=2.151$, p=.341), and fizzy drinks ($\chi^2=5.523$, p=.137). A difference was observed for fast foods/takeaways ($\chi^2=29.418$, p=<.001) reflecting a greater proportion of the PSHLP cohort were consuming these foods less than once a week.

9.3.3.2.  Gender and age-based variation at baseline

For each food or meal practice, students were divided into those presenting low/no-risk behaviours and those presenting behaviours known to contribute towards risk of obesity and NCDs. Very few gender- or age-based differences were identified, Table 9.6. Those observed included Y9 students being more likely to eat vegetables (potentially related to parental influence), and junk foods. Purchasing power influences the potential to consume junk foods. Purchasing food was usual before school (36%), at lunchtime (75%) and after school (27%). Y9 students were more likely to purchase food before school (p=.002). The higher rates of junk food consumption at Y9 may reflect experimentation with increased snack food purchasing power, often associated with the move to secondary school. A comparison with younger students would be valuable.

Fruit and vegetable consumption rates were very low with only 10% of students meeting the WHO recommendation of two servings of fruit and three servings of vegetables daily. This was expected as 85% of the adult population do not meet this standard (Table 9.1). Vegetable consumption was positively associated with growing food in the family (p=.001), an environmental factor reported to be present by 74% of students. The impact of the family living situation on the potential for fruit and vegetable consumption was demonstrated by the differing levels of access described by the four students represented in Table 9.5, Examples 9.1-9.4.
Table 9.6  Gender & age-based variance in participants within the ‘at-risk’ category for key nutritional practices

<table>
<thead>
<tr>
<th>Food Item or Meal Pattern</th>
<th>Self-reported consumption pattern defined as indicating risk</th>
<th>T0 Responses in ‘at risk’ category</th>
<th>Gender (Male or Female)</th>
<th>Odds Male/Odds Female being in the at risk category</th>
<th>Age (Y9 or Y11)</th>
<th>Odds Y9/Odds Y11 being in the at risk category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Fruit</td>
<td>&lt; 5 days per week</td>
<td>143 58.8</td>
<td>0.777 (95% CI 0.465-1.299), $\chi^2(1) = 0.926$, $p=.336$</td>
<td>1.077 (95% CI 0.625-1.857), $\chi^2(1) = 0.072$, $p=.788$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw or Salad Vegetable</td>
<td>&lt; 5 days per week</td>
<td>156 63.9</td>
<td>0.538 (95% CI 0.316-0.918), $\chi^2(1) =5.176$, $p=0.023^*$</td>
<td>0.650 (95% CI 0.365-1.157), $\chi^2(1) =2.143$, $p=.143$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked Green Vegetables</td>
<td>&lt; 5 days per week</td>
<td>141 58.3</td>
<td>0.867 (95% CI 0.514-1.463), $\chi^2(1) =0.286$, $p=.593$</td>
<td>0.416 (95% CI 0.234-0.739), $\chi^2(1) =8.956$, $p=0.003^*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doughnuts</td>
<td>&gt; 1 day per week</td>
<td>83 35.5</td>
<td>1.485 (95% CI 0.861-2.559), $\chi^2(1) =2.022$, $p=.155$</td>
<td>1.707 (95% CI 0.945-3.083), $\chi^2(1) =3.137$, $p=.077$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato Crisps</td>
<td>&gt; 1 day per week</td>
<td>106 44.7</td>
<td>0.913 (95% CI 0.543-1.537), $\chi^2(1) =0.117$, $p=.732$</td>
<td>1.853 (95% CI 1.059-3.241), $\chi^2(1) =4.669$, $p=0.031^*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Chips (Fries)</td>
<td>&gt; 1 day per week</td>
<td>92 39.5</td>
<td>0.962 (95% CI 0.567-1.633), $\chi^2(1) =0.020$, $p=.887$</td>
<td>1.300 (95% CI 0.740-2.285), $\chi^2(1) =0.832$, $p=.362$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat Pies / Sausage Rolls</td>
<td>&gt; 1 day per week</td>
<td>72 30.8</td>
<td>1.172 (95% CI 0.670-2.049), $\chi^2(1) =0.309$, $p=.578$</td>
<td>1.246 (95% CI 0.685-2.268), $\chi^2(1) =0.520$, $p=.471$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular Fizzy/ Soft Drinks</td>
<td>&gt; 1 day per week</td>
<td>137 58.1</td>
<td>0.707 (95% CI 0.419-1.193), $\chi^2(1) =1.687$, $p=.194$</td>
<td>1.261 (95% CI 0.727-2.186), $\chi^2(1) =0.681$, $p=.409$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Drinks</td>
<td>&gt; 1 day per week</td>
<td>104 44.1</td>
<td>0.999 (95% CI 0.587-1.698), $\chi^2(1) =0.000$, $p=.996$</td>
<td>2.833 (95% CI 1.577-5.089), $\chi^2(1) =12.140$, $p&lt;0.001^*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate Milk / Flavoured Milk Drinks</td>
<td>&gt; 1 day per week</td>
<td>137 57.6</td>
<td>1.142 (95% CI 0.680-1.916), $\chi^2(1) =0.252$, $p=.616$</td>
<td>0.916 (95% CI 0.529-1.585), $\chi^2(1) =0.098$, $p=.754$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td>&lt; 5 days per week</td>
<td>109 54.8</td>
<td>0.512 (95% CI 0.465-0.564), $\chi^2(1) =5.328$, $p=0.021^*$</td>
<td>0.778 (95% CI 0.703-0.861), $\chi^2(1) =0.675$, $p=.411$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-fat takeaway foods e.g. Pizza, burgers, deep-fried chicken</td>
<td>&gt; less than once a week</td>
<td>130 53.7</td>
<td>0.694 (95% CI 0.415-1.159), $\chi^2(1) =1.948$, $p=.163$</td>
<td>1.623 (95% CI 0.945-2.786), $\chi^2(1) =3.082$, $p=.079$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The effect of gender and age on the likelihood of participants falling into the ‘at-risk’ category for each food behaviour at T0 was assessed using ordinal logistic regression with proportional odds. *Bold: significant ($\alpha=0.05$). T0 = Pre-intervention; OR = Odds Ratio; CI = Confidence Interval ; Y= School Year Level
### Chapter 9 | Cook Islands Adolescents as Agents of Change in the Face of the NCD Crisis

#### Table 9.7  Pre- to 12-months post-intervention behaviour change in students demonstrating at-risk behaviours pre-intervention

<table>
<thead>
<tr>
<th>Food Item or Meal Pattern</th>
<th>Self-reported consumption pattern defined as indicating risk</th>
<th>T0 Responses in ‘at risk’ category n</th>
<th>%</th>
<th>T0-T2-T4 Change</th>
<th>T2: 12-weeks Post Intervention</th>
<th>Positive change (%)</th>
<th>Negative change (%)</th>
<th>P</th>
<th>T4: 12-months Post Intervention</th>
<th>Odds Ratio Change from T0 to T4</th>
<th>Gender – Male or Female Odds Male/Odds Female</th>
<th>Age – Y9 or Y11 Odds Y9/Odds Y11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Fruit</td>
<td>&lt; 5 days per week</td>
<td>143</td>
<td>58.8</td>
<td>17.035 &lt;.001*</td>
<td>32.9</td>
<td>11.2</td>
<td>&lt;.001*</td>
<td>34.3</td>
<td>14.7</td>
<td>.002*</td>
<td>1.372 (95% CI 0.730-2.579), χ²(1) = 0.964, p = .326</td>
<td>1.122 (95% CI 0.578-2.177), χ²(1) = 0.115, p = .734</td>
</tr>
<tr>
<td>Raw or Salad Vegetable</td>
<td>&lt; 5 days per week</td>
<td>156</td>
<td>63.9</td>
<td>12.635 .002*</td>
<td>34.0</td>
<td>17.9</td>
<td>.001*</td>
<td>36.5</td>
<td>17.9</td>
<td>&lt;.001*</td>
<td>1.018 (95% CI 0.558-1.857), χ²(1) = 0.003, p = .954</td>
<td>2.782 (95% CI 1.478-5.240), χ²(1) = 10.042, p = .002*</td>
</tr>
<tr>
<td>Cooked Green Vegetables</td>
<td>&lt; 5 days per week</td>
<td>141</td>
<td>58.3</td>
<td>18.609 &lt;.001*</td>
<td>38.3</td>
<td>17.7</td>
<td>&lt;.001*</td>
<td>44.0</td>
<td>17.7</td>
<td>&lt;.001*</td>
<td>0.947 (95% CI 0.507-1.766), χ²(1) = 0.030, p = .863</td>
<td>1.092 (95% CI 0.581-2.052), χ²(1) = 0.075, p = .784</td>
</tr>
<tr>
<td>Doughnuts</td>
<td>&gt; 1 day per week</td>
<td>83</td>
<td>35.5</td>
<td>71.515 &lt;.001*</td>
<td>74.7</td>
<td>6.0</td>
<td>&lt;.001*</td>
<td>73.5</td>
<td>6.0</td>
<td>&lt;.001*</td>
<td>2.657 (95% CI 0.977-7.224), χ²(1) = 1.977, p = .056</td>
<td>0.614 (95% CI 0.192-1.963), χ²(1) = 0.674, p = .411</td>
</tr>
<tr>
<td>Potato Crisps</td>
<td>&gt; 1 day per week</td>
<td>106</td>
<td>44.7</td>
<td>68.813 &lt;.001*</td>
<td>60.4</td>
<td>7.5</td>
<td>&lt;.001*</td>
<td>64.2</td>
<td>9.4</td>
<td>&lt;.001*</td>
<td>2.530 (95% CI 1.106-5.787), χ²(1) = 4.830, p = .028*</td>
<td>0.445 (95% CI 0.166-1.192), χ²(1) = 2.593, p = .107</td>
</tr>
<tr>
<td>Hot Chips (Fries)</td>
<td>&gt; 1 day per week</td>
<td>92</td>
<td>39.5</td>
<td>72.008 &lt;.001*</td>
<td>70.7</td>
<td>7.6</td>
<td>&lt;.001*</td>
<td>64.1</td>
<td>4.3</td>
<td>&lt;.001*</td>
<td>1.355 (95% CI 0.572-3.205), χ²(1) = 0.477, p = .490</td>
<td>0.604 (95% CI 0.230-1.586), χ²(1) = 0.048, p = 3.6</td>
</tr>
<tr>
<td>Meat Pies and/or Sausage Rolls</td>
<td>&gt; 1 day per week</td>
<td>72</td>
<td>30.8</td>
<td>60.329 &lt;.001*</td>
<td>66.7</td>
<td>5.6</td>
<td>&lt;.001*</td>
<td>69.4</td>
<td>5.6</td>
<td>&lt;.001*</td>
<td>1.047 (95% CI 0.384-2.852), χ²(1) = 0.008, p = .929</td>
<td>0.631 (95% CI 0.198-2.015), χ²(1) = 0.605, p = .437</td>
</tr>
<tr>
<td>Regular Fizzy/ Soft Drinks</td>
<td>&gt; 1 day per week</td>
<td>137</td>
<td>58.1</td>
<td>44.345 &lt;.001*</td>
<td>50.4</td>
<td>13.9</td>
<td>&lt;.001*</td>
<td>51.1</td>
<td>10.9</td>
<td>&lt;.001*</td>
<td>1.284 (95% CI 0.668-2.466), χ²(1) = 0.562, p = .454</td>
<td>1.298 (95% CI 0.653-2.578), χ²(1) = 0.554, p = .457</td>
</tr>
<tr>
<td>Energy Drinks</td>
<td>&gt; 1 day per week</td>
<td>104</td>
<td>44.1</td>
<td>66.987 &lt;.001*</td>
<td>67.3</td>
<td>5.8</td>
<td>&lt;.001*</td>
<td>65.4</td>
<td>11.5</td>
<td>&lt;.001*</td>
<td>1.994 (95% CI 0.886-4.468), χ²(1) = 2.782, p = .095</td>
<td>1.198 (95% CI 0.467-3.075), χ²(1) = 0.141, p = .707</td>
</tr>
<tr>
<td>Chocolate Milk &amp;/or Flavoured Milk Drinks</td>
<td>&gt; 1 day per week</td>
<td>137</td>
<td>57.6</td>
<td>48.489 &lt;.001*</td>
<td>56.2</td>
<td>11.7</td>
<td>&lt;.001*</td>
<td>56.2</td>
<td>17.5</td>
<td>&lt;.001*</td>
<td>0.879 (95% CI 0.457-1.692), χ²(1) = 0.149, p = .699</td>
<td>0.559 (95% CI 0.277-1.128), χ²(1) = 2.636, p = .104</td>
</tr>
<tr>
<td>Breakfast</td>
<td>&lt; 5 days per week</td>
<td>109</td>
<td>54.8</td>
<td>11.156 .004*</td>
<td>23.9</td>
<td>48.6</td>
<td>&lt;.001*</td>
<td>27.5</td>
<td>47.7</td>
<td>.004*</td>
<td>1.499 (95% CI 1.327-1.693), χ²(1) = 1.216, p = .270</td>
<td>0.714 (95% CI 0.631-2.089), χ²(1) = 0.809, p = .368</td>
</tr>
<tr>
<td>High-fat takeaway foods e.g. Pizza, burgers, deep-fried chicken</td>
<td>&gt; less than once a week</td>
<td>130</td>
<td>53.7</td>
<td>31.916 &lt;.001*</td>
<td>43.1</td>
<td>13.8</td>
<td>&lt;.001*</td>
<td>43.8</td>
<td>10.8</td>
<td>&lt;.001*</td>
<td>0.975 (95% CI 0.503-1.892), χ²(1) = 0.637, p = .941</td>
<td>1.315 (95% CI 0.636-2.720), χ²(1) = 1.001, p = .360</td>
</tr>
</tbody>
</table>

Individual responses were categorized as positive, neutral, or negative. Variance in distribution of matched responses at T0, T2 and T4 was measured using the Friedman test. Post hoc pairwise comparisons were conducted using Wilcoxon Signed-Rank test. The effect of gender and age on responses was assessed using ordinal logistic regression with proportional odds. *Bold: significant (α=0.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; P = Adjusted Significance values and include Bonferroni-Holm’s correction for multiple comparisons, OR = Odds Ratio, CI = Confidence Interval, Y = School Year Level.
9.3.4. Behaviour change

Self-reported nutritional practices were individually matched to assess change. Significant change towards more healthful behaviours was observed in the sub-group reporting risk-promoting practices pre-intervention, Table 9.7. Age and gender had minimal impact on the likelihood of change. Higher proportions of positive changes were observed in consumption patterns of discretionary foods such as doughnuts and crisps, compared to fruit and vegetables.

To assess the potential for general change in food consumption patterns we compared the at-risk and low/no-risk groups, Table 9.8. The odds of students in the low/no-risk groups making negative change towards less healthful behaviours were significantly lower than the odds of at-risk students changing towards more healthful behaviours for discretionary foods such as doughnuts and fizzy drinks. However, for fruit and vegetable consumption change was similar for both groups. Differences in the types of foods in which positive change was observed may reflect issues associated with the power to change, determined by factors described earlier relating to where adolescents make food choices and the foods available in their environment.

Weekly and daily consumption reporting was combined to calculate a weekly serving score. Change in weekly consumption score at T2 and T4 was plotted against baseline consumption scores, examples of which are presented in Figure 9.3. From this we can confirm that the patterns represented in the weekly consumption reporting were reflected in the more detailed reporting, suggesting that for ease in a school setting a ‘days per week’ record may be adequate. The score changes indicated, as in the weekly patterns, that students in the at-risk group were making changes, and that these were far more likely to occur in discretionary foods such as doughnuts, potato chips etc, compared to fruit and vegetables which the older students reported were expensive for families to obtain.
Table 9.8  Comparison of pre- to 12-months post-intervention behaviour change based on level of risk demonstrated pre-intervention (T0), n=246

<table>
<thead>
<tr>
<th>Food or Meal Item</th>
<th>Self-reported consumption pattern defined as indicating risk</th>
<th>T0 Behaviour Category = Risk</th>
<th>T0 Behaviour Category = No/low risk</th>
<th>Odds Ratio T0-Risk compared to T0-No/Low-Risk</th>
<th>Odds of changing towards the opposite category between T0 and T4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Negative change towards greater risk (%)</td>
<td>No change (%)</td>
<td>Positive ..toward no/low risk (%)</td>
<td>Change.. into the no/low risk (%)</td>
</tr>
<tr>
<td>Fresh Fruit</td>
<td>&lt; 5 days per week</td>
<td>143</td>
<td>14.7</td>
<td>51.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Raw or Salad Vegetable</td>
<td>&lt; 5 days per week</td>
<td>156</td>
<td>17.9</td>
<td>45.5</td>
<td>14.1</td>
</tr>
<tr>
<td>Cooked Green Vegetables</td>
<td>&lt; 5 days per week</td>
<td>141</td>
<td>17.7</td>
<td>38.3</td>
<td>20.6</td>
</tr>
<tr>
<td>Doughnuts</td>
<td>&gt; 1 day per week</td>
<td>83</td>
<td>6.0</td>
<td>20.5</td>
<td>24.1</td>
</tr>
<tr>
<td>Potato Crisps</td>
<td>&gt; 1 day per week</td>
<td>106</td>
<td>9.4</td>
<td>26.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Hot Chips (Fries)</td>
<td>&gt; 1 day per week</td>
<td>92</td>
<td>4.3</td>
<td>31.5</td>
<td>15.2</td>
</tr>
<tr>
<td>Meat Pies / Sausage Rolls</td>
<td>&gt; 1 day per week</td>
<td>72</td>
<td>5.6</td>
<td>25.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Regular Fizzy/Soft Drinks</td>
<td>&gt; 1 day per week</td>
<td>137</td>
<td>10.9</td>
<td>38.0</td>
<td>19.7</td>
</tr>
<tr>
<td>Energy Drinks</td>
<td>&gt; 1 day per week</td>
<td>104</td>
<td>11.5</td>
<td>23.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Chocolate Milk / Flavoured Milk Drinks</td>
<td>&gt; 1 day per week</td>
<td>137</td>
<td>17.5</td>
<td>26.3</td>
<td>16.8</td>
</tr>
<tr>
<td>Breakfast</td>
<td>&lt; 5 Days per week</td>
<td>109</td>
<td>27.5</td>
<td>24.8</td>
<td>26.6</td>
</tr>
<tr>
<td>High-fat takeaway foods e.g. Pizza, burgers, deep-fried chicken</td>
<td>&gt; less than once a week</td>
<td>130</td>
<td>10.8</td>
<td>45.4</td>
<td>14.6</td>
</tr>
</tbody>
</table>

Individual responses were categorized as positive, neutral, or negative. The likelihood of participants shifting to the opposite risk level category was assessed using ordinal logistic regression with proportional odds. *Bold: significant (\(\alpha=0.05\)). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number; p’ = Adjusted Significance values and include OR = Odds Ratio, CI = Confidence Interval, Y = School Year Level
Risk Promoting Foods – Example Doughnuts | A negative change in score denotes a reduction in risk
T0 Scores ≥ 3 represent the RISK group, i.e. consuming more than 2 servings of doughnuts weekly pre-intervention

a) Change in doughnut consumption scores T0 to T4
Risk (T0 > 2) n = 82  No Risk (T0 ≤ 2) n = 107
T0 = Pre-intervention, T4 = 12-months post-intervention

Risk Promoting Foods – Example Potato Crisps | A negative change in score denotes a reduction in risk
T0 Scores ≥ 3 represent the RISK group, i.e. consuming more than 2 servings of potato crisps weekly pre-intervention

c) Change in potato crisp consumption scores from T0 to T4
Risk (T0 > 2) n = 86  No Risk (T0 ≤ 2) n = 96
T0 = Pre-intervention, T4 = 12-months post-intervention

d) Change in potato crisp consumption scores at 3-months post-intervention (T2) and 12-months post-intervention (T4)
Risk (T0 > 2) n = 82  No Risk (T0 ≤ 2) n = 107

Health Promoting Foods – Example Fresh Fruit | A positive change in score denotes a reduction in risk
T0 Scores ≥ 14 represent the NO-RISK group, i.e. WHO Fruit guidelines are achieved

e) Change in Fresh Fruit consumption from T0 to T4
Risk (T0 < 14) n = 122  No Risk (T0 ≥ 14) n = 86
T0 = Pre-intervention, T4 = 12-months post-intervention

Health Promoting Foods – Example Fresh Fruit | A positive change in score denotes a reduction in risk
T0 Scores ≥ 14 represent the NO-RISK group, i.e. WHO Fruit guidelines are achieved

f) Change in fresh fruit consumption scores at 3-months post-intervention (T2) and 12-months post-intervention (T4)
Risk (T0 < 14) n = 122  No Risk (T0 ≥ 14) n = 86

Figure 9.3  Food behaviour change pre-intervention to 12-months post-intervention
9.3.5. **Facilitating decision-making, communication and change**

Focus group evidence supports identification of factors that help or hinder change, Table 9.5. These data suggest that access to evidence explored in class was supportive of development of awareness of frames of reference not previously experienced, which in turn supported decision-making, communication, and action, Table 5, Themes 5-6. A high level of awareness of environmental factors contributing to the challenge of translating intentions into behaviour change was evident. Y11 students reflected on both socio-economic and cultural factors relating to fruit and vegetable access, Table 5, Theme 9. This offers some explanation as to why the apparent positive change in junk food consumption was not matched in fruit and vegetable consumption. Other impacts associated with socio-economic factors included the perception that work commitments and access to shoes limited the potential for physical activity.

