

Science and Mathematics Education Centre

**Engaging with Controversial Science Issues – A Professional
Learning Programme for Secondary Science Teachers in
New Zealand**

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Doctor of Science Education
of
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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: *K. Saunders*

Date: *6-02-09*

ABSTRACT

Internationally there is concern that many science teachers do not address controversial science issues in their science classrooms, and there is a perception amongst many science teachers that science is about the delivery of facts, and that it is value-free. However with the increasingly complex, science-based dilemmas being presented to society, there is a growing call for future citizens to be more scientifically literate and to be able to make informed decisions on issues related to these dilemmas. There have been shifts in science curricula internationally, and in New Zealand, towards a focus on scientific literacy, but changes in teachers' pedagogical practice have not been widespread. The demands and challenges for teachers are high and to make such changes requires support and guidance.

Because of the paucity of literature available about teaching controversial science issues in New Zealand science classrooms, the purpose of this project was to firstly establish the current status of the teaching and learning about issues and to identify the support that teachers felt they required to address this in science classrooms. This information then informed the development of a professional learning programme to provide support for teachers. The project took a mixed-method approach and proceeded in three phases, with Phase One involving the development and administration of a survey to secondary teachers in the North Island of New Zealand, with follow-up interviews with some survey participants. The qualitative and quantitative data gathered enabled the current scene to be established. Phase Two involved the use of data from Phase One, together with information obtained mainly from the literature review, to design a professional learning programme, the focus of which was the development of a model for ethical inquiry. Phase Three involved two workshops, separated by eleven weeks, in which four teachers critiqued, trialled and evaluated the model in the classroom. A series of case studies was developed from each trial, with a cross-case analysis made to validate the usefulness of the model.

The findings of the survey and interviews indicated that to address controversial issues, there was a need to move New Zealand teachers away from a focus on content, towards a pedagogy that focused on ethical inquiry and the appropriate use of strategies and approaches to support this. The findings from the

professional learning programme confirmed that teachers had been supported in addressing controversial science issues by the use of the model for ethical inquiry and positive outcomes were reported for both teachers and students.

The project provided current information about how controversial science issues are addressed in New Zealand secondary science classrooms and validated the model for ethical inquiry in supporting teachers to address controversial science in the light of impending and changing requirements of *The New Zealand Curriculum* (2007) towards informed citizenry and scientific literacy. The project also supplements the very small amount of research that has been carried out in a New Zealand context on addressing controversial science issues in secondary science classrooms.

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CHAPTER 1: INTRODUCTION AND BACKGROUND

Overview

This chapter provides a rationale for my research into the teaching and learning about controversial science issues in New Zealand secondary science classrooms. It firstly provides an introduction to the research project, followed by a reflective account of my personal experiences that led to the development of the project. A background for this project is presented and supported by the identification of a lack of literature and classroom-based research in a New Zealand context on both the teaching of, and learning about, controversial science issues. The specific research questions are introduced and the research methodology used to answer the questions is outlined. The significance of the project is then discussed before finally providing an overview of this thesis.

Introduction

With the unfolding of the twenty-first century, science and technology are increasingly important and central in our lives, and as new science-based dilemmas are presented to us, there is an increased recognition of the need for citizens in today's society to be able to consider the implications of the emerging issues and make informed decisions related to these issues.

The call therefore by science education for scientifically literate citizenship is prominent (for example see arguments by Bybee, 1997; Dawson, 2001, 2006; Driver, Newton, & Osborne, 2000; Goodrum, Hackling, & Rennie, 2001; Jenkins, 1999; Osborne & Collins, 2000; Reiss, 2007; Van Rooy, 2004). One has only to listen to the news, or read a newspaper, to see and hear about science-based issues such as genetic engineering, cloning, genetic screening of embryos, use of mobile phones, use of nuclear power, vaccinations and environmental degradation. Our students need to be able to engage with, and debate such issues as informed, responsible future citizens. Zembylas (2005) claimed that "all citizens have the right and the responsibility to become scientifically literate" (p. 711), and Van Rooy (2004) also suggested that young people need to have an understanding of science knowledge so that they can develop their own social, ethical and moral perspectives to become informed, responsive and responsible global citizens. Aikenhead (2006)

elaborated further when he stated that students should not only be able to understand how science is related to daily activities, personal problems, social issues and global concerns, but also be able to critically evaluate the information that is presented to them.

Traditionally science education has dealt with well established, secure science knowledge that is unequivocal, uncontested and unquestioned (Claxton, 1991; Hodson, 2003). The model of the expert teacher, using a narrow range of transmissive pedagogies to deliver non-negotiable and stable science concepts to students, which are infrequently linked to everyday life, is still representative of school science (Lyons, 2006; Newton, Driver, & Osborne, 1999; Osborne & Collins, 2000). Aikenhead (2006) argued that traditional school science with its “canonical” delivery does not meet the needs of students, especially indigenous students, and that the “humanistic” science that emerges within issues is of greater interest and relevance to them. Hipkins (2006) argued for an emphasis of curriculum change, based on Latour’s (2004) idea, in which by shifting the emphasis of science education from “matters of fact” to “matters of concern”, would mean that issues are brought substantially into the curriculum.

The literature acknowledges a large number of purposes for including teaching and learning about controversial science issues in science classrooms, and these range from the wider aims of informed citizenry and the development of scientific literacy, to other more specific purposes such as development of science content knowledge, critical thinking skills, the development of ethical knowledge and deliberation, and increased motivation and interest in science.

In a large study carried out in the United Kingdom by Levinson and Turner (2001), almost half of all science teachers interviewed felt that the teaching of science should be value-free. However, the idea of science being value-neutral or value-free contrasts with today’s world where the complex nature of science in society shows that the separation of science from the society within which it exists, is no longer possible (Allchin, 1999; Claxton, 1997; Hall, 1998; Hildebrand, 2007; Levinson & Turner, 2001; Lloyd & Wallace, 2004).

There is a growing call in the international literature for teaching and learning about controversial science issues to be incorporated within science education

curricula (Driver et al., 2000; Hodson, 2003; Kolsto, 2001a; Patronis, Potari, & Spiliotopoulou, 1999; Zeidler, 2003). There have been shifts in science curricula internationally and governments, science educator researchers, and science education associations recognise that informed decision-making about controversial science issues plays an important role in the development of scientific literacy. These curriculum changes represent a move from the content laden curriculum, towards a focus on scientific literacy and “ideas about science” (Goodrum et al., 2001).