The need for support from peers, family and social structures in order to achieve change was recognized by students, Table 9.5, Themes 7-8. The opportunity to communicate with others as a means of engaging in development of change intention and translating this into change was valued. Changes described involved small manageable factors associated with every day occurrences. Combined with evidence that students were communicating with family and friends about change, these factors are supportive of the potential for sustainability of change. The value placed on family within Cook Islands culture is a supportive factor that could be explored further via the development of the programme to support greater family-level engagement, particularly in the area of fruit and vegetable consumption.

9.4. **Discussion**

This study examined the potential for context-embedded learning set within a narrative pedagogical model to facilitate empowerment of adolescents as engaged citizens. Such empowerment offers the potential for evidence-based actions to contribute to NCD risk reduction, and therefore development goals associated with the health, social and economic wellbeing. The study was conducted in the Cook Islands, a developing nation with the worst NCD statistics in the world, representative of a cluster of similar developing nations in the Western Pacific region. The challenge for developing nations is significant and urgent (Chand, 2012; Hawley and McGarvey, 2015).
Evaluative research arising out of the need to understand how practice and policy can influence a particular outcome must be pursued with methods that are relevant to the context (Chatterji, 2005). We have outlined the limitations of the pre-post interrupted time series methods in section 9.2.7, and noted reasons why a cluster randomised control trial (CRCT) would not be feasible. However, there is a deeper argument to be examined regarding the purpose of evaluative research in an education setting. RCTs usefully assess the effect of narrowly specifiable processes in controllable environments. Education settings are complex, making such generalisable findings difficult to obtain (Berliner, 2002). Furthermore, it is imperative that in an educational setting the *process* leading to the effect of an intervention in a specific context can be analysed and elucidated (Maxwell, 2004).

Good evidence is available highlighting the value of learning contextualised in SSIs to support development of knowledge, attitudes and skills associated with scientific literacy (Hodson, 2011). However, limited evidence of the potential of such learning to influence actions beyond the classroom exists. Results from this study demonstrate positive changes in attitudes and knowledge relevant to the issue of intergenerational NCD risk. In some cases, this nudged sustained behaviour change. Qualitative evidence identified that students used knowledge gained from the exploration of evidence in decision-making, a key goal of scientific literacy.

Differences were observed in knowledge gains relating to awareness of maternal environmental influences on later life NCD risk (explored by students) compared to paternal environmental influences (made known to teachers but not supported with learning resources for students). These differences indicate that the process of examining and making sense of evidence was associated with change in knowledge leading to actions. These differences are also relevant to the observed age and gender-based variance in programme response. The gender-based differential response to questions examining appreciation of the role of adolescent health in the potential health of future offspring indicates that both males and females were making evidence-based responses, based on the evidence to which they had access. The difference in responses between females in Years 9 and 11 indicates a need to continue exposure to experiences exploring issues such as NCD risk beyond the middle-school years.

Adolescence is a period of significant physical, cognitive, and psychosocial development (Crosby et al., 2009). Within this life stage the individual is gaining greater control over food choices (Birch and Fisher, 1998) and the influence of peers is increasingly overtaking the
influence of family in relation to elective food choices (Salvy et al., 2012; Smith et al., 2016). We observed positive changes in attitudes towards the importance of nutrition and variance in the type of foods associated with behaviour change in participants reporting risk-promoting nutritional behaviours pre-intervention. Nutritional attitudes are associated with eating behaviours in children, adolescents and adults (Hearty et al., 2007) and contribute towards onset of NCD risk during adolescence (Wade et al., 2016). Focus group evidence indicates that exposure of students to alternative perspectives created opportunities for discussion and reflection that supported attitude changes. While attitude change does not necessarily lead to behaviour change, it is a required step. Students described talking about these issues with peers and family, indicating that they were taking their learning into dialogue with those who will influence their nutritional behaviours. Having time and space to reflect on issues with significant others is associated with the likelihood of deeper shifts in values associated with behaviours (Sharpe, 2016).

Adolescent fruit and vegetable consumption patterns were found to be as low as those of adults in the population. Evidence from focus groups demonstrated a high level of awareness of the need to change these statistics, and the difficulties associated with making such changes in the socio-ecological context of Rarotonga. The poor outcomes in fruit and vegetable behaviour change need to be considered in the context of the setting. Addressing these issues will require change in factors at a community level regarding fruit and vegetable accessibility.

While fruit and vegetable consumption is a key concern, so too is the consumption of energy-dense junk foods, correlated strongly to the development of NCD risk factors (Larson, 2017). Significant positive changes in junk food consumption were observed. We propose that this may be associated with the level of self-determination that students had with regard to enacting decisions.

Programme sustainability is a key issue that has been highlighted as problematic in school-based health-promotion (Khambalia et al., 2012). Using a CBPR approach that respected sector-specific goals and recognised learning and pastoral care as the core business of schools has contributed to addressing issues associated with sustainability. The schools made the decision with the Ministries of Education and Health (appropriate for a small population) to undertake the development of the project and have been key decision-makers throughout the process. We observed in the first year of the project teachers identifying and developing opportunities to broaden the scope of the programmes. At the end of the second
year teachers proposed embedding greater depth of health-related analysis of impacts, reflecting their increasing understanding of, and commitment to primary NCD risk reduction as a health goal of value to their community. We are currently collecting and analysing data following the third round of intervention, allowing investigation of the impact of intervention at Years 9 and 11 for the 2014 cohort. Teachers have continued to develop the programmes and are currently planning ongoing evaluation of educational and health impacts. These actions identify that the CBPR approach has promoted opportunities for sustainability. They also reflect that for schools evaluation is a continuous process. The evaluation strategy that is evolving reflects an extended-term mixed-methods design (Chatterji, 2005) that will support ongoing evidence-based development of multi-sectoral efforts to engage education in health, social and economic development in the Cook Islands, and has the potential to contribute evidence that could be contextually applied in other settings.

9.5. Conclusions

The project has placed teachers of Social Studies, Science, and Health and PE in the role of health promoters through their development and use of contextual learning programmes that link directly to the Cook Islands National Curriculum. This study has demonstrated that participation positively influenced attitudes towards nutrition, relevant knowledge of scientific evidence and behaviours associated with discretionary food choices. Further investigation using a range of evaluation designs would enhance understanding of the potential of the programme to contribute towards youth empowerment. Phenomenological case studies at the level of student, teachers and schools would enable deeper understanding of the processes underpinning the observed results.
Chapter 10. School-based DOHaD interventions: Access and sustainability in a developing nation

Preface

Learning is situated, making understanding of context paramount. The data presented in Chapter 9 indicates that the cultural and contextual adaptation of the HSLEAP programmes within the Cook Islands enabled positive educational outcomes that supported students to take actions. This chapter presents a comparative case study examining aspects of HSLEAP programmes in the Cook Islands and New Zealand. Analysis of differences associated with context, resourcing, process and outcomes offer important evidence that can inform future contextual adaptation. This is of value to the ongoing development of HSLEAP in the Cook Islands and New Zealand, as well as in other Pacific contexts.

This paper is currently in preparation for submission to an academic journal. It will inform reporting to NZAid, and will be used to support the development of an advisory package for nations in the Pacific that are currently engaging in discussions with the project team regarding the adaptation of the programme into their settings.

This paper does not cover all aspects of useful comparison. Further case comparisons are planned, including those associated with differences in the contexts of Tonga and the Cook Islands.
10.1. Introduction

The global non-communicable disease (NCD) epidemic is creating extensive social and economic burdens that are disproportionately affecting developing nations (Bloom et al., 2011; World Health Organization, 2011). Addressing this complex socio-scientific issue (SSI) demands a broad matrix of sustainable multi-sectoral strategies that recognise biological and socio-ecological contributors to NCD vulnerability (World Health Organization, 2013a). The field of Developmental Origins of Health and Disease (DOHaD) has demonstrated the potential of life-course approaches to NCD risk reduction (Hanson and Gluckman, 2014). This has highlighted the importance of childhood and adolescence as key life stages offering crucial primary NCD prevention opportunities for young people (Proimos and Klein, 2012; Sawyer et al., 2012) and their future offspring (Hanson, 2016). The United Nations (UN) and World Health Organization (WHO) have identified schools as one setting for primary NCD risk prevention in children and adolescents, and the Commission on Ending Childhood Obesity (ECHO) examined this in depth (World Health Organization, 2013a, 2016b; United Nations General Assembly, 2011). While the potential for schools as a setting for health promotion is promising (Greenberg et al., 2003; Kriemler et al., 2011), issues of sustainability, connectedness to the core mission of schools, and heterogeneity of impact have been raised (Brown and Summerbell, 2009; Keshavarz Mohammadi et al., 2010; Kambalia et al., 2012; Waters et al., 2011). The ECHO report highlights the importance of ensuring that school-based interventions link to the core mission of schools, are educationally rigorous, integrate into main stream curricula, and connect with NCD risk reduction efforts in the broader community (World Health Organization, 2016b).

The Liggins Institute is a DOHaD/life-course research centre at the University of Auckland, New Zealand (NZ), with strong collaborative ties to the University of Southampton, a DOHaD research centre in the United Kingdom. Since 2006, the Institute’s LENScience programme has engaged in partnerships with schools to develop learning programmes linked to core school curricula, that empower adolescents to explore and use key DOHaD evidence in everyday decisions affecting their current and future NCD risk (Bay et al., 2016a; Bay et al., 2012b; Bay et al., 2012c). Educational goals supported by the programmes are associated with scientific and health literacies, key life competencies, and critically engaged citizenship (Bay et al., 2016a). Known as the Healthy Start to Life Education for Adolescents Project (HSLEAP), the programmes consist of adaptable learning resources.
that enable teachers to facilitate context-embedded inquiry learning examining aspects of the NCD epidemic as a SSI of relevance to students (Bay and Mora, 2009a; Bay, 2010; Bay and Mora, 2009b; Bay and Mora, 2014; Bay et al., 2012c; Bay JL, 2009). Key partner schools in Auckland co-led the development of the programmes and engaged in evaluative research. A wider group of schools throughout New Zealand have accessed and used the resultant resources, and the University of Southampton has adapted the concept into a contextually appropriate programme in the United Kingdom (Bagust L, 2014; Grace et al., 2012). When adapted by schools to fit within their local context, HSLEAP programmes support positive educational and health outcomes. Evaluative evidence shows that participating adolescents have developed understanding of life-course perspectives of NCD risk reduction, (Grace et al., 2012) and applied this in everyday decision-making (Bay et al., 2012a; Bay, 2015b). This creates the potential for adolescents to contribute towards community-wide reduction in long-term NCD risk.

Both the Liggins and Southampton initially relied on schools accessing Face-to-Face learning experiences within their respective Universities as part of the wider programme taught within schools (Bay et al., 2012c; Grace and Bay, 2011; Liggins Institute, 2016a). These university-based programmes facilitated the introduction of DOHaD science to adolescents, and provided opportunities for engagement with scientists. While this created strong and enduring connections between the DOHaD research centres and schools, (Bay et al., 2012b) and offered important opportunities for educational development, (France and Bay, 2010; Woods-Townsend et al., 2016) it placed limitations on programme access.

Since 2012, we have engaged in a partnership with the Cook Islands Ministries of Education and Health to develop culturally adapted HSLEAP programmes, and examine their potential to support adolescents in this setting to access curriculum-linked learning opportunities examine the NCD/DOHaD context. The Cook Islands is a Small Island Developing State (SIDS) within Oceania. Typical of SIDS, the Cook Islands is geographically isolated and has a small population spread across 15 islands in the Pacific Ocean within a 2.2 million square kilometre exclusive economic zone. Resultant of colonisation and globalisation the Cook Islands has experienced rapid nutritional transition. It carries one of the largest NCD burdens of any nation in the world, ranking highest globally for age-standardised prevalence of obesity (50.8%), insufficient physical activity (65%) and diabetes (29.1%) (World Health Organization, 2015b). WHO NCD surveillance data shows measured adult obesity/overweight at 91.1%.72.2% (Ministry of Health Cook
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While the SIDS of Oceania have small populations, their NCD status is worse than any other region globally (Finucane et al., 2011; World Health Organization, 2015b) and the need for action is urgent (Hawley and McGarvey, 2015). Furthermore, the impacts of human-induced climate change, driven by actions within large dominant economies, are creating an even more challenging future that will increase the NCD vulnerability of SIDS globally (Friel et al., 2011; Kjellstrom et al., 2010).

The purpose of this comparative case study was to examine the changes that were made to enable cultural and contextual adaptation of HSLEAP to facilitate engagement of adolescents from the Cook Islands in learning examining the NCD epidemic from a DOHaD / life-course perspective. The research question investigated whether a contextually adapted DOHaD exploration programme, without the support of a university-based learning experience, could enable adolescents to develop understanding of life-course approaches to NCD risk and its reduction so that they could apply this understanding in everyday decision-making?

10.2. Methods

This research applies a theory-centred comparative case study approach using cross-case and within-case empirical inquiry to evaluate process and outcomes (Rohlfing, 2012). The cases selected were HSLEAP programmes involving middle-school students in New Zealand and the Cook Islands. The study draws on evidence from HSLEAP evaluative research, approved by the University of Auckland Human Participants Ethics Committee (Ref. 011207 and 209/426) and the Cook Islands Research Committee (Ref. 05/14).

The proposition (Yin, 2014) under consideration is that adolescent education programmes that are embedded within core school curricula and which explore aspects of the NCD epidemic from a DOHaD/life course perspective can enable youth to engage with and apply DOHaD evidence in everyday decision-making. This proposition is underpinned by a theoretical framework that integrates concepts and evidence from education, health and science (Bay et al., 2016a; Bay et al., 2016c) to contribute towards addressing a SSI for which intervention (in this case a specifically designed learning experience) during adolescence offers significant potential benefit (Hanson, 2016). Analysis of the application of these theoretical perspectives within and between the cases was used to identify whether the HSLEAP model could be contextually adapted to be effective in the Cook Islands and therefore elsewhere subsequently.
Process differences were analysed via examination of learning resources, triangulated with teaching records to confirm enacted rather than intended processes. Impacts on student knowledge and attitudes were analysed within and across the cases using quantitative data collected at pre-intervention (T0), 3-months post-intervention (T2) and 12-months post-intervention (T4). This focused on examining the role of capabilities (knowledge, skills, attitudes, and values) associated with scientific literacy in supporting students to examine, interpret, and use evidence explored within the programmes in everyday decision-making.

As a small-n research study this work does not propose to develop generalizable theory. However, as a case-study engaging in analysis of causal effects and mechanisms within a bounded case where the complexity of context is acknowledged, it is possible to assess potential applicability and transferability to other contexts (Punch, 2009; Rohlfing, 2012).

10.2.1. The case study unit of analysis
This study compares two cases, encompassing adolescent DOHaD education programmes in New Zealand and the Cook Islands. This enables comparison of contexts with strong political, cultural and education system similarities, but significant economic and health differences. The sections that follow define the unit of analysis, describing each case as a bounded empirical phenomenon (Rohlfing, 2012).

10.2.1.1. Programme structure
Key to the philosophy of HSLEAP is the requirement for programmes to be contextually adapted to meet the differing needs of students (Bay et al., 2016c). Therefore, it is not appropriate to provide a rigid programme structure. However, it is possible to describe and evaluate overarching structure and resourcing from which teachers create class-specific programmes.

In both programmes the overarching objective was to support capability development associated with empowering youth to participate as critically engaged citizens, using evidence-based health-promoting actions to facilitate reduction in NCD risk for themselves, their potential future offspring, and their communities (Bay et al., 2016a). Both were based on the HSLEAP learning and teaching framework (Bay and Mora, 2014) involving exploration of the SSI, development of capabilities, inquiry, and action-taking. This enables application of our Science for Health Literacy pedagogical model (Grace and Bay, 2011), underpinned by concepts of collaborative narrative (Lauritzen and Jaeger, 1997)
and transformational learning theory (Taylor and Snyder, 2012). Methods used to support students to engage with and explore relevant scientific evidence differed between the cases with regard to:

a) opportunities to engage in dialogue with scientists
b) facilitation of narratives introducing DOHaD science and NCD risk and incidence data.

10.2.1.2. Societal context

New Zealand is a developed nation in Oceania with close ties to the Cook Islands. From 1901 to 1965 the Cook Islands was a colony of New Zealand, but since 1965 has been self-governing in free association with New Zealand. This means that the Cook Islands government controls all internal affairs but that Cook Islanders are New Zealand citizens and can freely live and work in New Zealand. More than 60,000 Cook Islands Māori live in New Zealand (Statistics New Zealand, 2014). Strong cultural and language similarities exist between New Zealand and Cook Islands Māori. Whalers, traders and missionaries migrated to the Cook Islands approximately 200 years ago. The introduction of an airport in 1974 led to the development of tourism, now the most significant industry. Collectively colonisation and globalisation have led to rapid nutritional transition, resulting in the Cook Islands ranking very highly in global obesity and NCD statistics (World Health Organization, 2015b). Table 10.1 provides a cross-case comparison of key social, economic and health indicators.
### Table 10.1 Social, economic and health indicator comparisons: New Zealand and the Cook Islands

<table>
<thead>
<tr>
<th>Political and Economic Indicators</th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political System</td>
<td>Constitutional monarchy</td>
<td>Self-governing in free association with NZ</td>
</tr>
<tr>
<td>Population</td>
<td>4.76 million (2016)</td>
<td>15.0 thousand (2011)</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>80.6 years</td>
<td>74.7 years</td>
</tr>
<tr>
<td>Median Age</td>
<td>37.0 years</td>
<td>32.0 years</td>
</tr>
<tr>
<td>Population density</td>
<td>16.0 persons per km²</td>
<td>46.2 persons per km²</td>
</tr>
<tr>
<td>Economic Status</td>
<td>High Income</td>
<td>Upper middle income</td>
</tr>
<tr>
<td>GDP per capita (NZD)</td>
<td>NZD 52,720 (2014)</td>
<td>NZD 18,085 (2014)</td>
</tr>
<tr>
<td>Grants in Aid</td>
<td>n/a</td>
<td>NZD 40 million (2016)</td>
</tr>
<tr>
<td>Per student spending on pre-tertiary education</td>
<td>USD 8,987 (2013)</td>
<td>USD 2,691 (2012)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adult Health Indicators (2015/16)</th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight / Obese</td>
<td>67% / 32%</td>
<td>91.1% / 72.2%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>16.6%</td>
<td>32.9%</td>
</tr>
<tr>
<td>Diabetes (excluding during pregnancy)</td>
<td>6.5%</td>
<td>26.8%</td>
</tr>
<tr>
<td>Elevated blood cholesterol</td>
<td>11.5%</td>
<td>50.9%</td>
</tr>
<tr>
<td>Meets 3+ Vegetable and 2+ fruit servings daily</td>
<td>40.1%</td>
<td>15.2%</td>
</tr>
<tr>
<td>Low daily physical activity</td>
<td>15.4%</td>
<td>33.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child Health Indicators (Age 10-14)</th>
<th>New Zealand (2015/16)</th>
<th>Cook Islands 92010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight / Obese</td>
<td>36.1% / 12.0%</td>
<td>60.3% / 26.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child Health Indicators</th>
<th>NZ Age 10 – 14 Years (2015/16)</th>
<th>Cook Islands Age 13-14 Years (2014/15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast eaten less than 5 days per week</td>
<td>16.5%</td>
<td>54.8%</td>
</tr>
<tr>
<td>Fizzy Drinks consumed at least once per week</td>
<td>64.6%</td>
<td>46.7%</td>
</tr>
<tr>
<td>Meets 2 servings of fruit daily</td>
<td>66.9%</td>
<td>35.5%</td>
</tr>
<tr>
<td>Fast Foods at least once per week</td>
<td>72.1%</td>
<td>55.1%</td>
</tr>
</tbody>
</table>

Data sources: CI Ministry of Health; CI Ministry of Education; OECD; NZ Health Survey, 2015/16; CI STEPS Survey 2015; CI Global School Based Health Survey, 2010; Pacific Science for Health Literacy CI baseline health survey 2014/15; Statistics NZ; CI Ministry for Finance and Economic Management
10.2.1.3. Education context

The Cook Islands and New Zealand education systems have strong parallels in terms of philosophy, curriculum structure, and assessment (Table 10.2). A significant proportion of teachers in the Cook Islands have trained and/or taught in New Zealand. Science was the predominant learning area within the HSLEAP programmes in all participating schools. Achievement objectives from the science curriculum that are supported by the programmes in both countries are associated with development of understanding of the nature of science (NOS) and the role of science in society, as well as knowledge and understanding associated with life-processes and the interaction of living organisms and their environment (Appendix 10A).