However, the change in teacher pedagogy to accommodate this shift has not been widespread, and the culture of school science still reflects this (Baggot la Velle, Brawn, McFarlane, & John, 2004). The key nature of school science has been remarkably resilient to recommendations for change (Tytler, 2007b) and secondary schools still rely predominantly on transmissive pedagogies, alongside approaches and contexts that do not establish relevance or motivate and engage student interest (Lyons, 2006). A study by Ratcliffe and Grace (2003) noted the tension experienced by teachers as they moved away from the “normal” practice in which science is dominated by content knowledge and delivery of information, to their attempts to promote discussion about issues and ethical reasoning. Levinson and Turner (2001) also reported on the “culture shock” experienced by teachers and students when working with controversial science issues in which there is no ‘right’ answer, and about which more questions may be asked. Constraints such as lack of pedagogical knowledge, content backgrounding the issue, classroom resources, time and assessment issues, also make the teaching of science-based issues problematic for a majority of teachers (Dawson, 2001; Forbes & Davis, 2007; Levinson & Turner, 2001; Osborne, Erduran, & Simon, 2004; Reiss, 1999; Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Van Rooy, 1994, 2000).

If we wish scientific literacy to be an aim for science education, one aspect that science educators need to explore is how an understanding of the nature of science, argumentation and cultural issues interacts with ethical reasoning to contribute to the scientific literacy of our students as future citizens. However there are challenges for both teachers and students in working towards scientific literacy. The demands are high on teachers, and to make changes in their pedagogy will require support in terms of resources, as well as opportunities to be part of a professional learning community. This research project explores these challenges

and the provision of more specific guidance and support for teachers on the handling of controversial science issues in the classroom so that they can assist students to reason ethically as one aspect of working towards functional scientific literacy.

Critics might argue that these idealistic aims are beyond attainment in real-life science classrooms ...But if science educators are not aiming to help students lead productive lives, capable of thinking for themselves and equipped to participate meaningfully in society, then why do science educators teach? (American Association for the Advancement of Science, cited in Sadler, 2004)

Personal background of the researcher

The research focus for this thesis developed from my experiences of teaching and learning about issues during 25 years of teaching in New Zealand secondary schools, including acting as a Head of Department in biology and science. During that time, I had close involvement in various stages of the development, writing and implementation of the curriculum document *Science in the New Zealand Curriculum* (SiNZC) (Ministry of Education, 1993). In the initial stages of teaching controversial science issues in my secondary science classroom, my interest was ignited by attending CONASTA (Conference of the Australian Science Teachers' Association) in 1995 where I attended a session given by Vaille Dawson on the use of a resource put out by the Australian Kidney Foundation on Transplantations. This resource provided a suggested teaching programme, activities, video and worksheets based on human organ and tissue transplantations. On my return to New Zealand, I subsequently purchased the resource and used it as a context to teach part of the "Form and Function in Animals" unit that was required as part of a Year 12 biology programme. The unit reinforced my enthusiasm and belief in the value of student-centred and collaborative strategies, but what I found remarkable, was the high level of engagement and motivation of the students and their ability to begin to articulate and justify their decisions on the various issues surrounding transplantations.

I encouraged other biology teachers in the department to try using this context and a selection of the activities from the resource, but was unprepared for the high level of enthusiasm from my biology colleagues. Other staff would not sit with us at intervals or lunchtimes if we were going to continue talking about

transplantations! The biologists were working enthusiastically in a collaborative way that had not been previously experienced. The success of this teaching and learning unit, well supported by a resource kit, meant that I wanted to do more. I decided to work with some Year 10 gifted and talented students. Here was an opportunity to teach free of the assessment constraints that were present at the Year 12 level. I introduced some basic bioethical principles to these students to help them in their decision making and once again, the engagement and motivation level was high. I was also experiencing a change in my pedagogical base of teaching. At all levels, I was becoming more of a facilitator and my teaching and learning strategies were more student-centred and based around co-operative learning approaches. My students were more involved in discussion, questioning, making and justifying their decisions, and listening more to others than I had previously observed in my classrooms.

I presented a paper at SCICON (Conference of the NZ Science Teachers' Association) in 1998 on the teaching and learning programme delivered to our senior biology students. By this stage, I had begun working as a secondary science adviser, working with approximately 80 secondary schools in the mid North Island region of New Zealand. One aspect of my work was with senior biology teachers in encouraging them to teach ethical issues as required in the biology curriculum in an active way, rather than the passive approach commonly used, in which students were asked to research the issue individually and then write an essay for assessment in national examinations. During this time, I was a member of the expert panel in biology for the National Certificate of Educational Achievement (NCEA)¹, a New Zealand national qualification being established for senior secondary students. I was also a developer of achievement standards related to that qualification as well as a national examiner and moderator in science and biology. Through these experiences, I had become more aware of curriculum and qualification requirements, the importance of the learning environment, the use of relevant teaching contexts, and the value of a range of student-centred teaching approaches. I was continuing to

¹ National Certificate of Educational Achievement, the senior secondary qualification in New Zealand which is made up of a number of internally and externally assessed achievement standards.

actively promote the usefulness and relevance of teaching controversial science issues in a range of science curriculum areas as well as biology.

During one not-to-be-forgotten meeting that I was facilitating with the region's Heads of Science, I was advocating for issues-based teaching enthusiastically to the group, when one of the Heads of Science became agitated and started to shout that this was not science and "over my dead body will I teach such rubbish!" He then left the meeting and did not return. I was astounded! Up until now my work in this area had always been positively received and I had assumed that others felt similarly to me. It was clear that I needed to think more about this event, and I discussed with the group this apparent lack of enthusiasm. It became clear for a number of reasons, that not all teachers were feeling confident about teaching issues, and there were some that did not think that it was "science". I carried out further informal discussions with teachers in a range of venues and events and began to think that the notion of teaching controversial science issues needed further exploration.

I did some further reading about bioethics education, and became aware of the work of Michael Reiss and Ralph Levinson in the United Kingdom. Eventually I was fortunate to be able to spend time discussing bioethics with both of these people and decided that after listening to their experiences and reading some of their writings, that a New Zealand context would be a worthwhile area of study. I was aware of my lack of depth and experience in formal research, so in 2000 I embarked on a Master of Science Education at Curtin University of Technology as a part-time, long-distance student. Although my directed study for this qualification was not based around teaching and learning of science-based issues, my interest still remained. I was now working as a senior lecturer in science and biology education at the University of Waikato with the responsibility of developing and delivering programmes in science and biology education to both undergraduates and graduates in the primary and secondary pre-service programmes. Inevitably, issues-based teaching came to the fore again as I became increasingly aware, from my personal experiences and my reading of the literature, of the importance of incorporating this into my programmes and the role it played in the development of scientific literacy. I read more widely in preparation for my teaching and became aware of the

possibilities and challenges of formalising this interest in teaching and learning about controversial science issues into a doctoral research project.

Background to this project

Although there is considerable literature internationally on teaching and learning about controversial science issues in science education, there has been little research carried out in a New Zealand context. Macer (1994) reported on a survey that 72% of biology teachers in Australia, New Zealand and Japan felt that they did not have enough resources to teach bioethics. Conner's (2002) New Zealand research on the implementation of a bioethics programme in senior biology classes identified the need for students to develop critical thinking skills as they worked with an issue in writing essays in the context of cancer. Consequently it is justifiable and timely to examine the current situation in New Zealand schools and to ask such questions as: Do New Zealand science teachers, like those surveyed in the United Kingdom by Levinson and Turner (2001), feel that science is value free? Do they feel that it is important to explicitly teach science-based issues in their classrooms? Do they recognise the same constraints of lack the time, resources, skills or the confidence to manage discussions on controversial science issues as identified by teachers in other countries? What support do they feel is necessary for them to address controversial science issues in their science classrooms?

Another justification for this project relates to the recent review of the curriculum document, *The New Zealand Curriculum* (Ministry of Education, 2007), from here on referred to as *The New Zealand Curriculum* (2007). This document clearly states that informed citizenry is an aim of science education and that decision making on controversial science issues is expected to be addressed in the various strands of the science learning area. However, no guidelines will be provided on how this might be done and there is no indication that any support or resources will be provided to assist in achieving this aim.

By establishing the current status of teaching and learning about controversial science issues, and by identifying the support that teachers feel they need in terms of addressing constraints and meeting the impending requirements of new curriculum, it seemed possible that a professional learning programme could be designed to provide support for New Zealand teachers to address controversial science issues in

their classrooms and supplement the small amount of classroom-based research that has been carried out in New Zealand.

Research focus and Research Questions

Based on the background described in the previous section, it was decided that the purpose of this project would be to explore the current status of teaching and learning about controversial science issues in New Zealand secondary science classrooms and to identify the support that teachers need to implement these issues with students in their classrooms. The information gained would be used to inform and design a professional learning programme to provide support for teachers in addressing controversial science issues.

The purpose of this project then, is to seek answers to the following research questions:

- 1. How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*
- 2. What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*
- 3. In what ways will a professional learning programme support teachers to address controversial science issues in secondary science classrooms?*

Research Design

This project took a mixed-method approach and proceeded in three phases to address the three research questions. Phase One of the project involved the development and administration of a postal survey to secondary science teachers in the mid North Island of New Zealand and this was followed by focused group interviews with some survey respondents. Phase One therefore established a picture of how New Zealand teachers currently address controversial science issues and the support that they identify is required to assist them to do this. The data generation and analysis from this phase informed Phase Two of the project.

In Phase Two, these data from Phase One, together with information gained from the literature review, my personal experiences of teaching science-based issues,

an examination of *The New Zealand Curriculum* (2007) and other international science curricula, informed the design and development of a professional learning programme, the focus of which was the introduction of a pedagogical model for ethical inquiry for trialing, critique and evaluation. The literature played a key role in planning the professional learning programme and the design of the model.

Phase Three of the project involved a mixed-method approach to data generation from two workshops, separated by a trial period of eleven weeks. Workshop 1 was designed to introduce a model for ethical inquiry which the teacher-researchers critiqued, and the workshop then prepared the teachers to trial the model. In Workshop 2, the teacher-researchers reported on the trials of the model in the classroom, followed by a final critique and evaluation of the model. Proceedings of both workshops were audio-taped and from these, a series of case studies were developed from each classroom trial. A cross-case analysis was then used to validate the usefulness of the model of ethical inquiry.

Significance of the project

The project is significant in that it contributes to the field of teaching and learning about controversial science issues in a number of ways. Firstly, although research on the teaching of controversial science issues has been carried out in other countries, very little has been conducted recently in New Zealand, particularly research that is classroom based. The project provides current information from the survey and focused group interviews on the state of controversial science issues teaching in New Zealand secondary science classrooms and it identifies the support teachers feel they need to address controversial science issues in their classrooms. It also identifies whether science in New Zealand schools is taught as if it were value-free, and whether the constraints perceived by New Zealand teachers in teaching science-based issues are similar to those identified in the international literature (Levinson & Turner, 2001; Simonneaux & Albe, 2003). This project is therefore significant in that it supplements the small amount of classroom based research carried out in the teaching and learning about controversial science issues in New Zealand secondary science classrooms.

Secondly, the project is significant in terms of its methodological approach. It uses both qualitative and quantitative data from the survey and the focused group

interviews. These data, together with the literature review information on current curricula requirements both nationally and internationally, are used to inform subsequent phases of the project, particularly the development of a professional learning programme. An important outcome of the professional learning programme is a pedagogical model for ethical inquiry that has been critiqued, tested and evaluated by the teacher-researchers.

Thirdly, further significance for this project relates to the impending requirements of the recently reviewed *The New Zealand Curriculum* (2007). In this document, although informed citizenry is an aim of science education and decision-making on controversial science issues is expected to be addressed in the various strands of the science learning area, it appears there will be no guidelines or resources provided for teachers about how informed citizenry may be developed with students in science education. The model for ethical inquiry, developed and validated in this research project, assists to fill this gap.

Outline of the thesis

This thesis is organised into seven chapters. Following this introductory chapter, the literature review in the second chapter reports on the theoretical perspectives from the literature, including a consideration of significant literature related to values, morals and ethics in science education, the aims and reasons for addressing controversial science issues in science education and reported constraints. Finally, the literature related to curriculum and pedagogical perspectives of teaching and learning about science-based issues are discussed.

Chapter 3 presents the three research questions to be answered, followed by a discussion of the main research paradigms and a description of the research methods employed in the three phases of the project. In addition, the procedures undertaken to ensure rigour and ethical concerns in the research project will be explained. In Chapter 4, Phase One of the project, the qualitative and quantitative findings from the survey and the focused group interviews are presented. Chapter 5 describes Phase Two of the project in which a pedagogical model for ethical inquiry is developed, and a professional learning programme is designed for introduction, trialling and evaluation of the model by teacher-researchers in secondary science classrooms.