Achievement objectives in both curricula are defined by Curriculum/Achievement Levels. These associate with school Year Levels variably according to the needs of the learner (Cook Islands Ministry of Education, 2002; Ministry of Education, 2007). This recognises that adolescents move through stages of development that are associated with, but not defined by chronological age. Curriculum levels assist teachers to identify achievement progress and provide appropriate learning opportunities for students. In any class, students will be working towards attainment at a range of achievement levels. The programmes under consideration support achievement objectives at Levels 4-5 of the New Zealand and Cook Islands curricula, crossing Years 7 - 10. Thus, comparison of programmes undertaken with Year 7-10 classes in New Zealand and Year 9 classes in the Cook Islands is valid.

Similarities in curriculum structure and achievement objectives in each country, alongside education system parallels enable the study to identify education systems and curriculum objectives as common to both cases.
Table 10.2 Comparative characteristics of New Zealand and the CI Education Systems

<table>
<thead>
<tr>
<th></th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum school leaving age</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Values</td>
<td>Excellence, Innovation, inquiry &amp; curiosity, Diversity, Equity, Community &amp; participation, Ecological sustainability, Integrity, Respect</td>
<td>Respect, Akangateitei, Honesty Tuatua tika, Integrity Tiratiratu, Care &amp; compassion Takinga meitaki, Aroa, Tukuanga tika tau, Tolerance Akakoromakii, Love, Inangaro, Charity, Ngakau oronga &amp; fulfilment of apai tuanga</td>
</tr>
<tr>
<td>Key Life Competencies</td>
<td>Thinking, Using language, symbols and texts, Managing self, Relating to others, Participating and contributing</td>
<td>The Essential Skills, Communication skills, Numeracy skills, Artistic &amp; Creative skills, Self-management, work and study skills, Physical skills, Social and cooperative skills, Information skills, Problem-solving skills</td>
</tr>
<tr>
<td>National Assessment Qualifications Awards</td>
<td>New Zealand Qualifications Authority, National Certificate of Educational Achievement Levels 1–3, New Zealand Scholarship</td>
<td>New Zealand Qualifications Authority, National Certificate of Educational Achievement Levels 1–3, New Zealand Scholarship</td>
</tr>
</tbody>
</table>

10.2.1.4. Participants

The evaluative studies from which this research draws evidence were undertaken in ten schools in Auckland, New Zealand between 2010 and 2013, and three schools in Rarotonga, Cook Islands, between 2014 and 2015 (Chapters 8 and 9). Table 10.3 provides a summary of participants by case. Learning resources and programme specific professional learning and development (PLD) was provided to participating teachers. Lead teachers provided further PLD within their schools. Available data included:

- student surveys at pre-intervention (T0), 3-months (T2) and 12-months (T4) post-intervention
- Student interviews or focus groups at approximately 6-months post-intervention
- lesson observations and student work
- teacher focus groups and planning documentation
Table 10.3 Comparative characteristics of New Zealand and the Cook Islands Programme Evaluation Participants (Number and Percentage of Total)

<table>
<thead>
<tr>
<th></th>
<th>Participating Students New Zealand</th>
<th>Participating Students Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention Participation</td>
<td>Data collected from 10 schools between 2010 and 2013</td>
</tr>
<tr>
<td></td>
<td>Baseline Data T0</td>
<td>Matched Data T0 – T2</td>
</tr>
<tr>
<td>Total</td>
<td>844</td>
<td>349</td>
</tr>
<tr>
<td>Year Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 7-8</td>
<td>227</td>
<td>140</td>
</tr>
<tr>
<td>Year 9-10</td>
<td>617</td>
<td>209</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>290</td>
<td>123</td>
</tr>
<tr>
<td>Female</td>
<td>554</td>
<td>226</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>NZ Māori</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Pacific</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Indian</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>NZ European</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>36</td>
</tr>
</tbody>
</table>

*CI Schools do not all differentiate in their recording of ethnicity of students from New Zealand. This determined the level of reporting possible.
10.3. Findings

10.3.1. Opportunities to meet scientists

Science is a social activity that is influenced by the culture in which it is embedded, (Lederman et al., 2013; Moss, 2001) and has a culture of its own. Opportunities to explore this culture support adolescents to identify with science as a perspective of relevance when examining SSIs. These opportunities were enabled by narratives such as those found in “My First 1000 Days”, (Appendix 4A), and by dialogue-based experiences with members of science communities.

10.3.1.1. Case-specific differences in approach

In facilitating dialogue-based encounters between adolescents and scientists we have identified that providing students with scaffolding to facilitate the preparation of questions prior to encounter supports the development of dialogue (Bay JL et al., 2009; France and Bay, 2010). In both cases learning episodes enabled students to engage in face-to-face dialogue with scientists and included prior development of questions for use during these encounters. These episodes supported students to describe and test their perceptions of who scientists are, what they do, and the types of skills and personality traits might be supportive of scientific research. To enable this in the Cook Islands, we needed to consider how the New Zealand programme, supported by a scientifically based faculty within a university, might be adapted for a setting without access to such a resource. Key differences in the learning episodes are outlined in Table 10.4. Scientists that participated in the Cook Islands came from local environmental and health agencies. The intention of the programme adaptation was to only change the place in which students met with scientists or researchers. However, limitations associated with researcher/scientist availability on-island precluded this. In the larger school, four scientists met with 120 students within a year-level assembly. In the smaller schools, one scientist/researcher met with each class. This limited the opportunity for small group interaction, creating differences in experience associated with place and group size.
## Table 10.4 Comparison of learning experiences associated with meeting scientists, New Zealand & Cook Islands

**Learning Objective:** To explore who scientists are, what they do, and identify skills and personality characteristics that are supportive of scientific research.

<table>
<thead>
<tr>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ: Meet-a-Scientist student handouts and teacher notes (<a href="#">Appendix 10B</a>)</td>
</tr>
<tr>
<td>CI: Think Like A Scientist, Student Learning Resource 10 (<a href="#">Appendix 10C</a>)</td>
</tr>
</tbody>
</table>

### A. Preparation

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>School classroom followed up at the Liggins Institute</td>
</tr>
<tr>
<td>Facilitator</td>
<td>School science teacher followed up by Liggins Institute teacher</td>
</tr>
<tr>
<td>Placement</td>
<td>Prior to visit</td>
</tr>
</tbody>
</table>

#### Task 1. Defining current perceptions of scientists (Common to both New Zealand and Cook Islands)

Students were told they would be meeting with a small group of scientists, and given names and a simple description of field of work for each scientist.

**Activity**

- a) **Small group activity:** Identifying perceptions of the skills and personality traits or characteristics required to undertake research
- b) **Whole-class activity:** Collate and discuss ideas; potentially amend personal record of ideas.

#### Task 2. Developing questions to test accuracy of current perceptions

- c) **Small group activity:** Selecting skills or characteristics to test; designing questions to examine predictions.

### B. Meeting

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Liggins Institute</td>
</tr>
<tr>
<td>Facilitator</td>
<td>Liggins Institute teacher supported by school science teacher</td>
</tr>
<tr>
<td>Placement</td>
<td>Following a 3-hour learning episode including narrative based exploration of the work of DOHaD scientists</td>
</tr>
</tbody>
</table>

- **Activity**
  - Three scientists joined the class which is divided into 3 groups. Each group engaged with two scientists via two 15-minute meetings involving:
    - 5 minutes for the scientist to tell students about what their work involves, and their journey into science.
    - 10 minutes for discussion, enabling students to question scientists and therefore test their predictions from Task 2.
  - Scientist(s) (1-4 variable by school) were introduced to the whole group (20 – 120 students variable by school).
  - Each scientist was given 5 minutes to tell the students about what they do and their journey into science.
  - Teachers facilitated a 20 minute question and answer session where students asked questions of the scientists to test their predictions from Task 2.

### C. Reflections

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Liggins Institute</td>
</tr>
<tr>
<td>Facilitator</td>
<td>Liggins teacher</td>
</tr>
<tr>
<td>Activity</td>
<td>Following the meetings students return to the collective brainstorm captured at the beginning of the day. The teacher leads a 15-minute discussion to confirm, remove, or add ideas to the board.</td>
</tr>
</tbody>
</table>
10.3.1.2. **Comparison of responses**

Pre- and post-intervention responses to the question “*Have you ever met a scientist?*” are summarised in Figure 10.1. Within case assessment using Cochran’s Q test (Cochran, 1950) identified that the percentage of students reporting having met a scientist was different across the three time points in New Zealand, $\chi^2(2)=98.255$, $p<.001$, and the Cook Islands $\chi^2(2)=61.255$, $p<.001$. Pairwise comparisons using Dunn’s (1964) procedure with Bonferroni correction for multiple comparisons determined that in both cases significant increases in students identifying with having met a scientist were found to occur between T0 and both T2 and T4, $p'<.001$. No significant change occurred between T2 and T4.

Comparison between the cases identified that the percentage increase in positive responses at T2 was 299% in the Cook Islands and 105% in New Zealand. At each data collection point a significantly higher proportion of students identified as having met a scientist in New Zealand compared to the Cook Islands. T0 $\chi^2(1)=22.838$, $p<.001$; T2 $\chi^2(1)=16.774$, $p<.001$; T4 $\chi^2(1)=17.584$, $p<.001$.

Students responding ‘yes’ to having met a scientist were asked to name the scientist or the type of work they did. This provided an indicator of whether a detail central to all encounters was retained. Significant differences emerged between the cases indicating that the Cook Islands experience using class or year-level encounters was not as effective in enabling students to engage with the experience of meeting with scientists.

Focus group evidence from both cases indicates that the experience of engaging with scientists contributed towards changing perceptions of who scientists were.

> “We thought scientists were people in white coats and glasses but they came in and they are just ordinary people. And, all of a sudden they are just the same person I’ve always walked past!”
> Year 9, Cook Islands

> “Yeah I talked to my family about all of this – about meeting the scientists – I told them that the scientists were pretty cool but they were different – not what you would expect.”
> Year 9, New Zealand

A further common theme emerged regarding the perception that scientists play a ‘helping’ role within the community.

> “Maybe we might want to grow up and be like them [the scientists] and help the community.”
> Year 9, Cook Islands
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“We talked about it with our friends – like the scientists are cool and they said if you stay in school and work hard you have cool jobs like theirs – and their jobs are important cos they are helping people.”

Year 9, New Zealand

<table>
<thead>
<tr>
<th>Question 1A. Have you ever met a scientist?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a &lt; b; p &lt; .001, a &lt; c, p &lt; .001; b &lt; d, p &lt; .001; c &lt; d, p &lt; .001</td>
</tr>
</tbody>
</table>

**Figure 10.1** Within and between-case comparisons regarding the experience of meeting scientists
Lower case letters indicate the outcome of chi-squared analysis conducted to assess differences between cases. Groups that do not share the same letter are significantly different from each other (p<.001).

<table>
<thead>
<tr>
<th>Question 1B. If your answer was yes, can you tell me who it was or what kind of scientist they were?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a &lt; b; p &lt; .001</td>
</tr>
</tbody>
</table>

10.3.2. Exploring and interpreting scientific evidence through narrative

HSLEAP utilises collaborative narratives (Lauritzen and Jaeger, 1997) to enable learners to engage with NCD evidence from science, health and their personal and local contexts. These narratives expose students to science and health research as a human endeavour that has relevance to their communities. Rather than presenting evidence as facts the stories engage students in exploring the process of scientific inquiry and examining and interpreting evidence.
**Table 10.5** Comparison of learning experiences exploring a DOHaD narrative, New Zealand and Cook Islands

**Learning Objective:** Develop understanding of evidence associating early-life nutritional exposures with later-life NCD risk in order to be able to apply this understanding in everyday decision-making.

<table>
<thead>
<tr>
<th>Resources</th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student</strong></td>
<td>Liggins Institute Face-To Face Programme (Liggins Institute, 2016a)</td>
<td>My First 1000 Days (Bay, 2016a)</td>
</tr>
<tr>
<td></td>
<td>Me, Myself, My Environment, Nutrition, Student Resource (Bay, 2010)</td>
<td>Ko au e toku aorangi: Kai no te Oranga Meitaki Me, Myself, My Environment, Nutrition, Cook Islands Ed (Bay and Yaqona, 2016)</td>
</tr>
<tr>
<td></td>
<td>Population Studies: A Resource for Science Classes (Bay and Mora, 2009b)</td>
<td>****</td>
</tr>
<tr>
<td><strong>Teacher</strong></td>
<td>LENSscience PLD Workshops, Liggins Institute</td>
<td>PSHLP PLD Workshops, Liggins Institute; CI MoH; CI MoE</td>
</tr>
<tr>
<td></td>
<td>Liggins Institute Face-To Face Programme* (Liggins Institute, 2016a)</td>
<td>Me, Myself, My Environment: Kai no te Oranga Meitaki, Differentiated Students Learning Resources (Bay and Yaqona, 2016)</td>
</tr>
<tr>
<td></td>
<td>Me, Myself, My Environment Growing Up, Teacher Resource (Bay and Mora, 2009a)</td>
<td>Exploring Type 2 Diabetes: A Socio-scientific Issue for My Community, Teacher Resource Cook Islands (Bay et al., 2016d)</td>
</tr>
<tr>
<td></td>
<td>Student</td>
<td>Nutrition in the Womb (Barker, 2008)</td>
</tr>
<tr>
<td></td>
<td>Related story</td>
<td>Mismatch: Why our world no longer fits our bodies (Gluckman and Hanson, 2006)</td>
</tr>
<tr>
<td></td>
<td>Related story</td>
<td>Understanding Gene Expression (Available online) (Bay JL, 2009)**</td>
</tr>
</tbody>
</table>

**Narrative exploration**

<table>
<thead>
<tr>
<th>Location &amp; Facilitator</th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School</strong></td>
<td>Liggins Institute</td>
<td>School classroom</td>
</tr>
<tr>
<td><strong>Student</strong></td>
<td>Liggins Institute teacher (school science teacher present)</td>
<td>School science teacher</td>
</tr>
<tr>
<td><strong>Teacher</strong></td>
<td>Variable by school within the module; Early phase of the day-programme</td>
<td>Variable: Suggested following exploration of NCD incidence and risk in the local community (including population studies), &amp; the nutritional environment &amp; practices of students/community</td>
</tr>
<tr>
<td><strong>Facilitator</strong></td>
<td>Teacher-led interactive narrative using whole-class and group activities that support students to examine and construct meaning of the data presented and link this to population-base studies being conducted in the New Zealand community (45 minutes) Hands-on exploration of blood pressure and the heart. Linking the evidence in the HCS story to exploration of what blood pressure is and why it is linked to heart health Followed by exploration of animal-model based research examining mechanisms by which early-life environmental exposures influence later-life NCD risk.</td>
<td>Variable, 2-4 lesson sequence: Interactive exploratory narrative, facilitated by the teacher; involving small group tasks and potentially role-play. Includes opportunities for engagement between the research story and the family histories of the students.</td>
</tr>
<tr>
<td><strong>Place</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity</strong></td>
<td>Teacher-led interactive narrative using whole-class and group activities that support students to examine and construct meaning of the data presented and link this to population-base studies being conducted in the New Zealand community (45 minutes) Hands-on exploration of blood pressure and the heart. Linking the evidence in the HCS story to exploration of what blood pressure is and why it is linked to heart health Followed by exploration of animal-model based research examining mechanisms by which early-life environmental exposures influence later-life NCD risk.</td>
<td></td>
</tr>
</tbody>
</table>

**Related development**

<table>
<thead>
<tr>
<th>Location &amp; Facilitator</th>
<th>New Zealand</th>
<th>Cook Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School</strong></td>
<td>School classroom</td>
<td>School classroom</td>
</tr>
<tr>
<td><strong>Facilitator</strong></td>
<td>School science teacher</td>
<td>School science teacher</td>
</tr>
<tr>
<td><strong>Activity</strong></td>
<td><strong>Exploration:</strong> The nutritional environment and practices of the students and their community</td>
<td><strong>Reflections:</strong> Linking the research process undertaken by the HCS team and the exploratory research undertaken by the students regarding perceptions of health and wellbeing.</td>
</tr>
<tr>
<td></td>
<td><strong>Linking:</strong> Exploration of Growing Up in New Zealand as a longitudinal study that is exploring the New Zealand population. Linking to the HCS findings.</td>
<td><strong>Exploration:</strong> Blood pressure and the heart. Linking the evidence in the HCS story to exploration of what blood pressure is and why it is linked to heart health</td>
</tr>
<tr>
<td></td>
<td><strong>Exploration:</strong> Blood pressure and the heart. Linking the evidence in the HCS story to exploration of what blood pressure is and why it is linked to heart health</td>
<td><strong>Related story:</strong> Exploring a story of scientists who used animal models to find out why a poor early life environment is associated with increased later-life NCD risk</td>
</tr>
<tr>
<td></td>
<td><strong>Related story:</strong> Exploring a story of scientists who used animal models to find out why a poor early life environment is associated with increased later-life NCD risk</td>
<td><strong>Personal links:</strong> Explore personal family history in terms of nutritional environment and heart health</td>
</tr>
<tr>
<td></td>
<td><strong>Inquiry:</strong> Design and carry out a small research task exploring a question (defined by the students) associated with exercise and heart rate</td>
<td><strong>Inquiry:</strong> Design and carry out a small research task exploring a question (defined by the students) associated with exercise and heart rate</td>
</tr>
<tr>
<td></td>
<td><strong>Consolidation, reflection, communication:</strong> Activities associated with collating and communicating the learning from the module, including consideration of actions.</td>
<td><strong>Consolidation, reflection, communication:</strong> Activities associated with collating and communicating the learning from the module, including consideration of actions.</td>
</tr>
</tbody>
</table>

*Many teachers noted that participation with their class in this programme offered significant PLD for them in terms of their understanding of, and ability to use the research stories

**Most participating New Zealand Biology teachers were also engaged with this Year 13 interactive partnership programme that explored the research in greater depth. Many non-biology science teachers, particularly physics teachers, reported using this online resource to support their understanding of the DOHaD research stories and update their understanding of core biological concepts.
10.3.2.1. Case-specific differences in approach

A key difference in approach between the cases relates to facilitation of learning engaging students in the narrative exploring the development and early findings of the Hertfordshire Cohort Study (HCS), Table 10.5. This study established epidemiological evidence of associations between pre-natal and early-life environmental exposures and later life metabolic and cardiovascular diseases (Barker and Osmond, 1988; Barker and Osmond, 1986; Hales et al., 1991). It is the focal point from which DOHaD emerged as a scientific community that has evolved to inform life-course approaches to NCD risk reduction (Hanson and Gluckman, 2014).

Teachers in both locations engaged in similar PLD experiences. These examined the HCS story, the relevance of the evidence uncovered, and the potential use of narratives of this genre in learning and teaching. In the Cook Islands teachers were also provided with “My First 1000 Days”, a student learning resource that explores the HCS story using the same components of the narrative as those used within the New Zealand programme (Bay, 2016a).

10.3.2.2. Comparison of responses

Survey responses to a series of seven statements were collected pre-intervention and 3- and 12-month post-intervention. The statements examine awareness of associations between:

1. maternal nutritional environment and both early and later-life health of offspring
2. paternal nutritional environment and both early and later-life health of offspring
3. adolescent nutritional environment and current and future health of the adolescent as well as future health of potential offspring

While all teacher PLD examined DOHaD evidence from maternal, paternal and adolescent perspectives, only the maternal and current personal perspectives were explored in the student learning resources. Paternal associations were mentioned briefly in the Liggins Institute programme experienced by the New Zealand students. However, data was neither presented nor explored.

Responses from each category were pooled to enable comparison of change within and between the cases. Statistical significance of average score change within each case was evaluated using paired t-tests ($\alpha=.05$) with Bonferroni correction for multiple testing. The effect size between the means was estimated using Cohen’s D, corrected for independence between the means in paired samples (Coe, 2002; Morris and DeShon, 2002). Table 10.6.
Table 10.6  Within case comparison of awareness of DOHaD concepts in middle-school students by gender and context

<table>
<thead>
<tr>
<th>Comparison</th>
<th>New Zealand Years 7 - 10</th>
<th>Cook Islands Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test  $\bar{x}$ (SD)</td>
<td>Post-test  $\bar{x}$ (SD)</td>
</tr>
<tr>
<td><strong>DOHaD Maternal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Awareness Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, $n = 74$</td>
<td>T0-T2</td>
<td>3.77 (0.88)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.77 (0.88)</td>
</tr>
<tr>
<td>Male, $n = 83$</td>
<td>T0-T2</td>
<td>3.97 (0.71)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.97 (0.71)</td>
</tr>
<tr>
<td>Female, $n = 117$</td>
<td>T0-T2</td>
<td>3.64 (0.95)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.64 (0.95)</td>
</tr>
<tr>
<td><strong>DOHaD Paternal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Awareness Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, $n = 75$</td>
<td>T0-T2</td>
<td>2.50 (1.13)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>2.50 (1.13)</td>
</tr>
<tr>
<td>Male, $n = 79$</td>
<td>T0-T2</td>
<td>2.91 (1.06)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>2.91 (1.06)</td>
</tr>
<tr>
<td>Female, $n = 117$</td>
<td>T0-T2</td>
<td>2.23 (1.09)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>2.23 (1.09)</td>
</tr>
<tr>
<td><strong>DOHaD Personal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Awareness Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, $n = 74$</td>
<td>T0-T2</td>
<td>3.87 (0.68)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.87 (0.68)</td>
</tr>
<tr>
<td>Male, $n = 79$</td>
<td>T0-T2</td>
<td>3.91 (0.67)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.91 (0.67)</td>
</tr>
<tr>
<td>Female, $n = 116$</td>
<td>T0-T2</td>
<td>3.84 (0.69)</td>
</tr>
<tr>
<td></td>
<td>T0-T4</td>
<td>3.84 (0.69)</td>
</tr>
</tbody>
</table>

Scores derived via aggregation of relevant question responses. Paired $t$-tests ($t$) and Cohen’s D effect size gains ($D$). $p'$ = adjusted significance (Bonferroni correction). T0 = Pre-intervention; T2 = 3-months post-intervention; T4 = 12-months post-intervention; $\bar{x}$ = mean; SD = standard deviation; n = number; Data limited to students responding at all three time points.
Between case assessments measured statistical and practical significance of differences in scores at each time point, using the independent samples $t$-test and Hedges’ $g$, a variant on Cohen’s D that weights effect size relative to sample size. Table 10.7. Effect size was assessed as 0.2, small; 0.5, medium; 0.8, large, acknowledging that these categories have limitations associated with the relevance of the change (Coe, 2002).

<table>
<thead>
<tr>
<th>DOHaD Maternal Impacts</th>
<th>Awareness Score</th>
<th>n</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>T0</th>
<th>T2</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>New Zealand</td>
<td>Cook Islands</td>
<td>New Zealand</td>
<td>Cook Islands</td>
<td>New Zealand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All</td>
<td>Male</td>
<td>Female</td>
<td>All</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>191</td>
<td>160</td>
<td>191</td>
<td>160</td>
<td>191</td>
</tr>
<tr>
<td>$\bar{x}$ (SD)</td>
<td></td>
<td></td>
<td>3.77 (0.88)</td>
<td>3.82 (0.81)</td>
<td>4.24 (0.71)</td>
<td>4.16 (0.74)</td>
<td>4.07 (0.80)</td>
</tr>
<tr>
<td>$t$ (p)</td>
<td></td>
<td></td>
<td>0.53 (.593)</td>
<td>-1.10 (.273)</td>
<td>0.94 (.349)</td>
<td>0.05</td>
<td>0.12</td>
</tr>
<tr>
<td>Hedges’ $g$</td>
<td></td>
<td></td>
<td>0.05</td>
<td>0.12</td>
<td>0.14</td>
<td>0.05</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Table 10.7 Between case comparisons of awareness of DOHaD concepts in middle-school students

Scores derived via aggregation of relevant question responses. Independent $t$-tests and Hedges’ $g$ effect size. T0 = Pre-intervention; T2 = 3-months post-intervention; T4 = 12-months post-intervention; $\bar{x}$ = mean; SD = standard deviation; n = number; p statistical significance;
10.3.2.2.1. **Awareness of DOHaD Maternal Impacts**

Within both cases average DOHaD Maternal Impacts Awareness scores at T2 were statistically and practically higher than at T0, \( p < .001 \), New Zealand \( D = 0.49 \); Cook Islands, \( D = 0.36 \). In the Cook Islands this was retained at T4. However, in New Zealand while the level of statistical significance was retained, the level of practical significance reduced at T4. In New Zealand the mean scores for male students were statistically and practically higher than those of females at all three time points, T0, \( p = 0.001, D = 0.38 \); T2, \( p = 0.001, D = 0.22 \); T4, \( p = 0.050, D = 0.30 \). While interviews with boys reflected strong opinions regarding the value of awareness of this evidence in terms of their families, this was also observed in girls. No statistical differences in mean scores were observed by gender in the Cook Islands, nor between cases at each time point. These data indicate that in both cases the programme supported the development of sustained awareness of associations between maternal nutritional environment during pregnancy and health in infancy and later-life, and that in the Cook Islands there was no reduction in the size of this change at 12-months post-intervention.

10.3.2.2.2. **Awareness of DOHaD Paternal Impacts**

Paternal impacts awareness scores in the Cook Islands were significantly lower than scores in New Zealand overall, shown to be an effect at the level of female students. Within the Cook Islands case no statistical or practical differences pre- and post-intervention was observed. In the New Zealand case a small statistical difference was observed between T0 and T4, however the effect size indicated that this was of no practical significance, \( p = 0.012, D = 0.18 \). A statistically and practically significant difference was observed between average paternal impact scores for male and female students at all three time points in New Zealand, T0, \( p < .001, D = 0.63 \); T2, \( p = 0.001, D = 0.22 \); T4, \( p = 0.050, D = 0.30 \). However, neither group shifted their responses significantly between T0 and either T2 or T4, This indicates that while the scores of male students were higher initially, the programme had no impact on their awareness of this association. Given that associations between paternal pre-conventional health and later-life offspring health were not examined in the programmes these data are as expected.

10.3.2.2.3. **Awareness of DOHaD from a Personal Perspective**

The personal impacts score examined questions pertaining to associations between adolescent nutrition and personal current and future health, and potential offspring health.
Given the emphasis of the programme on maternal nutrition, we anticipated a gender difference in this score. No gender difference was identified at baseline within or between countries. However, in the Cook Islands females showed a statistically and practically significant change between T0 and T2, \( p'=.014, D=0.32 \), and an even greater change by T4 \( p'< .001, D=0.57 \). This compares to no significant change for Cook Islands males at T2 and a smaller significant change at T4, \( p' = .012, D = 0.32 \). This increase in effect between T2 and T4 in the Cook Islands is likely to be resultant of ongoing school-based learning. Cook Islands classes were variably involved in a range of activities in the year following intervention that would be expected to strengthen impacts. Examples include school and community presentations; linked learning modules; presentations to the following year level; ambassadors at public health awareness events; class-level application of learning in planning and organisation of a food stall at the schools international food festival that reflected healthy eating. In contrast, only a small significant change was seen in New Zealand that for females was not practically significant.

### 10.3.3. Decision-making and Action

A universally agreed goal of scientific literacy is to enable the use of scientific knowledge and understanding in decision-making (Hodson, 2011). The measure of decision-making that we were interested in pertaining to the use of resources within the nutritional environment of the young people. Differences in the manner in which nutritional behaviour data was collected in the two cases has limited the analysis of behaviour effects to an overview comparison. (For detailed analysis of food behaviour please see Chapters 8 & 9).

In both cases we identified that baseline nutritional practices of the young people were strongly aligned to those recorded in national-level youth nutrition studies (Clinical Trials Research Unit Synovate, 2010; Cook Islands Ministry of Health, 2014). In any survey of nutritional behaviour change, it is important to recognise that not all young people need to alter their nutritional behaviours. Thus, we identified a group of key nutritional behaviours relating to health promoting practices (e.g. fruit and vegetable consumption) and risk promoting practices (e.g. consumption of crisps, fried foods etc.). In both cases we identified statistically significant positive behaviour change in students who pre-intervention reported risk promoting behaviours. This was also present for fruit and vegetable consumption in New Zealand. However, in the Cook Islands, we identified no significant change in fruit and vegetable behaviour when comparing the odds of at risk and
low-risk students making change. To put this in context, only 10% of Cook Islands adults manage to consume the WHO recommended two servings of fruit and three of vegetables daily. The baseline survey from our study found the same to be true for youth. This is linked to socio-ecological context, a factor discussed at length by the Year 11 students in the overall study (see Chapter 9). To quantify the challenge, using current prices, the minimum hourly wage in the Cook Islands would purchase approximately 1.5 locally grown lettuces, whereas in New Zealand the minimum hourly wage would purchase 4 or 5 lettuces depending on the season. Thus, the evidence indicates that while the learning opportunities did promote behaviour change, this is not possible where factors within the socio-ecological context prevent youth from having the power to take actions based on their decisions.

10.4. Discussion

Case studies offer the opportunity to simultaneously look at process and effect, factors that have been identified as requiring greater attention in research investigating evidence from school-based behavioural interventions (Khambalia et al., 2012). They are based on the premise that at least some empirical relationships are regular or systematic and that therefore systematic small-n research can reveal something of these relationships (Rohlfing, 2012). Analysis of process and response within and between two cases representing a developed and developing nation has enabled insights into the potential of adolescent education to support translation of DOHaD research within communities in developing nations. Key differences between the two cases were associated with resource limitations, alongside significantly greater NCD burden and a socio-ecological setting that makes access to fruit and vegetables far more challenging in the Cook Islands.

In both cases, the learning experiences associated with meeting scientists were recalled and retained for a significant proportion of participants, and these experiences were associated with changes in perceptions of scientists. However, the learning episode in New Zealand appears to have had a greater impact. Whether this was resultant of the setting (university vs school) or the difference in group-size remains unknown and should be investigated. Data capturing the collective pre- and post- class brainstorms are available from the New Zealand case and could be accessed from future Cook Islands cohorts. Comparative analysis of the characteristic and skills lists that students created pre- and post the meetings would offer valuable insight into the differences in approach between large and small group encounters. It is important to recognise that the pre-intervention experience of meeting
scientists in each case was significantly different. This reflects the reduced opportunity that Cook Islands teachers have to enable students to engage with scientists. Addressing this challenge in developing nations requires further investigation. The potential to utilise internet-based encounters was not feasible at the time of the study, however is now feasible and should be investigated.

Enabling narrative-based learning requires resources such as text, video, worksheets etc., as well as teachers with adequate depth of knowledge of the story and the science to facilitate use of the narrative as an educational tool. Comparison of these cases suggests that the narrative-based learning experience enabled by teachers in the Cook Islands was as effective as the combination of the university and school-based experiences in New Zealand in terms of supporting the development of understanding of DOHaD concepts associated with maternal nutrition. Furthermore, the data indicates that female students in the Cook Islands were applying DOHaD knowledge more effectively in their interpretation of the potential of the adolescent nutritional environment to influence the health of future offspring. This demonstrates a high level of critical and applied thinking. Combined with data showing that awareness of the DOHaD evidence diminished to an extent at 12-months post-intervention in the New Zealand students but did not in the Cook Islands, this suggests that the learning experiences facilitated by the Cook Islands teachers were more effective. This evidence contributes to the identified need to examine impacts of longer interventions (Khambalia et al., 2012) and we would also suggest offers insights into the learning that contributes to behaviour change following the intervention period (Bay et al., 2016c).

There are limitations within this study. Neither of the parent studies from which the data was derived have control groups. This is due to challenges associated with enabling truly matched controls within complex real world education settings (Berliner, 2002; Maxwell, 2004). However, responses to questions pertaining to evidence that was not presented in the learning modules (i.e. paternal associations) offers insights that suggest that in both cases the learning modules did effect development of knowledge that was sustained and applied by students. The studies both utilised assessment of impact at 12-weeks and 12-months post-intervention. When combined with the use of effect size, this assists in identification of the level to which learning had a sustained impact. This assessment distanced from the learning experience by a full academic year offers insight into the effect of the intervention and the associated learning facilitated by teachers following the modules that would not otherwise be evident (Ruiz-Primo et al., 2002).
Differences in the homogeneity of the populations in each case could be considered a limitation. The New Zealand case draws on data that is broadly representative of schools in a large urban centre in New Zealand, but has some limitations associated with representation of low socioeconomic communities within the study (Chapter 8). In contrast, the Cook Islands study draws from a comparatively homogeneous population. However, this may be considered as contextual difference rather than a limitation.

The development and application of capabilities associated with evidence-based decision-making is complex. Multiple factors associated with context (personal and social) will affect the response of students to learning experiences, and in turn multiple factors associated with the teacher, the school and the education and social setting will affect the learning programme. To mitigate the difficulties of interpreting this study we have provided detail of learning episodes, PLD and resourcing. This enables readers to interpret the evidence in the context of the learning programme, a factor that is often inadequately attended to in research examining the impacts of learning.

10.5. Conclusions

Resourcing is a significant limitation in developing nations. The positive results of this comparative study indicate that contextual adaptation alongside resourcing (PLD and learning resources) enabled teachers in the Cook Islands to facilitate learning that offered students opportunities to explore and use DOHaD evidence. This supports a position that learning that is culturally and contextually appropriate, and embedded in core school curricula, offers opportunities for school-based contributions to enabling youth as engaged citizens able to contribute towards addressing issues such as the NCD epidemic.
“Doing science and implementing scientific findings are so difficult in education because humans in schools are embedded in complex and changing networks of social interaction.”

Chapter 11. DOHaD and Adolescence: Summary of current research, challenges and future directions

“Like slavery and apartheid, poverty is not natural. It is man-made and it can be overcome and eradicated by the actions of human beings. Overcoming poverty is not a gesture of charity. It is an act of justice. It is the protection of a fundamental human right, the right to dignity and a decent life.”

Nelson Mandela, 3 February 2005

11.1. Introduction

The research programme presented in this thesis reflects a frame of reference that considers social justice central to what it means to be human, and identifies that a key goal of education is to disrupt social norms that create, support, and perpetuate inequities. Science has enormous potential to contribute towards addressing social injustices. However, as with education and health, advances in science have also brought negative impacts in populations, which have contributed towards perpetuating social injustices. This is in part because, as human endeavours, the cultures of science, education and health reflect the cultural norms of the societies in which they exist at any given time.

Advancements in science and technology have been used by humans to create social benefit for thousands of years. However, the rapid pace of scientific and technological development over the past 200 years, combined with the increasing complexity of science and technologies has contributed to globalisation and its associated inequities, including the noncommunicable disease (NCD) crisis. These advances have had most influence where dominant ideologies and social orders have served to create a divide between privileged and disadvantaged communities. A current example of this is the denial of evidence of human-induced climate change by leaders and their followers in some dominant developed economies. The resultant self-serving actions will create economic benefits within these societies while bringing about environmental impacts that will result in even greater levels of NCD vulnerability within Small Island Developing States (SIDS) such as those in Oceania (Friel et al., 2011; Kjellstrom et al., 2010).

Unacceptable differences in resourcing within and between communities throughout the world have resulted in economically deprived communities being entrapped by poverty
while dominant communities gain even greater levels of resourcing and privilege. The science of Developmental Origins of Health and Disease (DOHaD) has explained inextricable links between poverty and NCD vulnerability that were not understood 50 years ago (Hanson and Gluckman, 2014). With understanding comes responsibility to work with communities to enable contextual interpretation and application of this knowledge to alleviate poverty and its impact on health and wellbeing.

The right of all people to access science and its potential benefits was established in the 1948 United Nations Universal Declaration of Human Rights. The responsibility to act to enable this right for all sits with science, health, environment, education, UN agencies, and governments.

“Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits”

(United Nations General Assembly, 1948)

This vision of DOHaD scientists actively engaging in the contextual application of evidence to support wellbeing within society is expressed in the stated goals of the International Society for Developmental Origins of Health and Disease (International Society for Developmental Origins of Health and Disease., 2015)

This thesis examined the potential for multi-sectoral collaborations involving science, education and health to contribute towards communication of DOHaD science with adolescent populations in order to allow adolescents to translate this evidence into meaningful actions in their lives and their communities. The concept of access to scientific knowledge as a human right demands that the communication of science must be transactional, and occur alongside the development of capabilities associated with critically engaged citizenship. These capabilities contribute towards enabling young people, as citizens possessing the potential to exercise agency, to examine, question, contextually interpret, and act upon DOHaD evidence. In doing so they can contribute to disrupting the socio-economic, cultural and environmental factors that create the inequitable early-life exposures that drive the dominance of NCD burden within economically deprived communities.
11.2. Changing power relationships

Growing evidence of the extent and impacts of NCDs globally has driven research to understand NCD risk. This research has identified the intergenerational, socio-cultural, and environmental nature of NCD vulnerability. This has driven the call for integrated multi-sectoral approaches to address the NCD crisis. DOHaD, a relatively new field of research emerged from work initiated by Professor David Barker in the 1980s. DOHaD evidence has contributed significantly to understanding the early life origins of NCD vulnerability and has identified potential intervention points, including childhood and adolescence. The concept of science and education collaborating in support of the communication and translation of DOHaD evidence presented in this thesis is novel, and challenges traditional power relationships between science and education.

**Part I** of the thesis outlined the rationale for adolescence as a priority area for DOHaD informed interventions supporting primary NCD risk reduction, and the rationale for enlisting schools as one context within a matrix of multi-sectoral approaches that could contribute to NCD risk reduction. An underlying theme throughout this research programme is that of changing power relationships to enable adolescents to exercise agency. This has involved altering power relationships between science and education to enable multi-sectoral approaches that identify adolescents as citizens who possess and have the right to exercise agency, and acknowledging the importance of educational and scientific evidence in the development and implementation of appropriate interventions.

Agency is broadly defined as the potential of individuals to make decisions and take actions towards their own lives and wellbeing (DeJaeghere et al., 2016). Humans are social beings that exist within socio-ecological contexts involving interactions between people, systems, and the environments. These contexts and interactions influence the potential of individuals and/or groups to exercise agency. Thus from the perspective of this research programme it is important to identify that we conceptualise agency as being enabled through capability development within the socio-ecological context(s) that the adolescent has experienced throughout their development, and is currently living within.

11.2.1. Power relationships between science and education

**Part II** examined theoretical frameworks that have informed the development of programmes designed to facilitate the communication of DOHaD science with adolescents, alongside the development and assessment of capabilities to enable young people to
exercise agency in relation to NCD risk reduction. Central to these frameworks are issues pertaining to the role of power relationships in multi-sectoral collaborations.

Science ‘outreach’ is a well-established model that underpinned the Liggins Institute’s initial school programmes, designed around goals supporting access to biotechnologies and engagement with science (France and Bay, 2010; France et al., 2012). Much has been written about this model wherein science organisations are assisting schools by providing access to technologies, and activities that promote engagement in STEM subjects (Andrew et al., 2004; Dolan et al., 2004; Laursen et al., 2007; Munn et al., 1999; Palacio-Cayetano et al., 1999).

The Institute’s early outreach model involved an onsite classroom. While less common, this was a well-established strategy, for example at Cold Spring Harbor Laboratory’s DNA Learning Center where onsite classrooms had existed for 20 years (DNALC, 1985).

Within the traditional outreach model, science is assisting education to meet a need. This is frequently associated with science deciding what that need is, and a lack of connection to the core learning objectives represented in national curricula. This results in well documented issues pertaining to sustainability of school-based interventions (Keshavarz Mohammadi et al., 2010; Khambalia et al., 2012). The Institute’s original model recognised this shortcoming and was underpinned by application of knowledge and understanding of pedagogy and practice. However, the novel approach that Sir Peter Gluckman and I developed, that enabled the research presented in this thesis was the concept of education and science working as equal partners to support science, health and education goals, rather science ‘reaching out’ to ‘help’ education. The framework underpinning this model draws on literature from complexity theory, public health and education to address issues known to contribute to the common failure of multi-sectoral partnerships. Central to this is the development of shared vision and the recognition of sector-specific goals. While most partners are very enthusiastic about the concept of school-science interactions, the frames of reference that collaborators bring regarding partnerships are usually very different. Thus, the challenge in this research programme that is outlined from a theoretical perspective in Chapters 2 and 3, is associated with the bringing together of partners to openly discuss and consider frames of reference outside of their own sector.
11.2.2. **Shifting power by enabling agency freedoms**

To develop and exercise agency requires access to resources and the possession of capabilities required to interpret and act upon evidence. Unterhalter (2005) refers to this as ‘agency freedoms’.