Chapter 6 reports on the findings of Phase Three of the project which introduced, trialled and evaluated the model for ethical inquiry. The implementation and the outcomes of the two workshops of the project are reported, with Workshop 1 backgrounding and preparing the research-teachers to implement the model, and Workshop 2 reporting on the trials. Each trial is presented as an individual case study and a cross-case analysis of these case studies is used, along with the teacher-researchers' final critique and evaluation, to validate the model.

The conclusions derived from the research findings are presented in Chapter 7, which also outlines the limitations of the study and draws implications from the findings of the research project.

CHAPTER 2: LITERATURE REVIEW

Introduction

The recent rapid rate of scientific and technological progress has presented society with many new dilemmas and people, especially our students, need to be equipped with decision making skills to enable them, as citizens, to make well-informed decisions about problematic controversial science issues. Our students need to be able contribute to public debate about issues such as population growth, climate change, genetic screening, genetic engineering, cloning, reproductive technologies and environmental degradation. A lack of understanding about controversial issues, especially by the general community, may lead to feelings of fear, anger, and distrust towards the scientific community, and science teachers have an obligation to help students to develop decision making skills to evaluate such issues so that they become informed users of science and technology and are in a position to take an active and purposeful role in society (Armstrong & Weber, 1991; Hodson, 2003; Hughes, 2000; Mertens & Hendrix, 1990, Van Rooy, 2004).

Research carried out with teachers in the United Kingdom indicated that many science teachers perceive science as an objective and value-free realistic discipline (Allchin, 1999; Claxton, 1997; Levinson & Turner, 2001). The study carried out by Levinson and Turner (2001) indicated that the perception of half of all science teachers interviewed was that the teaching of science is about the delivery of content and that the teaching of “value free” concepts was preferred. Hodson (2003) reinforced this notion and commented that “traditionally, science education has dealt with established and secure knowledge, while contested knowledge, multiple solutions, controversy and ethics have been excluded” (p. 664). Lewis (2006) reported on the experiences of teachers involved in a pilot programme for the Salters-Nuffield Advanced Biology course (SNAB) and noted that dealing with opinion rather than fact left many teachers feeling uncomfortable.

However, although science is viewed by some as objective, analytical, and unaffected by personal morals and values (Allchin 1999; Charlesworth, Farrall, Stokes & Turnbull, 1989), the practice of science is a social endeavour, and its practice and application with today’s rapidly changing advances is inevitably influenced by our political, cultural, ethical and religious values (Allchin, 1999;

Dawson, 2001). Much of the literature discussed in this chapter argues that science teachers have a responsibility to discuss controversial science issues with their students so that the students can make better informed decisions about the scientific controversies that they face in society today and in the future. These decisions need to be based on sound science (Lewis & Leach, 2006; Oka & Macer, 2000) and good decision making skills need to be fostered if students are to become capable of making informed decisions (Dawson, 2001; Dawson & Soames, 2006).

This purpose of this chapter is to review key topics in the literature relating to the teaching and learning about controversial science issues in science education. Firstly it reports on theoretical perspectives from the literature, beginning with an examination of terminology and then an exploration of the literature that considers the significance of values, morals and ethics in science classrooms. The chapter then reports on the aims and reasons for addressing controversial science issues identified in the literature and this is followed by a discussion of reported constraints. Curriculum perspectives on the teaching and learning about controversial science issues are then presented and finally, existing pedagogical perspectives used to address controversial science issues are outlined.

Theoretical perspectives

What are controversial science issues?

The definition of controversial is itself viewed as controversial. Hermann (2008) identified some defining characteristics and firstly considered that controversial issues must have competing sides, with advocates and opponents in disagreement (Bailey, 1975). Secondly, he suggested that the opposition to an issue is heated and thirdly, he claimed that the solution to a controversial issue is not clear to all reasonable people (Kupperman, 1985). Fourthly, he stated that controversial knowledge is that about which uncertainty and disagreement is acknowledged (Nicholls & Nelson, 1992).

The terms controversial and socioscientific as descriptors for issues are often used synonymously. *Controversial issues* usually involve problems about which different individuals and groups urge conflicting courses of action (Stenhouse, 1970). Oulton, Dillon, and Grace (2004) identified controversial issues as meaning that significant numbers of people argue about them without reaching a conclusion,

and that the argument is usually underpinned by differences in key beliefs or understandings about the issue, such as religious, cultural or moral beliefs. They cautioned that based on Dearden's (1981) observation that individuals may interpret the same information differently, and Stradling's (1985) suggestion that this may be related back to the individual's different values, that "recourse to reasoning based on science alone may be insufficient in resolving conflict" (p. 411).

Socioscientific issues describe societal dilemmas with conceptual, procedural or technological links to science (Fleming, 1986a; Kolsto, 2001a; Patronis, Potari, & Spiliotopoulou, 1999; Sadler & Zeidler, 2004, 2005a; Sadler, Barab, & Scott, 2007). Ratcliffe and Grace (2003) identified socioscientific issues as multifaceted, and in addition to noting their basis in science, stated that they involve forming opinions and making choices at a societal level, are frequently media reported, deal with incomplete information because of incomplete scientific evidence, often require an understanding of probability and risk and involve values and ethical reasoning.

Many of the issues that arise from the interactions of science and society involve biotechnological advances such as genetic engineering, cloning, stem cell technologies, and environmental problems such as ozone depletion, global climate change and the introduction of exotic substances, both biotic and abiotic (Sadler & Zeidler, 2005).

I have chosen to use the term *controversial science issues* in this project and have interpreted it as the controversial nature of all issues that are based in science, including those that are societally based and at the interface of science and society, such as biotechnological and environmental issues. Such issues are typically contentious, open-ended and are subject to multiple perspectives. There are no simple solutions to these problems and for a person to make informed decisions regarding controversial science issues, consideration of values, morality and ethics is important.

Values, morals and ethics

The terms values, morals and ethics are not easily differentiated. Reiss (1999, 2003) considered the usefulness of distinguishing between morals and ethics as the two words are often used interchangeably. He suggested that moral decisions are made daily by us all on matters, both great and small, about what is the right thing to

do, whereas ethics is a particular discipline that probes the reasoning behind our moral life, by critically examining and analysing the reasoning which is, or could be, used to justify our moral choices and actions in particular situations.

In our constantly changing world, with technological advances happening with unprecedented speed, come choices that may challenge existing moral standards. We cannot separate our values from our experiences and values are part of the context of the life we live. The decisions we make both individually and of society, must be open to change as new situations are faced that require new courses of action.

The following sections explore in more depth some of the literature on values and values clarification and analysis, morals and moral reasoning and development, and ethics and ethical reasoning (including bioethics) associated with teaching controversial science issues.

Values, values analysis and values clarification associated with teaching controversial science issues

The term “values” has no agreed definition and is not easy to distinguish in the literature. However, there is general agreement that values are qualities that indicate what is important and worthwhile and are linked to beliefs and attitudes. Halstead’s (1996) commonly used definition described values as

The principles, fundamental convictions, ideals, standards, or life stances which act as general guides or as points of reference in decision-making or the evaluation of beliefs or actions and which are closely connected to personal integrity and personal identity. (p. 5)

Individuals and communities have their own values which may be influenced by a number of aspects such as family, peers, culture, race, religion and gender. Rogers (1985) stated that values give us our foundation and frame of reference to enable us to deal with the world around us.

Values are the part of the organising centre of human experience that enables us to have a frame of orientation and meaning as we arrange our time, make choices about relative goods, determine the pattern of our relationships, and appropriate the pain and the joy of the appreciable world. (p. 5)

Internationally there is a move to consider a wider view of science education and reconsider the nature and place of values in the intended, implemented and

attained curriculum (Gunstone, Corrigan & Dillon, 2007; Robitaille, Schmidt, Raizen, McKnight, Britton & Nichol, 1993). Allchin (1998) stated that

Values intersect with science in three primary ways. First there are values, particularly epistemic values, which guide scientific research itself. Second, because the scientific enterprise is always embedded in some particular culture, values enter science through its individual practitioners, whether consciously or not. Finally, values emerge from science, both as a product and a process, and can be re-distributed more broadly in the culture or society. (p. 1083)

Dewey (1939/1991) also recognised that science is guided by value judgments. Hildebrand, Bilica and Capps (2008) discussed how Dewey considered that the connection between science and values is a result of treating science as a problem solving activity and that it is important for social problems to be tackled with the resources and intelligence of science.

Hildebrand (2007) suggested that deciding which values should be taught and how they could best be taught in science education was “contested ground” (p. 45). She suggested we need to design ways that the diverse value positions of scientists, science educators, teachers and students can be embedded in our curricula. Lehr (2007), in acknowledging that science education cannot be value free, asked readers to consider which values they chose to value and why? Some science curricula are explicit about the values that are embedded in them (*The New Zealand Curriculum* [2007]; *Western Australian Curriculum Framework* [Curriculum Council, 1998]; *Victorian Essential Learning Standards* [2004]; *United States National Science Education Standards* [National Research Council, 1996]).

In *The New Zealand Curriculum* (2007), a set of core values is promoted and students are encouraged to value: excellence (by aiming high and by persevering in the face of difficulties); innovation, inquiry, and curiosity (by thinking critically, creatively, and reflectively); diversity (as found in our different cultures, languages, and heritages); equity (through fairness and social justice); community and participation for the common good; ecological sustainability; integrity (which involves being honest, responsible, and accountable and acting ethically) and to respect themselves, others, and human rights. The curriculum document goes on to state that through learning experiences students will learn about their own and others’ values, different kinds of values, the values that New Zealand’s cultural traditions are based upon and the values of other groups and cultures. It is intended

that through their learning experiences they will develop the ability to express their own values; explore with empathy the values of others; critically analyse values, make ethical decisions and act upon them. Keown, Parker and Tiakiwai (2005) noted that Māori values “transverse the whole range and breadth of Māori cultural experience” and stress that

Values for Māori imply much more than a number of set phrases or choice words that can be plucked from a list and utilised within certain contexts. For Māori, values imply intrinsic beliefs and ways of doing and knowing things that inform how and why certain practices and approaches are followed. (p. 17)

John Rangihau (as cited in Keown, Parker & Tiakiwai, 2005) cautioned people who are non Māori learning about Māori values without having an understanding of the depth and breadth of the meaning of such values. He emphasised that Māori values must be contextualised from a Māori perspective.

Hill (1991) suggested that values have cognitive, affective (emotional) and volitional dimensions and that people use these in making moral decisions. Consequently people with different sets of values will make different decisions. Fensham (2002), and Grace and Ratcliffe (2002), have shown from their studies that students base their arguments more on values and personal experiences than science concepts, and therefore decision making about controversial science issues is a complex process.

Jane (2007) suggested rethinking values in science education to include spirituality and argued for a paradigm shift to include a spiritual perspective that is inherent in “deep ecology”. She contended that in science education, spiritual knowledge promoted initiative and self reflexive thought; emphasised the connectedness of all things; could integrate heart, mind and soul to give meaning and purpose; and enabled ethical and compassionate choices to be made.

Superka, Ahrens and Hedstrom (1976) put forward five basic approaches to values education: inculcation, moral development, values analysis, values clarification and action learning. Inculcation attempts to instil certain values in students and may also attempt to change values so they reflect certain desired values. In the moral development approach students are urged to develop more complex reasoning patterns through sequential stages. The purpose of values analysis is to enable students to use rational, analytical processes and scientific investigation in

dealing with values, with the process being guided by facts and reason and not by emotional thinking. Values clarification, in comparison, helps students to become aware of and clarify their own values and those of others by using both rational thinking and emotional awareness. The final values education approach of action learning, involved students moving beyond thinking and feeling to action and provided the students with opportunities for personal and social action based on their values. In this approach students are encouraged to view themselves as members of a community or social system. Superka et al. (1976), as well as suggesting the above five basic approaches to values education, also proposed in their typology a range of teaching tools that could be utilised with each approach.

It is important that values clarification is not confused with ethical reasoning. Although ethical decisions are made by individuals based on their values, which have been shaped by family, cultural backgrounds, religious beliefs and personal experiences, ethical reasoning goes beyond values clarification. Values clarification is the starting point and students need to be moved towards a more analytical decision making process in which decisions are made with the realisation that there is seldom one “right” answer and that the decision is based on common ethical frameworks (Goodlet, 1976).

The model that was designed for this present research (see Chapter 5) considered the use of values clarification as an initial starting point for students to decide individually and freely their choices on a specific issue. It was intended that this phase of the model was to be a preliminary step in thinking about one’s individual choices so that internal cognitive and affective factors determined the choice rather than external factors.

Moral development, moral reasoning and informal reasoning

As defined above, moral decisions are made daily about what is the right thing to do. Morals are codes of conduct governing behaviour and are an expression of values reflected in actions. They can be held at a communal or individual level and are “culturally bound.” Bauman (1994) argued that a moral response is emotionally based and personal and resides with the “I” or personal self. He stated, “I am moral *before* I think” (p. 61), and considered that a moral response is not utilitarian or rational as it exists before rational thought.