> “Having the conditions to exercise agency, that is access to information, the chance for discussion and evaluation of goals, including education; the freedom to make up one’s mind without violence” (Unterhalter, 2005)

To enable agency freedoms that offer adolescents opportunities to make, and act upon decisions about when and how science knowledge can be appropriately used requires a significant shift in power. Bruce Alberts, former Editor-in Chief of Science, has pointed out that scientists have done more than anyone else to create a situation where for too long students in schools have been told about science and asked to remember facts rather than being given the opportunity to learn how to think scientifically (Alberts, 2013). Therefore, the proposal that through education adolescents might examine and contextually interpret scientific evidence has required a significant shift in thinking within the contributing science communities. We have examined the need for shifts in thinking in relation to science communication in Chapter 2, and outlined the integrated capabilities required by young people to engage with scientific evidence in such a way as to enable contextual interpretation, decision-making and action-taking.

To make available evidence of processes used to address the challenge of providing agency freedoms, Part III engaged in examination of concepts of collaborative narrative and transformative learning, examining through case analysis the implementation of these pedagogical strategies in the facilitation of learning. The in-depth examination in Chapter 4 of an exemplar learning resource provides a case analysis informing the potential for contextual transfer. The increasing evidence of the use of transformative learning as a model of relevance to adolescents as well as to adults is of interest and is examined through Chapters 5 to 7, looking at the application of transformative learning theory within different stakeholder groups. Of particular note is Chapter 6, which presents participatory action research that emerged from the application of collective narrative as a vehicle for transformative learning within teacher professional development. This provided an environment in which teachers could, in a safe manner, led by their thinking, challenge frames of reference that were central to their context. The resultant research process
provided these teachers with agency freedoms that in turn resulted in their exercising of agency to change practice within the constraints of national policy and resourcing.

11.3. Evaluative evidence

Part IV examines evidence from perspectives of attitudes, knowledge, understanding and application, identifying the extent to which the model has enabled adolescents to examine, question, contextually interpret, and act upon DOHaD evidence. To achieve this we have examined evaluative evidence from cohorts in New Zealand and the Cook Islands, each followed to 12-months post-intervention. Other than our colleagues at the University of Southampton who are investigating the efficacy of a contextually adapted version of our model in the UK, this is the only research currently examining this model in relation to adolescent engagement with DOHaD concepts. This research draws on the extensive literature examining the role of context in supporting development of aspects of scientific literacy including NOS understanding (Sadler, 2009; Sadler et al., 2004), argumentation (Venville and Dawson, 2010), substantive knowledge associated with the SSI and general scientific content knowledge (Sadler et al., 2016; Yager et al., 2006; Zohar and Nemet, 2002). It adds to this body of knowledge by examining the potential for learning supporting contextual examination of SSIs to facilitate students to take evidence-informed actions, the overall purpose of the development of scientific literacy. We have examined in Chapter 3 the challenges associated with assessing this goal, and acknowledge the limitations associated with our current evidence.

Our findings relating to associations between programme exposure, capability development and actions are limited to the contexts of New Zealand, a developed nation in Oceania, and the Cook Islands, an upper middle-income Small Island Developing State (SIDS) in Oceania. The research programme is also working with Tonga, a middle-income SIDS also in Oceania. While some evidence from this work is presented in Part III, the full evaluative evidence will not be available until late 2017.

Within the settings of New Zealand and the Cook Islands, our evidence indicates that DOHaD/NCD issues provide broad opportunities for context-embedded or future focussed learning in Years 7 – 11. The use of a learning model based on concepts of collaborative narrative have supported students to engage with the NCD crisis as an issue of relevance to their communities. Statistically and practically significant increases in awareness of these issues post-intervention have been demonstrated. Using triangulated evidence, we have
identified that in New Zealand, students who pre-intervention reported nutritional practices that placed them at increased risk of vulnerability to NCDs, made and sustained behaviour changes the logic for which they could link back to their learning experience. In the Cook Islands, these patterns were observed for junk foods but not for fruit and vegetables. Examination of context would suggest that this difference in response is associated with environmental constraints in the Cook Islands that restrict agency freedoms.

Prior to the work represented in this thesis, our data was inadequate to examine associations between gender, age and outcomes resultant from application of the model within schools. The research presented has enabled this and suggests negligible differences in engagement and outcomes in New Zealand between males and females. However, there are limitations associated with these data, as the distribution of males in the cohort was disproportionately associated with higher socioeconomic communities, a factor likely to influence the potential for adolescents to exercise agency with respect to freedom of food choices.

In the Cook Islands differences in the responses of females in Year 11, compared to males in Years 9 and 11, and females in Year 9 is suggestive of Year 11 females in this context responding to the learning experience by applying higher levels of critical thinking than their peers. This is an important finding worthy of further examination.

The contexts of New Zealand and the Cook Islands have similarities in terms of educational philosophy and curriculum structure. However, the Cook Islands represents a SIDS with one of the worst levels of NCD risk and incidence in the world. While an upper-middle income nation, the burdens of limited economic capacity, geographic spread and isolation, small population size, a history of colonisation, and the ongoing impacts of globalisation and climate change define the differences in context between these two settings. The evidence presented in Chapter 10 is an initial examination of the effects of application of the model, culturally and contextually adapted for each setting. There are multiple contributing factors within the complexity of school-settings that cannot be controlled for when making comparisons. Importantly, the model recognises that education must be contextual and cannot be assessed without consideration of contexts. Therefore, our comparison is made within the bounds of contextual and process differences. The positive results reported in Chapter 10 indicate that when teachers were provided with a framework from which they could adapt and develop context-embedded learning to support adolescent exploration of DOHaD/NCD contexts, this provided an environment within which adolescents could develop capabilities that in some cases resulted in sustained actions.
These actions are appropriately small and personal, creating the potential for sustainability, and therefore for long-term impact.

11.4. Limitations
In working within and between sectors, we have faced critique from each sector that has reflected sector-specific thinking that does not consider diversity of perspectives required in multi-sectoral programmes. Chapter 3 presents an important analysis of differences between public health and education perspectives pertaining to evaluation of school-based interventions.

The lack of health data in the form of anthropometric and metabolic measures pre- and significantly post-intervention is an acknowledged limitation. Reasons for the inclusion of data of this type are presented and challenges analysed in Chapter 3. In Chapter 9 we examine a positive process that has addressed issues associated with single-sector thinking that initially saw the education sector showing concern at the prospect of health measures. Through the development of trust within our multi-sectoral collaboration we reached a point 3 years into the partnership where education leaders proposed that the inclusion of health data needed to be reconsidered. The model that has evolved, funded by the Cook Islands Ministry of Health, has seen both education and health shift their positions and engage with new approaches. Education have accepted the importance of the collection of health data, and identified this as a learning opportunity. Health have reconsidered processes associated with the data collection, engaged in professional development with teachers to ensure a higher level of understanding of the data, and collectively the partnership has developed learning resources to support students to access, understand and use their own data. From this has evolved a research project that is exploring students’ perspectives of the process of data collection and the exploration of health data in the learning programmes. The project is working with students to understand why they have expressed a desire to engage with their health data, and how they intend to, or have used it. Furthermore, the health data will be available to match with knowledge, attitude and behaviours data, and evidence from classroom learning to assess the potential of the programme to affect long-term health outcomes.

This process reflects the potential offered by community-based participatory research (CBPR). Without the initial research, identified by traditional standards in public health as inadequate, the more in-depth and inclusive work that is now evolving could not have
occurred. Furthermore, as the participating schools and ministries (health and education) have been the initiators of these decisions, sustainability is being built through ownership of decision-making within the project. This research collaboration, initially funded for three years, is now seeking funding to build and extend the project. This demonstrates the value of CBPR partnerships in enabling sustainability.

A further limitation of this work is our inability to use randomised control trials (RCTs). Given the differences in perspective within multi-sectoral partnerships, it is important to engage in a discussion of the issues of appropriate methods in evaluative research involving education (Ryan and Hood, 2004). We have noted (Chapter 9) that there is a place for RCTs within education when assessing narrowly specified reproducible processes that can occur within a carefully controlled setting (Weinstein, 2004). However, the complexity of schools and classrooms and the multiple factors associated with the context of students, teachers and school communities render true control groups very challenging (Berliner, 2002; Maxwell, 2004). This creates the need to identify research methods that account for the complexity of context, while acknowledging that this creates evidence that is less generalizable (Kuger and Klieme, 2016). Issues with compatibility of control groups are not just about the students demographic features. They are also concerned with the prior knowledge and experience of both students and the teacher, resourcing, and the socio-ecological context of the school. When a specific pedagogical model is being examined further complications arise associated with trying to manufacture a learning experience that allows students in the ‘control’ group to experience learning that is aligned to the same objectives of the curriculum or standards, and is of equal quality but variant in nature to the model being tested (Sadler et al., 2016). The potential to assign experimental and control groups to different classes in the same school has been used effectively (Dawson and Venville, 2013) to enable controlled experiments in a school setting. When this is associated with whole learning modules as per our study this presents difficulties for teachers who would need to control carefully their use of material across multiple classes, and in the case of a fully integrated model, the potential for contamination from student to student when learning experiences are shared in the home and or community.

We have presented reasons for not using RCT models in both settings. These are primarily associated with the complexity of context and the need for methods to be contextually relevant, an issue identified in both public health and education as a limitation to the use of RCT models (Berliner, 2002; Sanson-Fisher et al., 2007). We acknowledge that in New
Zealand, if significant funding was made available to build a cluster of schools that could collectively develop a participatory research partnership, engagement in a cluster randomised control trial using a step-wedge model (Brown and Lilford, 2006) could be possible. We have addressed that lack of control groups via the use of individually matched pre-post analysis of the responses of each student, aggregated to enable the assessment of cohort wide change patterns. This follows the guidelines for evaluation using pre-post comparative assessment set by the US National Institutes of Health (National Institutes of Health, 2014). We have included in the evaluation questions relating to associations between paternal nutritional environments in the periconceptional period, not explored in the learning programmes. The evidence demonstrating no change in knowledge of this concept compared to significant positive change in knowledge of maternal associations supports our conclusion that the programme has supported students to examine and engage with DOHaD evidence. Our use of extended-term research including mixed methods has allowed us to identify the ability of students to discuss these concepts and their application of them at 6-months post-intervention, and triangulate this with re-assessment of knowledge, attitudes and behaviours at 12-month post-intervention. This represents an extended-term mixed methods design (Chatterji, 2005), creating the potential for evaluation evidence that includes examination of process (Maxwell, 2004) and offers applicability and transferability to other contexts.

11.5. Future Directions

Multiple areas of extension would usefully support greater understanding of the role of multi-sectoral partnerships in facilitating learning programmes of the type we have described. Priority needs to be given to work that will inform and support the efforts of classroom teachers as the facilitators of such programmes. Our current collaboration with the Cook Islands Ministries of Education and Health is already extending on the work presented in this thesis. Analysis of the 2016 cohort is enabling understanding of the value of students engaging with differing aspects contexts at different stages of their educational journey. Data collected by the Cook Islands Ministries of Health and Education will support a cross sectional study within this cohort that will characterise associations between metabolic health profile, cognitive profile, and response to programme participation. Deeper understanding of the student voice is being explored via a phenomenological case study working with students who have and have not made change, and engaging the
perspective of their families. A cross-country collaboration whereby one of the original New Zealand schools is looking at the integrated learning programme that evolved in the Cook Islands and developing this within a New Zealand context is also underway. This will further illuminate the requirements needed to enable learning from one setting to be contextually adapted for another. That the direction of knowledge sharing in this case is from developing to developed nation is pleasing.

Examination of the challenges of more remote settings such as the Pa Enau (outer islands) of the Cook Islands groups has been proposed by the Cook Islands Ministries of Education and Health as a priority for future research. Future prospective research is already enabled in all three contexts, and in the Cook Islands where health measures have been included this will potentially be very informative.

Tonga represents a very different setting to the Cook Islands. While both countries share a position as SIDS within the Pacific, differences in cultural, social and political systems as well as education systems mean that comparison of the development and outcomes of the project in these two developing nation settings is very important ongoing research.

A further significant area of work that should be prioritised is understanding of the ongoing relationship between research communities and teaching communities that can support the potential to keep programmes such as this relevant to science, education and society as each evolves, and accessible to all communities. This supports the overarching purpose of this research, to facilitate strategies that support adolescents to access, examine and act upon evidence that has the potential to positively influence their health and wellbeing and that of their family.

11.6. Conclusions

This novel research programme was established to examine and enable opportunities for adolescents to engage with and act upon DOHaD evidence. It is underpinned by the need to address issues of inequity that arise through differing resource levels that influence early-life environmental exposures associated with vulnerability to NCD risk. The NCD crisis is a complex adaptive system that engages with education and health, each of which are also complex adaptive systems. Neither a single sector, nor a single programme or paradigm can resolve the NCD crisis. Our work prior to 2012 established a relationship between education and science in regard to DOHaD and NCDs. The work between 2012 and 2016 represented by this thesis has consolidated this relationship and provided evidence that
supports the potential of school-based programmes that are designed using principles of multi-sectoral engagement to allow adolescents to translate DOHaD evidence into meaningful actions. The resultant actions that we have observed and measured are pleasingly small. To be sustainable, behaviour change must nudge rather than landslide. To identify evidence of small positive changes in nutritional practise of adolescents who prior to programme participation were engaging in risk-promoting practices is positive. That we have identified longevity in these changes, alongside understanding of why the change was made, is extremely hopeful. The most significant factor in any programme of this nature is relationships. The respectful relationship building that has occurred between the Liggins Institute and schools in New Zealand and the Pacific offers potential for longevity of this work. If developed, this work offers the prospect that each cohort of adolescents in New Zealand and the Pacific might be provided with opportunities that would allow them to express agency regarding the translation of DOHaD evidence into meaningful action in their lives.
Appendices

Appendix 4A  My First 1000 Days

LENScience Healthy Start to Life Education for Adolescents Project

My First 1000 Days
LENScience Healthy Start to Life Education for Adolescents Project

My First 1000 Days

Jacquie Bay

Liggins Education Network for Science, Liggins Institute, University of Auckland
Gravida: National Centre for Growth and Development

Read Pacific Publishing Limited
Introduction for Teachers

The Healthy Start to Life Education for Adolescents Project was developed by the Liggins Institute to enable communication and translation of Developmental Origins of Health and Disease (DOHaD) research for adolescents. The LENSscience team worked with teachers from schools throughout Auckland to explore whether or not DOHaD was an appropriate context to facilitate development of scientific and health literacy, via exploration of scientific research associated with socio-scientific issues. The answer was an unequivocal yes, including when we extended this work to the Cook Islands and Tonga. We have found that across a wide range of communities, 11 to 14 year olds are fascinated by exploration of evidence of the association between early-life nutrition and life-long wellbeing; 13 to 14 year olds are captured by evidence exploring why their generation has entered puberty earlier than their parents, and what long-term impacts this might have; 15 to 16 year olds are passionately interested in evidence demonstrating that the prevalence of type 2 diabetes, rampant in many New Zealand and Pacific communities, could be reduced by health-promoting actions during adolescence and prior to parenthood; and 17 to 18 year olds find that engaging in exploration of DOHaD research enhances their understanding of concepts of gene expression and epigenetics, and supports their development of capabilities associated with critical citizenship.

Central to the success of these learning experiences has been the use of stories of scientists, linking research with relevant socio-scientific issues. These stories allow adolescents to unpack the process of science, examine research evidence linked to issues that impact their communities, and use this evidence in active decision-making (Grace & Bay, 2011). We have shown that participation by adolescents in school-based science learning programmes that explore DOHaD research in the context of socially relevant issues is strongly associated with the development of scientific and health literacy that leads to health-promoting actions, initiated and sustained by participating adolescents (Bay et al., 2012).

The scientific story presented in this booklet is that of Professor David Barker, and his team at the University of Southampton. The story introduces the concept of DOHaD, and can be used with young people from 11 to 14 years and upwards. It is a story from which exploration of many aspects of DOHaD evidence can be developed. We have greatly appreciated the support of the University of Southampton in providing access to enable this work, and in particular Professor Hazel Insko, the family of Mr Ron Farr, and the MRC LifeCourse Epidemiology Unit.

If you are using DOHaD research as a context in your classroom, welcome to a growing international community of teachers from science, health & PE, languages and social sciences who are participating in the communication and translation of DOHaD research, while simultaneously facilitating high quality learning in their classrooms. The LENSScience Pacific team has developed a model that enables teachers to insert research specific to their country into internationally relevant learning programmes, and adapt these for their local curriculum and community. This booklet forms an important part of the model. Background information for teachers and further learning resources can be found in publications listed on our website.

In the UK, teachers should look to the LifeLab Southampton team for direct support. In Oceania and elsewhere, please contact the LENSScience team for support.

Jacquie Bay
Director, LENSScience


Message of Support from the University of Southampton

Professor Hazel Inskip
Deputy Director and Professor of Statistical Epidemiology
MRC Lifecourse Epidemiology Unit
University of Southampton
United Kingdom

The University of Southampton is the home of the late Professor David Barker and the Hertfordshire Cohort Study. The ground-breaking work of Professor Barker and the Hertfordshire Cohort Study team in the 1980s and 90s led to a new field of international scientific research that became known as the Developmental Origins of Health and Disease, or DOHaD. This research has explained how our environment in early life (even before we were born) impacts our health and wellbeing throughout our lives, and how this impact can also affect our children and grandchildren.

At the University of Southampton we have a long history of collaboration with the University of Auckland. Professor Sir Peter Gluckman and Professors Mark Hanson and Keith Godfrey have led many initiatives between our universities that have taken the field of DOHaD research forwards.

When LENS Science was established at the Liggins Institute in 2006, we were enthusiastic about the opportunities that this brought for communication and translation of the work of DOHaD scientists, particularly for young people and their families. LENS Science has led the way in sharing the story of our research, particularly the Hertfordshire Cohort Study, with young people.

In 2007 Professors Godfrey and Hanson visited LENS Science, bringing back to Southampton information and ideas that enabled us to develop a programme based on the work of LENS Science. Here at the University of Southampton, we have established LifeLab to share the DOHaD story with young people in our city.

From the classroom at the Liggins Institute in 2006, through to this exciting new series of learning resources for schools in the Pacific region, the LENS Science team have establish and developed the telling of our story to young people. We are thrilled to see this book published and wish all schools and students well in their journey of DOHaD exploration.
How old are you?
That's a simple question. We all know how old we are.

But what about the time BEFORE you were born?
Does that count?

We all come from an egg and a sperm, which join to make an EMBRYO.

An embryo grows into a FETUS, and after about 40 weeks, or almost 300 days, inside the mother it is ready to be born.

We all carry our family story with us...

Did you know that the egg you came from was already made and stored safely inside your mum when she was born?

And the egg that formed your dad was made and stored inside his mum!

A female baby is born with all the eggs that she will ever have, stored safely inside her ovaries. So the egg that formed you is actually as old as your mum! Maybe you are older than you think you are.

What was the world like when your grandmothers were pregnant with your mum and your dad?

...we are all part of our family's future.
A healthy start to a long life

We all know that babies are very special, but scientists have now found out that the first 1000 days of our lives, from when the sperm met the egg until we are about 2 years old, is a really important time.

A healthy start in the first 1000 days helps us to be healthy and well all the way through to old age.

A healthy start to life is about:

- Our mum and dad being healthy and well before we are born: eating well, getting regular exercise and not being affected by drugs and pollutants like cigarette smoke.

- Our mum getting enough of the right kinds of food when she was pregnant.

- Our mum getting enough rest when she was pregnant and not being affected by stress, drugs and toxins like alcohol and cigarette smoke.

- Our mum and dad having enough time and resources to be able to take good care of us when we were very small: getting good food, playing, talking to us, having lots of rest and growing up in a safe and happy place.

So what makes scientists so sure that our first 1000 days are so important?
The Journey Of A Scientific Discovery

In the 1980s there was a scientist who was interested in studying populations. His name was Professor David Barker and he lived in England, which is part of the United Kingdom, a group of big islands off the coast of Europe.

David worked at the University of Southampton. His work was about health and wellbeing. He was interested in finding out what made some people more likely to be healthy and well than others.

Sometimes our health and wellbeing is affected by where we live. That might be because of pollution, the weather or things like being able to easily get healthy food to eat.

In England during the 1960s and 1970s, many people (particularly men) were dying from heart disease when they were still quite young. David and his team were trying to find out more so they could help reduce the number of men who were dying from heart disease.