Moral development

Zeidler and Keefer (2003) identified, in an overview of trends in moral development research, that although there is a number of models of moral reasoning and development, most of the research has expanded or modified Kohlberg's (1971, 1976) structural stage model of moral development. Kohlberg argued that moral development in children progressed through six sequential stages. The first two stages showed an egocentric self interest concern, and stages 3 and 4 showed individuals extending their self interest concerns to peers and society in general, until by stages 5 and 6 their moral reflection drew on abstract, universal principles of justice. This model was based on the premise that moral development is driven by individuals' realisation of the limitations of their current thinking and their desire for more effective ways to resolve issues. Kohlberg put forward a "hierarchical preference" with a fully mature judgment or highest stage in moral development being the most principled. He argued that mature moral judgment was deontological, that is, it was a matter of rights and duties and principles of justice. Kohlberg also recognised that there were quite varied rates of development through these stages of moral development and regarded that children's interaction with the physical and social environment contributed to their moral as well as their cognitive development. Kohlberg, like Piaget (1965) and Dewey (1930) before him, saw these stages of development as being a continuous process of transformation over the human lifespan.

Moral reasoning

Gilligan (1982) critiqued Kohlberg's work and added a care ethic to Kohlberg's ethic of justice. She argued that, because he focused exclusively on males, he did not use a female perspective whereas her work indicated that females made moral decisions based also on the morality of care, rather than solely the principles of justice proposed by Kohlberg. She argued that care-based moral reasoning was as valid in resolving moral issues as the application of the "principled" or "rule-based" approaches. She also stressed the importance of focusing on more than one perspective. This notion of care has been elaborated by Noddings (1992) who suggested that schools develop curricula based around principles of care for self, family, community, ecosystems and the planet. Caring is recognised by Noddings (1984, 1992, 2002a) as a foundation of ethical decision

making and she expressed the importance of teachers nurturing students' ethical ideas through dialogue, practice, confirmation and modelling.

While some researchers questioned Gilligan's claims (Golding, Pratt, Hunter & Sampson, 1988; Walker, 1989), the door was opened for wider neo-Kolbergian conceptualisations of moral reasoning and development. In an attempt to bring together diverse literature in this area of moral development and reasoning, a four component model was developed by Narvaez and Rest (1995). In this model, four processes of moral sensitivity, moral judgment, moral motivation and moral character were identified as major processes in the making of socioscientific decisions. Further models developed by Berkowitz (1997) also included elements of Narvaez and Rest's four component model.

Straughan (1988) regarded it as crucial that students make up their own minds in arriving at moral decisions and argued that "moral education must aim ultimately at getting children not simply to obey certain rules, but to seek the justification for them and subject them to rational criticism" (p. 85).

Nucci (1989) favoured integrating moral education within the curriculum rather than making it a separate and additional curriculum requirement. He argued that the use of discussion in the classroom acknowledged that moral development is not simply a process of learning society's rules and values, but that it is a gradual process in which students actively transform their understanding of morality through reflection and construction. He suggested that moral development is a function of meaning-making rather than mere compliance with externally imposed values. Similarly, Wilson (1990) discussed the importance of students being taught moral methodology, rather than particular moral values and beliefs, if they are to make their own moral decisions that will lead to effective action. Swanson and Hill (1993) suggested that the ability to reflect upon one's own moral decision-making (meta-moral knowledge) may also impact upon both moral development and reasoning.

Drawing in part on a neo-Kohlbergian perspective, Zeidler and Keefer (2003) developed a framework for promoting moral reasoning as a component of scientific literacy. Their framework incorporated themes of moral reasoning/development, cognitive reasoning/development, emotive belief systems and moral/character education which envelop four broad pedagogical issues that they regarded as central

to the teaching of socioscientific issues and derived from contemporary views of scientific literacy. These four themes of Nature of Science issues, classroom discourse issues, cultural issues and case bases and Science-Technology-Society-Environment (STSE) issues are regarded as playing a central role in moving between the outer, broad educational themes and the development of a functional view of scientific literacy which is central in their framework.

Zeidler and Keefer (2003) stated that moral reasoning is based on specific thought processes at different stages of moral development and reflected the individual's interpretation of the rules and principles. They acknowledged that moral growth is multi-dimensional and supported many aspects of Kohlberg's theory of moral reasoning and development and they reiterated that, "although the context of the situation may vary [religious and cultural environments], the basic moral principles, the reasoning of individuals, reflects a universal order" (p. 17). The joint construction of scientific knowledge that is "at once personally relevant and socially shared" was considered by Zeidler & Keefer (2003, p. 8) to be important in assisting the development of moral reasoning.

In light of the definitions of morals and ethics that I established earlier in this chapter, where morals is the emotionally based, personal and subjective stance which precedes the ethics, which is the probing of the reasoning behind the moral choice, I contend that Zeidler and Keefer (2003), and Sadler and Zeidler (2004) in their discussion on moral reasoning, were in fact discussing ethical thinking and reasoning. It is interesting to note that in their writings from 2005, the term "moral reasoning" is replaced with the term "ethical thinking" and more recently Sadler (2008, p. 3) justified the use of the term "socioscientific reasoning". Witz and McGregor (2003), in their writing about morality, spirituality and science in the classroom, link the morals and ethics together and use the term moral-ethics in their discussions. It appears that not all researchers clearly distinguish between the two terms. For the purposes of this project, I will use the term "ethics" and "ethical reasoning" as suggested by Reiss (1999, 2003), in which ethics is a discipline that probes the reasoning behind our moral life.

Informal reasoning

The idea of informal reasoning put forward by Tweney (1991), and writers such as Means and Voss (1996), provided a description of informal reasoning as that which “assumes importance when information is less accessible, or when problems are more open-ended, debatable, complex, or ill-structured, and especially when the issue requires that the individual build an argument to support a claim” (p. 140). Sadler (2004) commented that just as scientists use informal reasoning to give insights to the natural world, individuals also use the process of informal reasoning to negotiate and resolve controversial issues. He reviewed a number of empirical studies on aspects of informal reasoning related to socioscientific issues and concluded that students need to have opportunities to engage in informal reasoning, including examination of evidence, and opportunities to express views through argumentation.

Sadler and Zeidler (2004) also examined patterns of informal reasoning that emerged from a study which explored how college students negotiated and resolved genetic engineering problems. They described the different informal reasoning patterns as rationalistic, emotive and intuitive. Rationalistic informal reasoning described reasoned-based considerations; emotive informal reasoning described care-based considerations and intuitive reasoning described considerations that were immediate or “gut level” reactions. They reported this form of informal reasoning as preceding other forms of reasoning and further commented that the three patterns of informal reasoning did not operate independently and highlighted the need to ensure that all three patterns needed to be valued. Their findings also indicated that the patterns employed tended to vary according to the context. They also considered that moral reasoning was a “subset” of informal reasoning.

The concept of informal reasoning was also described by Zohar and Nemet (2002) in an article discussing student thinking on human genetics dilemmas.

It [informal reasoning] involves reasoning about causes and consequences and about advantages and disadvantages, or pros and cons, of particular propositions or decision alternatives. It underlies attitudes and opinions, involves ill-structured problems that have no definite solution, and often involves inductive (rather than deduction) reasoning problems. (p. 38)

This concept of informal reasoning, especially that of rationalistic informal reasoning, shows strong links to the ideas of ethical reasoning and thinking as discussed in the following section.

Ethics and ethical reasoning

Bauman (1994) argued that ethics are different from morals as they are impersonal, rational and universal, in contrast to morals that he perceived as subjective, personal and emotional. Reiss (1999) suggested that ethics refers to the reasoning behind our moral life, particularly the critical examination and analysis of the thinking which is, or could be used, to justify our moral choices and actions in particular situations. Ethics attempts to arrive at reasoning using principles that can be applied when considering a range of perspectives and interest. It seeks to provide a systematic and rational way to work through a problem and to determine the best course of action. It also attempts to describe what people believe to be right and wrong. Wertz (1996) also used “right” and “wrong” when she defined ethics as “a system of inquiry that examines the bases of human goals and the foundations of ‘right’ and ‘wrong’ human actions that further these goals” (p. 6).

Bioethics

The investigation of biological and scientific technology and associated ethical issues are combined to form the field of bioethics. Bioethics was defined by Potter (1971) as “biology that is combined with diverse humanistic knowledge forging a science that sets a system on medical and environmental priorities for accepted survival” (p. 2).

Kieffer (1992) suggested that bioethics establishes the premise that we operate through humanistic knowledge with our rejection of superstition, where humans are in control of their own destiny, and that our actions are based in principles of ethical thinking. Macer (1994) defined bioethics as the study of ethical issues associated with the use of living organisms and medicine and established the premise that our actions are based on ethical thinking and moral principles. Macer, Asada, Tsuzki, Akiyama (1996), and Macer (1994) stated that bioethics education enabled students to appreciate the range of bioethical issues associated with living organisms and medicine and assisted students to develop decision making skills based on ethical theories. They reiterated, as did Levinson (2003), that teaching of

decision making skills is not concerned with defining a “correct” decision, but is about understanding how the decision is made and how bioethical arguments can be constructed.

Ethical frameworks and ethical reasoning

There is no universally accepted framework for ethical reasoning (O’Neill, 1996) and this is reinforced by Zucker, Borchert, and Stewart (1992), who commented “there are competing [ethical] theories...and ...none of these theories has achieved acceptance by everybody” (p. 8).

Foundational work by Beauchamp and Childress (1983) discussed convergence of moral theory to “judgments about what ought to be done in particular situations are justified by moral rules which in turn are grounded in principles and ultimately ethical theories” (p. 6). This can be represented by Figure. 2

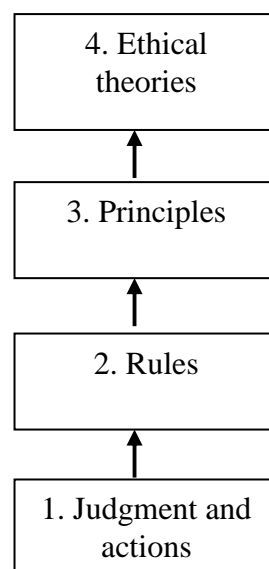


Figure 1. Levels of moral theory based on Beauchamp and Childress (1983).

Beauchamp and Childress (1983) claimed that although there may be a difference at the level of ethical thinking (Level 4) there is a tendency for a consensus on the principles at Level 3. They first published their four principles in 1979 and their publication is now in its sixth edition (2008). These four principles (established by Beauchamp and Childress) include *beneficence* (promoting good with a balance

between risk and benefit of actions); *nonmaleficence* (avoidance of harm); *autonomy* (right of a person to dignity, respect from others and the entitlement of adequate information before informed consent is obtained); and *justice* (fair and equitable treatment). The latest edition of Beauchamp and Childress (2008) also reworks former discussions of the ethics of care as a form of virtue ethics.

Sadler and Zeidler (2004) identified three broad moral philosophies that could be applied to socioscientific decision making: deontology based on the upholding of rules and principles (e.g. justice); consequentialism, also referred to as utilitarianism based on the expected outcome of a decision, with the decision producing the greatest positive outcome corresponding to the most morally acceptable decision; and care-based morality which involves an emotive and relational approach.

The polarisation between ethics and morals, as considered by Bauman (1994), may be resolved by considering ethical thinking that considers an ethic of care. The boundary between morals and ethics need not be so abrupt, and embedding an ethics of care or “virtue ethics” may re-personalise ethics and enable a broader acceptance of teaching ethics in science. This notion has been further explored by Reiss (2006), who discussed how a new context based course for 16- to 18-year-olds in the United Kingdom (Salter-Nuffield Advanced Biology) presented four frameworks for ethical ways of thinking: consequentialism (projected outcome of a decision), rights and duties, autonomy (making decisions for yourself), and virtue ethics (leading a virtuous life considering virtues valued in society such as honesty, truthfulness, integrity, compassion). Reiss considered that consequentialism is a framework through which any moral question can be addressed and that consequences alone are sufficient to make a decision about the rightness or not of an action. He also stressed that it does not underplay pleasure seeking and happiness as driving factors in ethical thinking. After examination of sample reports of the summative assessment of the course, Reiss (2006) reported that students were able to use ethical reasoning validly in their reports, with consequentialism being the most widely used and the other ethical frameworks the students had been introduced to (autonomy, rights and duties and virtue ethics) being less frequently used. He also argued that both teachers and students needed support if they are to be introduced to these frameworks and use them to reason ethically. Although it is valuable to have

students discuss controversial science issues, the students can easily jump to their first impressions and then try to justify their responses. It is important to encourage the notion that ethics is a process in which students assess the information related to the issue and use models that help them to understand types of ethical frameworks that people commonly use. A basic introduction to ethical frameworks can assist students with the language to give shape to their thoughts and provide depth to their discussions (Reiss, 2006).