David and his team COLLECTED DATA about how many men were dying from heart disease in different parts of the country. They used the data to draw a map.

In places where a lot of men were dying from heart disease, the map is coloured RED.

In places where not as many men were dying the map is coloured GREEN.

### Activity 1: Looking For Patterns

Scientists look for PATTERNS in their DATA.

1. What did Professor Barker want to find out?
2. What patterns can you see on the map showing Professor Barker’s data?

Patterns in data lead to new questions.

3. If you were in Professor Barker’s team, what new questions would you ask now you have seen the patterns on this map?
Professor Barker looks for more evidence...

Professor Barker and his team came across another map that had been drawn by scientists almost 70 years earlier in 1910. This map was drawn at a time when many babies were dying before they reached their first birthday. In places where many babies died before their first birthday, the map is shaded BLACK.

Map showing which parts of England and Wales had high (BLACK) and low (GREY) numbers of babies dying between 1901 and 1910.
(Image courtesy of MRC LRP, University of Southampton)

Map showing which parts of England and Wales had high and low numbers of men dying from heart disease between 1968 and 1978.
(Gardner et al., John Wiley & Sons Ltd Chichester, 1984)

Activity 2: Comparing Patterns

1. Are the patterns in the maps similar or different?
2. Imagine you are in Professor Barker’s team. What new questions would you ask now you have seen both maps?
3. In your family, who was alive in 1910? Were your great grandparents born by then?
Sometimes Science Is Surprising!

Professor Barker and his team were very surprised when they saw the maps sitting side by side. They knew that the usual reasons babies and infants died were because of:

- How healthy their mums were during the pregnancy.
- Whether or not the babies and infants had good food, warm clothing, shelter and clean water (their environment).

Professor Barker's Question

The questions Professor Barker asked after he saw the two maps side by side were:

- Why are the patterns so similar? (This was very surprising!)
- Does this mean that heart disease when you are 50 or 60 years old could have something to do with what happened when you were a baby?
- Does your health and wellbeing when you are a baby affect your chances of having a heart disease when you are 60 years old?

Professor Barker and his team where really puzzled.

The DATA was SO unexpected!

Professor Barker’s team used evidence to form an hypothesis.
Activity 3: Making An Hypothesis

1. Why was Professor Barker so surprised by the **patterns** he saw in the two maps?
2. What was the **hypothesis** that Professor Barker needed to test?
3. What kind of **evidence** would Professor Barker need to test his **hypothesis**?
Eureka - The Team Finds Birth Records!

Professor Barker and his team searched all over England to find records of children born between 1900 and 1910. It was not easy! They wanted to know about things like how much the children weighed, who their parents were, where they lived, and whether they were healthy or not in their first years of life.

After a very long search they had success - a EUREKA moment.

In 1986, in a place called Hertfordshire, they found the birth records of thousands of children who had been born between 1911 and 1939. The children and their mothers had all been cared for by a group of health workers led by a young midwife named Margaret Burnside. Miss Burnside and her nurses worked in the community, helping women to keep their babies healthy and well.

Miss Burnside and her team kept very good records about each baby.

Miss E. Margaret Burnside
(Image courtesy of MRCLEU, University of Southampton)

A page from Miss Burnside’s records about the children
(Image courtesy of MRCLEU, University of Southampton)

Professor Barker’s team got permission from the town to use Miss Burnside’s data, and a new scientific study called the Hertfordshire Cohort Study was born!

It is a good thing that Professor Barker and his team were determined and persistent in their work. The information from the Hertfordshire Cohort Study has been used to improve the understanding of health and wellbeing all around the world.
## Miss Burnside’s Data

<table>
<thead>
<tr>
<th>Weight at Birth</th>
<th>Weight 1st Year</th>
<th>Food.</th>
<th>No. of Visits</th>
<th>Condition, and Remarks of Health Visitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 1/2 lbs</td>
<td>24 1/2 lbs</td>
<td>13</td>
<td>11</td>
<td>W, V, D, T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Healthy &amp; well developed, Auckland School, Card to S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15 1/4 lbs, 18, 12 h, y, y, s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Good at 6 mos, was fed milk.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Had measles, pneumonia, 8 1/2, Dec. 11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19, 9, 22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Healthy &amp; normal, Auckland School, Card.</td>
</tr>
</tbody>
</table>

### Activity 4: Birth Records

Do you know how much you weighed when you were born? If you ask your Mum or Dad they can probably tell you. They might even have a book about your health when you were a baby.

Miss Burnside asked her team to collect the same data about each child. They collected information about:

- The child’s name and address;
- How much they weighed when they were born, and when they were 1 year old;
- Whether they were feed breast milk or bottle milk;
- When their mum started giving them solid foods (weaning them off milk);
- Whether they were vaccinated against small pox (a disease that was killing people at that time).

Each year until they were 5 years old, the health workers visited the families and made comments in their records about the children.

1. Do you think Miss Burnside’s team were collecting scientific data? Why or why not?
2. What kind of data does the Ministry of Health collect about babies in your country? You could find out by contacting the Ministry of Health, or by asking your doctor or your family about what records they have about you when you were born and growing up.
Finding The Hertfordshire Study Babies

Professor Barker and his team had Miss Burnside’s data. The next job was to search for all the babies, who were by this time about 60 years old. How would they find them all?

Mothers and their babies at the Baldock Health Clinic in Hertfordshire in 1924
(Image courtesy of MRC EPU, University of Southampton)

Activity 5: Tracing The Children

Professor Barker’s team needed to get permission from the National Health Service to contact or look up people’s records in the National Health Service records. They even had to get permission to find out whether the people were still alive.

1. Why do you think they needed to get permission before they contacted the people or looked up their records?

Have you ever taken part in a research study? What was it about? Did you have to give the research team permission?

2. Imagine you are a member of the research team calling Mr Ron Farr. He was one of the children Professor Barker’s team had records about. Mr Farr was born in Hitchin in 1926.

You are going to role-play a telephone conversation with Mr Farr.

- You have to call him up to tell him about Professor Barker and his hypothesis.
- You need to tell Mr Farr about Miss Burnside’s records and tell him what Professor Barker’s study is about and why you would like to meet him to talk about taking part.
- Make a list of the things you are going to say to Mr Farr.
- Using a phone or a tablet, record your conversation with ‘Mr Farr’.

Listen back to your conversation. Do you think Mr Farr would be happy to talk to you again - or would he look like the man in the cartoon?

Professor Barker’s team needed to be good communicators. Do all scientists need to be good communicators?

(Image courtesy of MRC EPU, University of Southampton)
Mr Farr joined the Hertfordshire Cohort Study in 1996 when he was 70 years old. Top Row: Photos of Mr Farr growing up. From age 6 months to 12 years old. Bottom Row: Mr Farr at age 22, 45, and with his wife Hilda in 2004 at age 78 years. (Images provided by MRC CEGU, University of Southampton, with thanks to the family of Mr Ron Farr)

Visit the Hertfordshire Cohort Study website to hear Mr Farr talking about his life and how he has been involved in the Hertfordshire study. http://www.mrc.soton.ac.uk/herts/participants/

**Activity 6: Our Environment And Our Health**

1. What are some of the things that Mr Farr remembers from when he was growing up?
2. How do you think the food environment when Mr Farr was growing up could have affected his health and wellbeing?
What Did Professor Barker’s Team Find Out?

Professor Barker’s team met with hundreds of the Hertfordshire children when they were at least 60 years old. They asked them questions about their life, and they took measurements to find out about their health and wellbeing.

Members of the research team taking measurements from participants in the Hertfordshire Cohort Study.

(Images courtesy of MRC Epi, University of Southampton)

Remember the research question:

Could having heart disease when you are 60 years or older have anything to do with your health and wellbeing when you were a baby?
What did they find out?

They found that men who were smaller when they were 1 year old were 2-3 times more likely to have died from heart disease before they reached 60 years old.

They measured the blood pressure of the men who were alive at 60+ years old. Having high blood pressure means you have a higher RISK of heart disease.

The graph below shows their DATA.

Birth Weight vs Average Blood Pressure at 60+ Years Old

(Blood Pressure)

<5.5  5.5-6.5  6.5-7.5  7.5-8.5  >8.5

Birth Weight (lb)

High Blood Pressure

Normal Blood Pressure

(Redrawn from Barker et al., British Medical Journal, 1996, with permission. Fetal and placental size and risk of hypertension in adult life.)

Activity 7: Professor Barker’s Data

1. Why did the research team measure blood pressure?
2. What did they plot blood pressure against in the graph?
3. On average, did smaller babies have higher or lower blood pressure when they were 60+ years old?
4. What may be some of the reasons why some babies are born smaller than others?

© University of Auckland 2015
The scientists had lots of QUESTIONS

Scientists all around the world have been working to understand more about this increased risk. They now know that:

- NOT HAVING ENOUGH FOOD, or having the WRONG TYPES OF FOOD (not enough vitamins and minerals) or TOO MUCH FAT when we are very small (even before we are born) is ONE of the reasons why some people are more likely to get heart disease than others when they are older. It also means these people are more likely to put on weight easily.

- The scientists have also found out that being very big when you are born puts you at a similar risk as being very small.

Does INCREASED RISK mean that smaller babies will definitely have high blood pressure when they grow up?

What could you do to REDUCE your risk of developing high blood pressure if you knew you were a small baby or a very large baby?
It took a whole team of scientists quite a long time to COLLECT, PROCESS and ANALYSE the DATA.

Professor Barker found some amazing data about children born in a place called Hertfordshire. Wow - just what he needed!

If he could find these people (they were at least 60 years old!) he would be able to test his hypothesis!

Because Professor Barker COMMUNICATED his work so well, there are now thousands of scientists around the world that have helped unravel this scientific question.

This would be impossible for just one team!

The work of all these scientists is helping communities around the world to become healthier and happier.

What is the hypothesis that Professor Barker wanted to test?

Professor Barker needed to find people who had heart disease at age 50-60, and find out about what their life was like when they were babies. Who would he compare these people to?

RESEARCH QUESTION: Could getting heart disease when you are 50 or 60 years old have something to do with what happened when you were a baby?

This is the symbol for the International Society for Developmental Origins of Health and Disease (DOHaD). Scientists all over the world belong to this DOHaD society. They work together to continue the work that Professor Barker’s team started.
Appendix 5A  Extract from Me, Myself, My Environment: Kai no to Otaanga Meitaki

Ko Au e Toku Aorangi: Kai No te Oraanga Meitaki

Me, Myself, My Environment: Nutrition

Student Book
Cook Islands Edition

Jacquie Bay and Delaney Yaqona

with
Karen Tairea, Mark Vickers, Deborah Sloboda and Helen Mora

Liggins Education Network for Science, Liggins Institute, University of Auckland
Gravida: National Centre for Growth and Development, New Zealand
Cook Islands Ministry of Education, Maraurau o te Pae Apiti
Te Marae Ora, Cook Islands Ministry of Health

Read Pacific Publishing Limited
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2 Ko Au o Toku Aorangi: Kai No te Oraanga Meitaki
Oraanga e Pitoenua
Health and Wellbeing

I think so, Roimata - let's find out what Oraanga e Pitoenua means for us and for other people...

Hey Tama, are you healthy and well?

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Activity 3: Oraanga e Pitoenua (Health and Wellbeing)

- Oraanga e Pituena or health and wellbeing is about all the things that contribute to making us healthy, happy and well.
- What are the things that make you and your friends feel healthy, happy and well?
- Are those things the same for everyone?

PITOENUA

What makes us healthy, happy and well?

Collect ACTIVITY 3 from your teacher. Using the worksheet, record at least FIVE ideas from your group about the kind of things that make us healthy, happy and well.
Asking About Oraanga e Pitoenua
(Health and Wellbeing)

When you talked in your class about Oraanga e Pitoenua, did different people have different opinions? Did hearing different ideas make you think about your own ideas?

Having different opinions is called DIVERSITY. Is hearing different opinions useful?

What could you find out if you asked the same questions to people who are different ages, or people who live in different places or who have had different experiences?
Activities 4-9: Oranga e Pitoenua Research Task

Use a survey (no more than four questions) to find the answer to Roimata’s question.

Do people of different ages have similar or different ideas about what makes us healthy, happy and well?

Design and carry out a simple survey to find out whether people of different ages have similar or different opinions about health and wellbeing.

INSTRUCTIONS:
Your task is to use a survey to find our whether people of different ages have similar or different ideas about what makes us healthy, happy and well.

The worksheets will help you step through the stages of your research. You will need to:

- **REFINE** your QUESTION
- Write an **HYPOTHESIS** (prediction)
- Decide on your **VARIABLES**
- **WRITE** your SURVEY
- Get your SURVEY APPROVED
- **INVITE** people to take part
- **COLLECT** your DATA
- **PROCESS** your data to work out what it tells you
- **PRESENT** your FIRST DRAFT report for review
- **EDIT** your report and present your findings.
Think Like A Researcher

How would a researcher find out whether people of different ages had similar or different ideas about what makes people healthy, happy and well?

1. **Brainstorm possible research questions**
2. **Choose one question**
3. **Design, test & refine a survey**
4. **Ask people to take part**
5. **Process data & write a report**
6. **Edit the report**
7. **Report on what you have learnt to other researchers and to the community**
8. **Ask another researcher to review the report**

Explore a BIG question
STEP 1 REFINE A BIG QUESTION

Do people of different ages have similar or different ideas about what makes us healthy, happy and well?

INSTRUCTIONS:
The question that Roimata asked is actually TOO BIG!
Researchers REFINE big questions into SMALLER questions so that they can be answered.
There are TWO problems to sort out with this question.

The first problem with the question is the word PEOPLE.

PEOPLE could mean all people all over the world!
That would be a very difficult question to answer and would take you a long time!

The second problem is the phrase DIFFERENT AGES.

DIFFERENT AGES could mean people of any ages from babies to elderly. Can you really ask a baby or a toddler what pitoenua means to them?

Remember to think about TIME!
Your research question needs to be the RIGHT SIZE for the AMOUNT OF TIME you have to complete your research.
Check with your teacher about how much time you have.

Collect ACTIVITY 4 from your teacher. Use the worksheet to REFINE your research question.

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Pitoenua | 15
STEP 2  WRITE AN HYPOTHESIS

An hypothesis is a prediction.
It is not a guess.
An hypothesis is based on facts that you know or you could find out about.

What do I predict I will find out from my research?

Why do I think that?

Do I need to look up some facts before I make my prediction?

AN HYPOTHESIS

Did you notice we write and say an hypothesis, not a hypothesis.
An hypothesis might sound funny because in English, we usually use ‘a’ in front of words unless they start with a vowel [A, E, I, O, U] and H. An hypothesis is correct.
We do RESEARCH or an EXPERIMENT to TEST an HYPOTHESIS.
An example of an hypothesis

**RESEARCH QUESTION**
Do shirts dry faster on the clothesline hanging from the collar or the tail?

**HYPOTHESIS**
That shirts hung from their tails will dry faster than shirts hung from their collars.

My hypothesis is based on the FACT that the collar is the THICKEST part of the shirt.

Thick things dry slower than thin things.

I think it will take longer to dry if the thick part of the shirt is at the top.

Collect ACTIVITY 5 from your teacher. Use the worksheet to write your hypothesis.
STEP 3 DECIDE ON VARIABLES

When researchers design EXPERIMENTS they have to set the VARIABLES.

The INDEPENDENT variable is the factor we CHANGE.
The DEPENDENT variable is what we will MEASURE to find the answer to our research question.
The CONTROL variables are ALL the factors we will KEEP THE SAME to make it a fair test.

Question:
Do shirts dry faster on the clothesline hanging from the collar or the tail?

What are the VARIABLES in the experiment?
What was changed?
What was kept the same?
What was measured?

Collect ACTIVITY 6 from your teacher. Use the worksheet to decide on your VARIABLES.
A survey can ask different TYPES of QUESTIONS and collect different kinds of information or DATA.

- Your survey needs to be SHORT.
- It should not take more than 5 minutes to answer.
- Your survey should fit onto ONE page.
- You MUST ask HOW OLD the person is.
- You can ask UP TO THREE other questions.
- Use the worksheet to help write your survey.

As well as writing your survey, you will need to write your SCRIPT. This is what you are going to say when you ask people to take part.

Survey Script

1. Hello, my name is __________ and I am ________________
2. I am doing a survey to find out ________________
3. My survey does not collect names, so no one apart from you and I will know you took part.
4. It will take about 5 minutes.
5. Would you like to take part?

When you have finished, check out your survey by testing it on a friend.

Once you think it is ready to go, take it to your teacher for REVIEW and APPROVAL.

Researchers always have to get their surveys approved before they can start their work.

Collect ACTIVITY 7 from your teacher. Use the worksheet to write your SURVEY.
STEP 5 | COLLECT YOUR DATA

Plan Your Data Collection

When scientists **COLLECT DATA** they want very accurate records.
This means that they have to be very well organised.

Tama has collected data about his shirts. He has put the data into a table so that it is **ORGANISED**. Tama could get everyone in his class to take part in the experiment using their school uniform shirts so that they had a lot more data to look at. **BUT**, if they are working as a **TEAM** they all need to collect the data the same way.

Scientists almost always work in **TEAMS**. **TEAMS** make it easier to collect more data. More data usually means scientists can be more certain about what they find out.

Scientists often use **CHECKLISTS** when they are getting ready to collect data.
Create a checklist to make sure you will get all your data collected **ACCURATELY** and **ON TIME**.

Collect **ACTIVITY 8** from your teacher.
Organise your research team to collect your data.

---

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An example of data collection

Tama has collected DATA from his experiment. As well as his timing records, he made a set of questions about the day to help improve his data. Tama has PROCESSED the data so that he can look for PATTERNS and find the answer to his question.

<table>
<thead>
<tr>
<th>Time</th>
<th>Shirt A</th>
<th>Shirt B</th>
<th>Shirt C</th>
<th>Shirt D</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:15 am</td>
<td>Very Wet</td>
<td>Very Wet</td>
<td>Very Wet</td>
<td>Very Wet</td>
</tr>
<tr>
<td>10:15 am</td>
<td>Damp</td>
<td>Wet</td>
<td>Damp</td>
<td>Wet</td>
</tr>
<tr>
<td>11:15 am</td>
<td>Slightly damp</td>
<td>Damp</td>
<td>Slightly damp</td>
<td>Damp</td>
</tr>
<tr>
<td>12:15 am</td>
<td>Very dry</td>
<td>Dry</td>
<td>Very dry</td>
<td>Dry</td>
</tr>
</tbody>
</table>

The weather

<table>
<thead>
<tr>
<th>Time</th>
<th>Weather</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:15 am</td>
<td>Cloudy</td>
<td>22°C</td>
</tr>
<tr>
<td>10:15 am</td>
<td>Sunny</td>
<td>22°C</td>
</tr>
<tr>
<td>11:15 am</td>
<td>Sunny</td>
<td>23°C</td>
</tr>
<tr>
<td>12:15 pm</td>
<td>Cloudy</td>
<td>23°C</td>
</tr>
</tbody>
</table>
STEP 6 PROCESS YOUR DATA

Looking For Patterns In Your Data Set

Scientists PROCESS their data by putting it into TABLES and GRAPHS so that they can look for patterns.

Processing Data

Processing data is a bit like doing a jigsaw puzzle. You have all the pieces, but you need to SORT or PROCESS them to make sense of the jigsaw puzzle.

When all the pieces are PROCESSED, you can see the PATTERNS in your data and tell the STORY.

To tell the story of your data you will need to:

1. Organise your data into a SUMMARY table.
2. Add up the TOTAL number of responses for each question.
3. COMPARE different groups, e.g. boys and girls, OR old and young.
4. PRESENT your data in TABLES or GRAPHS to show the PATTERNS.
Looking For Patterns In Your Data Set

**AVERAGE or MEAN**
Calculating the average age of your younger or older survey group may be useful.

\[
\text{Average Age} = \frac{\text{Total of all the ages of the people in my DATA SET}}{\text{Total number of people in my DATA SET}}
\]

<table>
<thead>
<tr>
<th>Person</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
</tr>
</tbody>
</table>

**TALLY or TOTALS**
Adding up the number of people who chose the different options for each question helps us see patterns. We can create a PICTURE of the pattern using a graph.

<table>
<thead>
<tr>
<th>Person</th>
<th>Living by the sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very important</td>
</tr>
<tr>
<td>2</td>
<td>Not very important</td>
</tr>
<tr>
<td>3</td>
<td>Not very important</td>
</tr>
<tr>
<td>4</td>
<td>Important</td>
</tr>
<tr>
<td>5</td>
<td>Important</td>
</tr>
<tr>
<td>6</td>
<td>Not very important</td>
</tr>
<tr>
<td>7</td>
<td>Important</td>
</tr>
<tr>
<td>8</td>
<td>Very important</td>
</tr>
<tr>
<td>9</td>
<td>Not very important</td>
</tr>
<tr>
<td>10</td>
<td>Very important</td>
</tr>
</tbody>
</table>

Total VI: 3
Total I: 3
Total N: 4

Does living by the sea help keep us healthy, happy and well?
The opinions of Year 9 students

What People Thought (Opinions)

Collect ACTIVITY 9 from your teacher and PROCESS your data to find the answer to your question.
STEP 7 PRESENT YOUR FINDINGS

Present Your Data - Telling Your Story

Researchers often use POSTERS to present their reports. Good poster design is EYE-CATCHING, and tells the STORY of your research.

Make sure your TITLE tells people what your poster is about.

**Aim:** What did you want to find out?

**Hypothesis:** What did you predict would happen?

**Method:** How did you do the research? (Use bullet points!)
- Step 1
- Step 2

**Results:**

**Conclusions:** What is the overall message?
WRITE YOUR POSTER

ASK SOMEONE YOU RESPECT TO REVIEW IT

THINK ABOUT THE CHANGES SUGGESTED

EDIT YOUR POSTER

SEND IT BACK TO YOUR REVIEWER FOR A FINAL CHECK

MAKE YOUR FINAL EDITS

PRESENT YOUR POSTER
The series below is an example of a differentiated student learning resource. Three levels of differentiation were used.
**Step 4: Writing My Survey**

**My Pitoenua Survey**

**TASK:** Fill in the form to write your survey.

**Instructions are in red italics. Do not read the instructions out when you do your survey.**

**My Interview Script (read from the script)**

Hello, my name is __________ and I am from __________ school.

My teacher's name is ________________________.

We are learning about oranga a pitoenua / health and wellbeing.

I am doing a survey to find out whether people of different ages have similar or different ideas about ________________________________.

My survey is voluntary - that means ________________________________.

My survey does not collect names. That means ________________________________.

It will take about 5 minutes. Would you like to take part?

If the person says “no thanks” you say... “Thank you for listening. Have a nice day.”

If the person says “yes” or “ok” you say... “Thank you, is there anything else you want to know about my survey before we start?”

**Survey ITEM**

<table>
<thead>
<tr>
<th>Survey ITEM</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having family or friends who care about me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Being able to exercise every day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is there anything else you think is REALLY Important for keeping us healthy, happy and well?

Would you mind telling me which age group you belong to? Are you:

Start reading out the age groups - most people will just tell you...

<table>
<thead>
<tr>
<th>Age Group</th>
<th>(Tick)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record whether the person is a female or a male:

Female [ ]

Male [ ]
**My Pitoenua Survey**

**TASK:** Fill in the form to write your survey.

**My Interview Script (read from the script)**

Hello, my name is ____________ and I am from ____________ school.

My teachers name is ____________.

We are learning about oranga e pitoenua / health and wellbeing.

I am doing a survey to find out whether people of different ages have similar or different ideas about ____________.

My survey is voluntary - that means ____________.

My survey does not collect names. That means ____________.

It will take about 5 minutes. Would you like to take part?

If the person says "no thanks" you say... "Thank you for listening. Have a nice day."

If the person says "yes or ok" you say... "Thank you, is there anything else you want to know about my survey before we start?"

**Step 4: Writing My Survey**

There are just _______ questions.

1. ____________

2. ____________

3. ____________

4. Would you mind telling me which age group you belong to? Are you:

   Start reading out the age groups - most people will just tell you:

   Fill in age groups for your survey e.g., 20-30 years old, 30-40 years old, etc.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>(Tick)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record whether the person is a female or a male:

Female [ ] Male [ ]

Thank you for taking part in my survey.
Appendices

Appendix 8A  Data representation check

Comparison of T0 responses from participants who did not and who did provide T2 and T4 responses. Numbers are values (percentages).

Variance in response patterns at baseline (T0) from the two groups were assessed using Fisher’s exact and Mann-Whitney U tests. *Bold: significant (α=.05). T0 = Pre-intervention; T2 = 6-12 weeks post-intervention; T4 = 12-months post-intervention; n = number;

### Demographic factors

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Decile Band</th>
<th>Year Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0 or T0-T2 Response only</td>
<td>Male</td>
<td>(30.4)</td>
<td>50.1</td>
</tr>
<tr>
<td>T0-T2-T4 matched</td>
<td>77 (38.8)</td>
<td>124 (61.7)</td>
<td>40 (19.9)</td>
</tr>
</tbody>
</table>

χ²=2.341, p=.126

### Attitudes to health and wellbeing

<table>
<thead>
<tr>
<th>How much does it matter whether or not you exercise or are physically active every day</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
</tr>
</thead>
<tbody>
<tr>
<td>A lot</td>
<td>102 (69.9)</td>
<td>109 (55.1)</td>
<td>66 (44.9)</td>
<td>78 (39.0)</td>
<td>65 (4.5)</td>
<td>101 (51.0)</td>
</tr>
<tr>
<td>Quite a lot</td>
<td>38 (26.0)</td>
<td>78 (39.4)</td>
<td>55 (37.4)</td>
<td>99 (49.5)</td>
<td>67 (5.9)</td>
<td>73 (36.9)</td>
</tr>
<tr>
<td>Not Very Much</td>
<td>4 (2.7)</td>
<td>11 (5.6)</td>
<td>24 (16.3)</td>
<td>22 (11.0)</td>
<td>11 (7.5)</td>
<td>23 (11.6)</td>
</tr>
<tr>
<td>Not at all</td>
<td>2 (1.4)</td>
<td>0 (0.0)</td>
<td>2 (1.4)</td>
<td>1 (0.5)</td>
<td>3 (2.1)</td>
<td>1 (0.5)</td>
</tr>
</tbody>
</table>

U=16,599, z=2.701, p=.007*

### Awareness of associations between nutritional environment and health (self)

<table>
<thead>
<tr>
<th>The food I eat now will affect my health in the future</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
<th>It is important for me to eat healthy food now</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>56 (38.1)</td>
<td>78 (39.8)</td>
<td>91 (61.9)</td>
<td>120 (61.2)</td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>73 (49.7)</td>
<td>102 (52.0)</td>
<td>48 (32.7)</td>
<td>71 (36.2)</td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td>3 (2.0)</td>
<td>1 (0.5)</td>
<td>1 (0.7)</td>
<td>1 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>10 (6.8)</td>
<td>6 (3.1)</td>
<td>3 (2.0)</td>
<td>1 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>5 (3.4)</td>
<td>9 (4.6)</td>
<td>4 (2.7)</td>
<td>3 (1.5)</td>
<td></td>
</tr>
</tbody>
</table>

U=13,872, z=.654, p=.513

### Awareness of associations between nutritional environment and health (intergenerational)

<table>
<thead>
<tr>
<th>The food a woman eats when she is pregnant affects the health of her baby</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
<th>The food a woman eats when she is pregnant affects the health of her baby when it is grown up</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
<th>The food I eat now will affect the health of any children I have in the future</th>
<th>T0/T0-T2 Only</th>
<th>T0-T2-T4 match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>74 (50.7)</td>
<td>104 (52.8)</td>
<td>21 (14.4)</td>
<td>29 (15.2)</td>
<td>15 (10.3)</td>
<td>20 (10.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>58 (39.7)</td>
<td>81 (41.1)</td>
<td>49 (33.6)</td>
<td>72 (37.7)</td>
<td>40 (27.4)</td>
<td>64 (32.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>2 (1.4)</td>
<td>2 (1.0)</td>
<td>10 (6.8)</td>
<td>13 (6.8)</td>
<td>16 (11.0)</td>
<td>19 (9.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>9 (6.2)</td>
<td>8 (4.0)</td>
<td>41 (28.1)</td>
<td>49 (25.7)</td>
<td>31 (21.2)</td>
<td>45 (23.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>3 (2.1)</td>
<td>2 (1.0)</td>
<td>25 (17.1)</td>
<td>28 (14.7)</td>
<td>44 (30.1)</td>
<td>47 (24.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

U=13,854, z=.652, p=.515

U=13,281, z=.850, p=.396

U=13,307, z=1.062, p=.288
## Nutritional behaviours

<table>
<thead>
<tr>
<th></th>
<th>Potato Chips</th>
<th></th>
<th></th>
<th>Soft Drinks</th>
<th></th>
<th></th>
<th>Fried Foods</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td></td>
</tr>
<tr>
<td><strong>Daily</strong></td>
<td>12 (10.2)</td>
<td>7 (4.1)</td>
<td>6 (5.1)</td>
<td>6 (3.6)</td>
<td>2 (1.7)</td>
<td>5 (3.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2-4 Times/wk</strong></td>
<td>38 (32.2)</td>
<td>63 (37.3)</td>
<td>23 (19.5)</td>
<td>35 (21.0)</td>
<td>19 (16.1)</td>
<td>32 (19.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Once per week</strong></td>
<td>24 (20.3)</td>
<td>43 (25.4)</td>
<td>27 (22.9)</td>
<td>42 (25.1)</td>
<td>36 (30.5)</td>
<td>60 (35.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt; Once per week</strong></td>
<td>38 (32.2)</td>
<td>50 (29.6)</td>
<td>49 (41.5)</td>
<td>72 (43.1)</td>
<td>56 (47.5)</td>
<td>66 (39.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Never</strong></td>
<td>6 (5.1)</td>
<td>6 (3.6)</td>
<td>13 (11.0)</td>
<td>12 (7.2)</td>
<td>5 (4.2)</td>
<td>4 (2.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U=10,001, z=.045, p=.964</td>
<td>U=, z=.467, p=.641</td>
<td>U=13,307, z=1.062, p=.288</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Green Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td>T0/T0-T2 Only</td>
<td>T0-T2-T4 match</td>
<td></td>
</tr>
<tr>
<td><strong>Daily</strong></td>
<td>88 (73.9)</td>
<td>105 (63.3)</td>
<td>90 (75.6)</td>
<td>111 (66.1)</td>
<td>52 (44.1)</td>
<td>78 (46.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2-4 Times/wk</strong></td>
<td>23 (19.3)</td>
<td>53 (31.9)</td>
<td>24 (20.2)</td>
<td>44 (26.2)</td>
<td>43 (36.4)</td>
<td>43 (25.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Once per week</strong></td>
<td>5 (4.2)</td>
<td>6 (3.6)</td>
<td>3 (2.5)</td>
<td>8 (4.8)</td>
<td>15 (12.7)</td>
<td>23 (13.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt; Once per week</strong></td>
<td>2 (1.7)</td>
<td>1 (0.6)</td>
<td>2 (1.7)</td>
<td>4 (2.4)</td>
<td>6 (5.1)</td>
<td>17 (10.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Never</strong></td>
<td>1 (0.8)</td>
<td>1 (0.6)</td>
<td>0 (0.0)</td>
<td>1 (0.6)</td>
<td>2 (1.7)</td>
<td>7 (4.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U=10,810, z=1.661, p=.097</td>
<td>U=10,998, z=1.804, p=.071</td>
<td>U=10,286, z=.580, p=.562</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 9A  
**Cook Islands cohort characteristics by year of intervention (2014 and 2015)**

<table>
<thead>
<tr>
<th>Intervention participation</th>
<th>Evaluation Participants 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes</td>
<td>Students</td>
</tr>
<tr>
<td>Year 9</td>
<td>5</td>
</tr>
<tr>
<td>Year 11</td>
<td>5</td>
</tr>
<tr>
<td>All</td>
<td>10</td>
</tr>
</tbody>
</table>

| School A [Year 7-11] | Year 9 | 1 | 37 | 25.3 | 19 | 51.4 | 17 | 24.6 | 89.5 | 17 | 38.6 | 89.5 | 16 | 40.0 | 84.2 |
| Year 11 | 1 | 19 | 19.2 | 10 | 52.6 | 6 | 22.5 | 90.0 | 9 | 22.5 | 90.0 | 6 | 22.2 | 60.0 |
| School B [Year 9 – 13] | Year 9 | 4 | 109 | 74.7 | 67 | 61.5 | 52 | 75.4 | 77.6 | 27 | 61.4 | 40.3 | 24 | 60.0 | 35.8 |
| Year 11 | 3 | 69 | 69.7 | 24 | 34.8 | 21 | 52.5 | 87.5 | 15 | 55.6 | 62.5 | 13 | 52.0 | 54.2 |
| School C [Year 7 - 11] | Year 9 | 0 | 0 | 0 | n/a | 0 | n/a | n/a | 0 | n/a | n/a | 6 | 22.2 | 54.5 |
| Year 11 | 1 | 11 | 11.1 | 11 | 100.0 | 10 | 25.0 | 90.9 | 6 | 22.2 | 54.5 | 6 | 24.0 | 54.5 |

| Gender | Year 9 | Male | 118 | 48.4 | 62 | 52.5 | 49 | 45.0 | 79.0 | 32 | 45.1 | 51.6 | 29 | 44.6 | 46.8 |
| Female | 126 | 51.6 | 69 | 54.8 | 60 | 55.0 | 87.0 | 39 | 54.9 | 56.5 | 36 | 55.4 | 52.2 |
| Year 11 | Male | 67 | 46.2 | 40 | 59.7 | 31 | 44.9 | 77.5 | 20 | 45.5 | 50.0 | 19 | 47.5 | 47.5 |
| Female | 78 | 53.8 | 46 | 59.0 | 38 | 55.1 | 82.6 | 24 | 54.5 | 52.2 | 21 | 52.5 | 45.7 |

<table>
<thead>
<tr>
<th>Median age at intervention [Inter-quartile range]</th>
<th>All</th>
<th>Year 9</th>
<th>Year 11</th>
<th>14y2m [13y7m to 15y4m]</th>
<th>14y0m [13y7m to 15y2m]</th>
<th>14y0m [13y7m to 15y2m]</th>
<th>14y0m [13y7m to 15y2m]</th>
<th>13y11m [13y6m to 15y4m]</th>
<th>13y11m [13y6m to 15y4m]</th>
<th>13y11m [13y6m to 15y4m]</th>
<th>13y11m [13y6m to 15y4m]</th>
<th>13y11m [13y6m to 15y4m]</th>
<th>13y11m [13y6m to 15y4m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Islands Māori</td>
<td>223</td>
<td>93.7</td>
<td>124</td>
<td>55.6</td>
<td>105</td>
<td>96.3</td>
<td>84.7</td>
<td>70</td>
<td>98.6</td>
<td>56.5</td>
<td>65</td>
<td>100.0</td>
<td>52.4</td>
</tr>
<tr>
<td>All</td>
<td>9</td>
<td>3.8</td>
<td>4</td>
<td>44.4</td>
<td>2</td>
<td>1.8</td>
<td>50.0</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other Pacific</td>
<td>4</td>
<td>1.7</td>
<td>3</td>
<td>75.0</td>
<td>2</td>
<td>1.8</td>
<td>66.7</td>
<td>1</td>
<td>1.4</td>
<td>33.3</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0.8</td>
<td>0</td>
<td>0.0</td>
<td>2</td>
<td>0.0</td>
<td>n/a</td>
<td>0</td>
<td>0.0</td>
<td>n/a</td>
<td>0</td>
<td>0.0</td>
<td>n/a</td>
</tr>
</tbody>
</table>

| Ethnicity | Year 9 | Cook Islands Māori | 130 | 92.9 | 81 | 62.3 | 66 | 95.7 | 81.5 | 43 | 97.7 | 53.1 | 40 | 100.0 | 49.4 |
| New Zealand | 7 | 5.0 | 2 | 28.6 | 1 | 1.4 | 50.0 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 |
| Other Pacific | 3 | 2.1 | 3 | 100.0 | 2 | 2.9 | 66.7 | 1 | 2.3 | 33.3 | 0 | 0.0 | 0.0 |
| Other | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | n/a | 0 | 0.0 | n/a | 0 | 0.0 | n/a |

| Year 11 | Cook Islands Māori | 93 | 94.9 | 43 | 46.2 | 39 | 97.5 | 90.7 | 27 | 100.0 | 62.8 | 25 | 100.0 | 58.1 |
| New Zealand | 2 | 2.0 | 2 | 100.0 | 1 | 2.5 | 50.0 | 0 | 0.0 | 0.0 | 0 | 0.0 | n/a |
| Other Pacific | 1 | 1.0 | 0 | 0.0 | 0 | 0.0 | n/a | 0 | 0.0 | n/a | 0 | 0.0 | n/a |
| Other | 2 | 2.0 | 0 | 0.0 | 0 | 0.0 | n/a | 0 | 0.0 | n/a | 0 | 0.0 | n/a |
### Appendix 9A | Cook Islands cohort characteristics by year of intervention (2014 and 2015)

<table>
<thead>
<tr>
<th>Intervention participation 2015</th>
<th>T0</th>
<th>% Intervention cohort</th>
<th>T0 - T2</th>
<th>Evaluation Participants 2015</th>
<th>T0 - T4</th>
<th>T0 - T4 - T0 Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classes</td>
<td>Students</td>
<td></td>
<td>Matched</td>
<td>62.9</td>
<td>87.0</td>
</tr>
<tr>
<td>Year 9</td>
<td>6</td>
<td>161</td>
<td>63.9</td>
<td>154</td>
<td>95.7</td>
<td>134</td>
</tr>
<tr>
<td>Year 11</td>
<td>5</td>
<td>91</td>
<td>36.1</td>
<td>86</td>
<td>94.5</td>
<td>79</td>
</tr>
<tr>
<td>All</td>
<td>11</td>
<td>252</td>
<td></td>
<td>240</td>
<td>95.2</td>
<td>213</td>
</tr>
<tr>
<td>School A (Year 7-11)</td>
<td>Year 9</td>
<td>1</td>
<td>33</td>
<td>20.5</td>
<td>31</td>
<td>93.9</td>
</tr>
<tr>
<td>Year 11</td>
<td>1</td>
<td>21</td>
<td>23.1</td>
<td>20</td>
<td>95.2</td>
<td>15</td>
</tr>
<tr>
<td>School B (Year 9 – 13)</td>
<td>Year 9</td>
<td>4</td>
<td>115</td>
<td>71.4</td>
<td>112</td>
<td>97.4</td>
</tr>
<tr>
<td>Year 11</td>
<td>3</td>
<td>61</td>
<td>67.0</td>
<td>58</td>
<td>95.1</td>
<td>57</td>
</tr>
<tr>
<td>School C (Year 7 - 11)</td>
<td>Year 9</td>
<td>1</td>
<td>13</td>
<td>8.1</td>
<td>11</td>
<td>84.6</td>
</tr>
<tr>
<td>Year 11</td>
<td>1</td>
<td>9</td>
<td>9.9</td>
<td>8</td>
<td>88.9</td>
<td>7</td>
</tr>
</tbody>
</table>

#### Gender

| Year 9 | Male | 125 | 49.6 | 118 | 94.4 | 105 | 49.3 | 89.0 | 94 | 49.7 | 79.7 | 91 | 50.3 | 77.1 |
|        | Female | 127 | 50.4 | 122 | 96.1 | 108 | 50.7 | 88.5 | 95 | 50.3 | 77.9 | 90 | 49.7 | 73.8 |
| Year 11 | Male | 85 | 52.8 | 81 | 95.3 | 71 | 53.0 | 87.7 | 68 | 53.1 | 84.0 | 66 | 53.7 | 81.5 |
|        | Female | 76 | 47.2 | 73 | 96.1 | 63 | 47.0 | 86.3 | 60 | 46.9 | 82.2 | 57 | 46.3 | 78.1 |

#### Median age at intervention [Inter-quartile range]

| Year 9 | 14y2m [13y9m to 15y4m] | 14y0m [13y9m to 15y1m] | 14y1m [13y9m to 15y4m] | 14y1m [13y9m to 15y2m] | 13y11m [13y7m to 14y1m] | 13y11m [13y7m to 15y2m] | 13y6m [15y2m to 15y11m] | 13y6m [15y2m to 15y5m] | 13y11m [13y7m to 14y1m] | 15y6m [15y2m to 15y9m] | 15y11m [13y7m to 14y1m] | 15y6m [15y2m to 15y9m] |
|---------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| All     | 234 | 92.9 | 223 | 95.3 | 200 | 94.8 | 89.7 | 178 | 94.7 | 79.8 | 172 | 95.6 | 77.1 |
| New Zealand | 6 | 2.4 | 5 | 83.3 | 4 | 1.9 | 80.0 | 3 | 1.6 | 60.0 | 3 | 1.7 | 60.0 |
| Other Pacific | 8 | 3.2 | 7 | 87.5 | 4 | 1.9 | 57.1 | 5 | 2.7 | 71.4 | 3 | 1.7 | 42.9 |
| Other | 4 | 1.6 | 3 | 75.0 | 3 | 1.4 | 100.0 | 2 | 1.1 | 66.7 | 2 | 1.1 | 66.7 |
| Year 9 | 154 | 95.7 | 148 | 96.1 | 130 | 97.7 | 87.8 | 125 | 98.4 | 84.5 | 120 | 98.4 | 81.1 |
| New Zealand | 4 | 2.5 | 3 | 75.0 | 2 | 1.5 | 66.7 | 1 | 0.8 | 33.3 | 1 | 0.8 | 33.3 |
| Other Pacific | 2 | 1.2 | 2 | 100.0 | 1 | 0.8 | 50.0 | 1 | 0.8 | 50.0 | 1 | 0.8 | 50.0 |
| Other | 1 | 0.6 | 0 | 0.0 | 0 | 0.0 | na | 0 | 0.0 | na | 0 | 0.0 | na |
| Year 11 | 80 | 87.9 | 75 | 93.8 | 70 | 89.7 | 93.3 | 53 | 86.9 | 70.7 | 52 | 89.7 | 69.3 |
| New Zealand | 2 | 2.2 | 2 | 100.0 | 2 | 2.6 | 100.0 | 2 | 3.3 | 100.0 | 2 | 3.4 | 100.0 |
| Other Pacific | 6 | 6.6 | 5 | 83.3 | 3 | 3.8 | 60.0 | 4 | 6.6 | 80.0 | 2 | 3.4 | 40.0 |
| Other | 3 | 3.3 | 3 | 100.0 | 3 | 3.8 | 100.0 | 2 | 3.3 | 66.7 | 2 | 3.4 | 66.7 |
## Appendix 10A Science Achievement Objectives,

<table>
<thead>
<tr>
<th>Understanding about Science</th>
<th>Curriculum Level 4 (Years 7 – 9)</th>
<th>Curriculum Level 5 (Years 9-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appreciate that science is a way of explaining the world and that science knowledge changes over time. Identify ways in which scientists work together and provide evidence to support their ideas.</td>
<td>Understand that scientists’ investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument.</td>
<td></td>
</tr>
<tr>
<td>Investigating in science</td>
<td>Build on prior experiences, working together to share and examine their own and others’ knowledge. Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.</td>
<td>Develop and carry out more complex investigations, including using models. Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables.</td>
</tr>
<tr>
<td>Communicating in science</td>
<td>Begin to use a range of scientific symbols, conventions, and vocabulary. Engage with a range of science texts and begin to question the purposes for which these texts are constructed.</td>
<td>Use a wider range of science vocabulary, symbols, and conventions. Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).</td>
</tr>
<tr>
<td>Participating and contributing</td>
<td>Use their growing science knowledge when considering issues of concern to them. Explore various aspects of an issue and make decisions about possible actions.</td>
<td>Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.</td>
</tr>
</tbody>
</table>

### New Zealand

<table>
<thead>
<tr>
<th>Life processes</th>
<th>Recognise that there are life processes common to all living things and that these occur in different ways. Identify the key structural features and functions involved in the life processes of plants and animals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>Explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced. Investigate the interdependence of living things (including humans) in an ecosystem.</td>
</tr>
</tbody>
</table>

### Cook Islands

<table>
<thead>
<tr>
<th>Science and Society</th>
<th>Develop an awareness and understanding of how science affects society and how society promotes or constrains science. Identify and compare the views of different groups of people about a given scientific issue and how it has promoted or constrained science.</th>
</tr>
</thead>
</table>

### Scientific Skills

<table>
<thead>
<tr>
<th>Focusing and Planning</th>
<th>Use their prior knowledge and observations to suggest solutions to questions. Start to design a test to trial their solutions. Consider the idea of controls. Make testable predictions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Gathering</td>
<td>Write and complete a survey to find out other peoples ideas. Take measurements and record observations using appropriate equipment for enhancement. Select and use instruments to make quantitative and qualitative observations.</td>
</tr>
<tr>
<td>Processing and Interpreting</td>
<td>Group findings according to common features or outcomes. Find trends or patterns - make links from organized data. Analyse data using statistical and graphing procedures.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Write a report of what they found out. Use scientific report structure, e.g. title, aim, method, results, conclusions. Write reports that include processed relevant data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living World</th>
<th>Investigate how particular structures and functions allow plants and animals to survive.</th>
</tr>
</thead>
</table>
Appendix 10B  Meet a Scientist Learning Resources New Zealand

Meet-a-Scientist

teacher instructions

Meet-a-Scientist Activity

An important part of the LENscience Face-to-Face classroom programmes are the Meet-a-Scientist sessions. This is a 30 minute, small group discussion between scientists (includes researchers, postgrad students, technicians, lecturers and clinicians) and school students, split into two 15 minute sessions.

This is an opportunity for students to start understanding the breadth of science research in the community, and participate in discussions with the people involved in creating science knowledge. Three scientists are invited to participate in each of the day programmes and students will have an opportunity to meet two of the three scientists present.

Our research evidence has shown how student perceptions of scientists develop after having opportunities to meet with scientists and reflect on these experiences.

What students need to do

**pre-visit**

**HYPOTHESIS FORMATION**
- What skills and characteristics do you think a scientist might need.
- Develop questions to test this hypothesis during your visit to LENScience.
  - Complete TASK 1: Hypothesis
  - Complete TASK 2: Testing your hypothesis (skill or characteristic, our question)

**Face-to-Face classroom experience**

**MEET-a-SCIENTIST**
- Data collection - asking scientists about skills and characteristics needed to do their work
  - Complete TASK 2: The hypothesis/scientist's response

**post-visit**

- Sharing data with others in the classroom
- Analysing class data on predictions about scientists
- Upload your class ideas online and share with other schools
  - Complete TASK 3: Who did we meet?
  - Complete TASK 4: Were our predictions correct?
Think Like a Kaipūtaiao

Science/Putāiao is a way of exploring and understanding the world, the universe and all living and non-living things. This includes people and how they interact with the world, with other living things, and with each other.

PEOPLE of EVERY CULTURE have been exploring the natural, physical, technological and social worlds for thousands of years. In modern times we have more tools to help us explore!

Science/Putāiao is about ASKING QUESTIONS, and using EVIDENCE to make DECISIONS.

1. Ask a QUESTION
2. Gather INFORMATION
3. Make a PREDICTION
4. TEST your PREDICTION using experiments, models, observations or surveys.
5. PROCESS your DATA and ANALYSE the EVIDENCE
6. SHARE your FINDINGS with other scientists and with the community.

Who is a Scientist?

kaipūtaiao

What skills & characteristics does a scientist need?
**Meet-a-Scientist**

**kaipūtaiao**

What are the SKILLS and CHARACTERISTICS that you would expect to find in person who is a kaipūtaiao/scientist or researcher?

**TASK 1: Hypothesis** *(to be completed at school)*

In your group, create a list of skills and a list of personality traits or characteristics that you think a scientist or a researcher might need or might find useful.

---

### Meet-a-Scientist

**TASK 2: Testing your hypothesis**

You will have an opportunity to meet at least TWO different people who are scientists or researchers. In your group, write at least THREE questions to test your hypothesis.

Your questions need to test out whether the skills or characteristics you PREDICTED would be useful for a kaipūtaiao/scientist, are found in the people you meet.

<table>
<thead>
<tr>
<th>Skill or Characteristic</th>
<th>Our question</th>
<th>The kaipūtaiao/scientists or researchers response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>(to be completed at school)</em></td>
<td><em>(to be completed at the Liggins Institute)</em></td>
</tr>
<tr>
<td>Being good with numbers and maths</td>
<td>Do you enjoy working with numbers and doing maths?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you use maths skills in your job?</td>
<td></td>
</tr>
</tbody>
</table>
Meet-a-Scientist

TASK 3: Who did we meet?
(You will be given this information about the kaipōtakaro/scientist you met at the Liggin Institute)

WORK WITH YOUR WHOLE CLASS:
Complete the table about the kaipōtakaro/scientists that you met...

The kaipōtakaro/scientists and researchers we met...

<table>
<thead>
<tr>
<th>Name</th>
<th>What kind of work do they do?</th>
<th>Where do they work?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Meet-a-Scientist

TASK 4: Were our predictions correct?
(To be completed at school)

WORK WITH YOUR WHOLE CLASS: Complete the table to show what you learnt about the skills and characteristics that scientists have from your conversations with scientists.

Some of the skills and characteristics of the kaipōtakaro/scientists we met...

<table>
<thead>
<tr>
<th>SKILLS or CHARACTERISTICS we predicted the scientists would have?</th>
<th>Was our prediction right?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YES</td>
</tr>
</tbody>
</table>

Other SKILLS or CHARACTERISTICS we found that the kaipōtakaro/scientists had...
Appendix 10C  Meet a Scientist Learning Resources Cook Islands

This file contains pages 26-30 from the Cook Islands HSLEAP learning resource, including student worksheets (Bay and Yaqona, 2016).

Kimi Manako mei te Taunga Taieni

Science is a way of exploring and understanding the world, the universe and all living and non-living things. This includes people and how they interact with the world, with other living things, and with each other.

PEOPLE of EVERY CULTURE have been exploring the natural, physical, technological and social worlds for thousands of years. In modern times we have more tools to help us explore.

TAINI is about ASKING QUESTIONS, and using EVIDENCE to make DECISIONS.

Who is a Scientist?

Taunga Taieni

What types of skills and characteristics do scientists need?
Appendix 10C | Meet a Scientist Learning Resources Cook Islands

Scientists Are People In Our Community

Dr Nele Tamanae Herman is a Public Health Scientist in the Cook Islands. Nele studied in Fiji, Australia and New Zealand. She has worked as a nurse and held a number of senior positions within the Cook Islands Ministry of Health. Her research looked into developing a way to improve health and wellbeing, focusing on mental health and helping youth to be the best they can be.

Today Nele is the Director of Community Health Services for the Cook Islands Ministry of Health.

Jacquie Evans is an Environmental Scientist in the Cook Islands.

Jacquie studied in Hawai’i and Fiji. She has worked on fisheries surveillance, marine education, marine life conservation, environmental science, wastewater management and has established marine protected areas. Today Jacquie’s main role is Marine Protection and Media Liaison for the Cook Islands Government.

Chris Maka is an Environmental Scientist in Thailand.

Chris studied in Hawai’i and Fiji. He manages the design and implementation of overseas and projects including USAID and the United Nations Development Programme.

Today Chris works at the AECOM Asia Pacific Region Office. AECOM is a company that provides services such as architecture, engineering and design for people wanting to build really big projects, like a whole new school.

His main role is specialising in rural and coastal infrastructure in Thailand.

Dr Amanda Noonoo-Hill is a medical doctor and lecturer in Fiji. Dr Noonoo-Hill received her Doctor of Medicine in Fiji. She has been involved in various research projects in Canada and with the World Health Organization. Her research looked at things that could go wrong when you are pregnant. Today she is working as a medical doctor and lecturer in Fiji. Her main role is to teach students studying medicine about pregnancy.

Dr Teina Rongo is a Climate Scientist and a Marine Biologist in the Cook Islands. Dr Rongo studied at the Florida Institute of Technology in the USA, and is recognised as the only locally based Cook Islander with a doctorate in Marine Biology (a doctorate is when you do six to seven years of research at university). He studied ciguatera, the sickness you can get after eating infected red fish. Today he is the Climate Change Advisor for the Cook Island’s Prime Minister.

Mr Kahi Mason is a Paediatric Surgeon based in Christchurch.

Kahi studied in New Zealand, and is one of New Zealand’s and the Pacific’s leading surgeons. He has helped to develop health services for countries throughout the Pacific region and is involved in the training of doctors and nurses. He is an Associate Dean Pacific and a Senior Lecturer in Paediatric Surgery at the University of Otago. He provides advice to the Cook Islands Ministry of Health. He is the President of Pa’ihiia Medical Association and the chairperson of several boards.

Collect ACTIVITY 3D from your teacher and prepare 5 questions to ask a scientist.
Meet a Scientist

Taunga Taieni

What are the SKILLS and CHARACTERISTICS that you would expect to find in person who is a taunga taieni, a researcher or a scientist?

**TASK 1: Hypothesis**

In your group, create a list of skills and a list of personality traits or characteristics that you think a scientist or a researcher might need or might find useful.

**SKILLS**

**CHARACTERISTICS**

**TASK 2: Testing Your Hypothesis**

You will have an opportunity to meet at least TWO different people who are scientists or researchers. In YOUR group, write at least THREE questions to test your hypothesis.

Your questions need to test out whether the skills or characteristics you PREDICTED would be useful for taunga talent / scientists and researchers are found in the people you meet.

<table>
<thead>
<tr>
<th>Skill or Characteristic</th>
<th>Our question</th>
<th>The scientists/researchers response</th>
</tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>Do you use maths skills in your job?</td>
<td></td>
</tr>
</tbody>
</table>
Meet a Scientist

TASK 3: Who Did We Meet?
WORK WITH YOUR WHOLE CLASS: Complete the table about the scientists / taunga taini or researchers that you met...

The taunga taini / scientists and researchers we met...

<table>
<thead>
<tr>
<th>Name</th>
<th>What kind of work do they do?</th>
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<tr>
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<td></td>
<td></td>
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</tbody>
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TASK 4: Were Our Predictions Correct?
WORK WITH YOUR WHOLE CLASS: Complete the table to show what you learnt about the skills and characteristics that scientists have from your conversations with scientists.

Some of the skills and characteristics of the taunga taini / scientists and researchers we met...

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</thead>
<tbody>
<tr>
<td></td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>NO</td>
</tr>
</tbody>
</table>

Other SKILLS or CHARACTERISTICS we found that the scientists had...
Appendix 12 Authorship Administration Forms

Co-Authorship Form

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. Please include one copy of this form for each co-authored work. Completed forms should be included in all copies of your thesis submitted for examination and library deposit (including digital deposit), following your thesis Acknowledgements.

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

The co-authored work is within Chapters 2/3.

This has been published as: Bay J.L., Morton S.M., Vickers M.H., Realizing the Potential of Adolescence to Prevent Transgenerational Conditioning of Noncommunicable Disease Risk: Multi-Sectoral Design Frameworks. Healthcare, 2016, 4,39.

Nature of contribution by PhD candidate

Lead author and collaboration lead:
- Wrote the grant application proposing the development of the collaboration from which this paper has emerged, as specified in the grant proposal;
- Led research workshops that contributed to the development of the manuscript;
- Drafted the initial version of the manuscript and led the writing process, combining perspectives from authors to create the submitted manuscript;
- Led review discussions with the authors following feedback from the journal;
- Wrote the final manuscript.

Extent of contribution by PhD candidate (%)

90%

CO-AUTHORS

Name | Nature of Contribution
--- | ---
Susan Morton | Co-author - Perspectives on Public health collaborating with education - NCD risk reduction
Mark Vickers | Co-author - Perspective: DOHaD/NCD theory & physiology; science community collaboration with education, public health and community; education-science-health partnerships

Certification by Co-Authors

The undersigned hereby certify that:
- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
- in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

<table>
<thead>
<tr>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susan Morton</td>
<td>[Signature]</td>
<td>1/03/2017</td>
</tr>
<tr>
<td>Mark Vickers</td>
<td>[Signature]</td>
<td>1/03/2017</td>
</tr>
</tbody>
</table>

Last updated: 25 March 2013
Co-Authorship Form

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Please indicate the character(s)/section(s) of the thesis that are co-authored and give the title and publication details or details of submission of the co-authored work.

The co-authored work is within Chapter 3.


Nature of contribution by PhD candidate

Lead author and collaboration (n/a):
- Wrote the grant application proposing the development of the collaboration from which this paper has emerged, as specified in the grant proposal;
- Led research workshops that contributed to the development of the manuscript;
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<table>
<thead>
<tr>
<th>Name</th>
<th>Nature of Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosemary Hopkins</td>
<td>Co-author - Perspective: Pedagogy, curriculum and assessment</td>
</tr>
<tr>
<td>Kamran Siddiqi</td>
<td>Co-author - Perspective: Public health collaborating with education - NCD risk reduction</td>
</tr>
<tr>
<td>Rumana Haque</td>
<td>Co-author - Perspective: Public health collaborating with education - NCD risk reduction</td>
</tr>
<tr>
<td>Robyn Dixon</td>
<td>Co-author - Perspective: Public health - health literacy</td>
</tr>
<tr>
<td>Debra Shirley</td>
<td>Co-author - Perspective: Public health - physical activity</td>
</tr>
<tr>
<td>Karen Taran</td>
<td>Co-author - Perspective: Public health collaborating with education - NCD risk reduction</td>
</tr>
<tr>
<td>Delaney Vagnozzi</td>
<td>Co-author - Perspective: Education collaborating with public health - NCD risk reduction</td>
</tr>
<tr>
<td>Amanda Mason-Jones</td>
<td>Co-author - Perspective: Public health - health literacy and NCD risk reduction</td>
</tr>
<tr>
<td>Nick Vickers</td>
<td>Co-author - Perspective: DQ5054 physiology collaborating with education &amp; public health</td>
</tr>
</tbody>
</table>

Certification by Co-Authors

The undersigned hereby certify that:

Φ The above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Φ In cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

<table>
<thead>
<tr>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosemary Hopkins</td>
<td>[Signature]</td>
<td>06/03/2017</td>
</tr>
<tr>
<td>Kamran Siddiqi</td>
<td>[Signature]</td>
<td>03/06/17</td>
</tr>
<tr>
<td>Rumana Haque</td>
<td>[Signature]</td>
<td>02/03/2017</td>
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<tr>
<td>Amanda Mason-Jones</td>
<td>[Signature]</td>
<td>27/03/17</td>
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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

The co-authored work is within Chapter 9.

This has been published as: Bay J.L., Vickers M.H., Adolescent education: an opportunity to create a Developmental Origins of Health and Disease (DOHaD) circuit breaker. Journal of Developmental Origins of Health and Disease, 2016, 7, 501-504

### Nature of contribution by PhD candidate

- **Lead author and collaboration lead:**
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  - Led research workshops that contributed to the development of the manuscript;
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  - Led review discussions with the authors following feedback from the journal;
  - Wrote the final manuscript.

### Extent of contribution by PhD candidate (%)

- 90%

## Co-authors

<table>
<thead>
<tr>
<th>Name</th>
<th>Nature of Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark Vickers</td>
<td>Co-author - Perspectives on DOHaD health literacy collaboration with education &amp; public health &amp; NCD risk reduction.</td>
</tr>
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</table>

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<tbody>
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<td>Mark Vickers</td>
<td>[Signature]</td>
<td>2/03/2017</td>
</tr>
</tbody>
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Last updated: 25 March 2015
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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

The co-authored work is within Chapter B.


Nature of contribution by PhD candidate

- Lead author and collaboration lead:
  - Wrote the grant application proposing the development of the collaboration from which this paper has emerged, as specified in the grant proposal;
  - Led research workshops that contributed to the development of the manuscript;
  - Drafted the initial version of the manuscript and led the writing process, combining perspectives from authors to create the submitted manuscript;
  - Led review discussions with the authors following feedback from the journal;
  - Wrote the final manuscript.

Extent of contribution by PhD candidate (%)

80%

CO-AUTHORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Nature of Contribution</th>
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<td>Co-author-Teacher: student instruction, data collection, recording, coding, analysing &amp; interpreting</td>
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<td>Emeli Pounamu</td>
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Last updated: 25 March 2013
Co-Authorship Form

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. Please include one copy of this form for each co-authored work. Completed forms should be included in all copies of your thesis submitted for examination and library deposit (including digital deposit), following your thesis Acknowledgements.

Nature of contribution by PhD candidate:
- Lead author and collaboration (led):
  - Wrote the grant application (leading the development of the collaboration from which this paper has emerged), as specified in the grant proposal;
  - Led research workshops that contributed to the development of the manuscript;
  - Drafted the initial version of the manuscript and led the writing process, combining perspectives from authors to create the current manuscript;
  - Led review discussions with the authors following feedback from the journal;
  - Wrote the final manuscript.

Extent of contribution by PhD candidate (%): 100%

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<td>Mark Vickers</td>
<td>Co-author - Perspectives on OMEGAS/KICES theory &amp; methodology; science community collaboration with educators, public health and community; education-science-health partnerships; provided assistance with research, professional development.</td>
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<td>Helen Mora</td>
<td>Participated in teacher professional development, study &amp; intervention tool design</td>
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<td>Deborah Sloboda</td>
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<td>Susan Martin</td>
<td>Co-author - Perspectives on Public Health collaboration with education - NCD risk reduction</td>
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Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate’s contribution to this work, and the nature of the contribution of each of the co-authors; and
- in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

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