Reiss (1999) also suggested that confidence in the validity and worth of the ethical conclusions that people make could be examined using three criteria. Firstly, were the arguments that led to the conclusion convincingly supported by reason? Secondly, were the arguments conducted within a well established bioethical framework? Thirdly, did a reasonable degree of consensus exist about the validity of the conclusions, arising from the process of genuine debate? He stressed that one of these criteria used alone was not sufficient to have confidence about a bioethical conclusion and maintained that ethically based conclusions needed to be based both on reason that takes into account well established bioethical principles, and on consensus that is based upon genuine debate. Reiss identified that while consensus may eventually be possible, there is an interim period when it is the engagement in respectful debate and seeking for truth through dialogue that is valuable. Moreno (1995) also acknowledged that reason alone may not be sufficient to make ethical decisions and that there is value in seeking for social consensus, although there are times when consensus cannot be reached.

Consideration of pluralism

A further issue when considering ethical frameworks is that we live in an increasingly pluralistic society and in today's classrooms this diversity is manifested in a number of ways that include gender (Brickhouse, 2001; Gilligan, 1987; Tsai, 2000), developmental abilities (Mastropieri & Scruggs, 1992; McGinnis, 2000) and ethnicity (Aikenhead, 1996; Cobern & Loving, 2000; Lemke, 2001). A pluralist society respects values of others and shows sensitivity to others' rights, recognising different ethical frameworks and encompassing a range of diverse and sometimes opposing practices and ideas. One of the principles in the Universal Declaration on Bioethics and Human Rights (UNESCO, 2005) is respect for pluralism and cultural diversity. Pluralism is regarded as a means for individual and societal development

by Dewey, Piaget and Kohlberg (Power & Lapsley, 1992) and is also recognised by Nicgorski (1992) as a goal for moral education.

Levinson (2001) commented that effective teaching of bioethics needs to reflect the diverse, informed value positions of voices that may be out of the mainstream, such as ethnic minorities, disabled people, feminists, gays and lesbians. Reiss (1993) also recognised the importance of a pluralist science education that included multicultural, anti-racist and feminist views. He elaborated that this would allow school science to be taught within a broader historical context which recognised contributions of all scientists, including women and non-western scientists. He considered this would challenge “attitudes and behaviours which lead to prejudice, discrimination and injustice” and that consideration of social, ethical and moral questions would model “cooperation and respect for different forms of knowledge, including the subjective” (p. 14). Sadler, Chambers, and Zeidler (2002) suggested that we need more research in this area to create a culturally responsive pedagogy when addressing socioscientific contexts.

Cobern (1993) considered that a people’s world view provides a special framework of ideas, activities and values that allows the plausibility of any assertion to be gauged. He goes on to recognise that a world view is a concept that recognises fundamental presuppositions about what constitutes valid and important knowledge about the world. Endicott, Bock and Narvaez (2002) commented that ethical and cognitive growth show strong connections in the development of intercultural understanding.

Aikenhead (1996) similarly discussed world views as being culture-laden frameworks from which daily norms and values flow and argued that Western science is a culture in its own right, with its own beliefs, traditions and epistemologies. He suggested that students cross many borders as they move from their everyday life into school science. The crossings for indigenous students often entail a different world view, different ways of thinking and unfamiliar contexts. Students respond by integrating or keeping the cultures separate. The evidence shows that border crossings can be stressful and recognition of other world views and their ways of thinking and knowing in science classrooms could provide sources of innovation as different cultures learn from each other. Aikenhead (2001) suggested that science communicators (including educators) with pre-requisites of

sensitivity and knowledge, could act as “culture brokers” to assist audiences to cross the cultural borders more smoothly between Western science and other world views.

Aikenhead and Huntley (1997) and Aikenhead (2001) argued for a more inclusive science education that recognised that indigenous science has something to offer western science. Hodson (1998) similarly argued for a more culturally sensitive view of science in science education, which showed science “being used and developed by diverse people in diverse situations” (p. 5).

There is diversity in values held by indigenous people in many parts of the world, including New Zealand Māori, Australian Aborigines, Canadian First Nations people, Japanese Ainu, African and Islamic people. A set of “Values and Ethics Guidelines” produced in Australia recognised the extent of indigenous cultural diversity across Australia and the importance of providing opportunities for interpretation of local cultural values and protocols (Dunbar & Scrimgeour, 2006). A study carried out by Brodwin (2000) in the USA, led him to conclude that “we treat culture not as a new variable to be fitted in to established bioethical formulae, but as a multiple determinant of moral experience in its own right” (p. 7).

In New Zealand, greater emphasis needs to be given to cultural aspects, particularly Māori perspectives in New Zealand where the Treaty of Waitangi, which is a partnership between Māori and the Crown signed in 1840, means that the Crown as a treaty partner is required by law to protect *te ao Māori* (the Māori world) and heed Māori advice. Roberts and Wills (1998) in their writing compared the fundamental Māori ontological principle of *whakapapa* (an orientation to the past that connects a person through generations to the land), with a Western science orientation that dominates with “matter and causal mechanisms” (p. 22).

Rodriguez (2001) challenged science educators to find the “courage” to become “cultural warriors” so that science curricula are more inclusive of diversity, not only in the intended curriculum, but also in the enacted curriculum and consequently evident in the realised curriculum.

I believe that consideration of pluralist aspects can provide a richer view on ethical perspectives and consequently suggest that awareness of other world views and identities needs consideration and should not be ignored or marginalised in the resolving of controversial science issues in our science classrooms. This idea of

pluralism is discussed further in Chapter 5 where I consider the influence of the literature in the development of a model of ethical inquiry and argue for pluralism as an additional ethical framework to discuss controversial science issues.

Aims for teaching controversial science issues

Goldfarb and Pritchard (2000) put forward some general aims for teaching ethics in the science classroom and argued that such teaching stimulated the moral imagination of students; helped students recognize moral issues; helped students analyse key moral concepts and principles; stimulated students' sense of responsibility and assisted students to deal effectively with moral ambiguity and disagreement. Van Rooy (2004) expressed a general aim when she suggested that “young people need to become empowered with science knowledge understandings as well as develop their own social, ethical and moral perspectives in order for them to become informed, responsive and responsible global citizens” (p. 196). Allchin (1991) also stated that a general aim for issues-based education in secondary science classrooms was that it could “nurture both morally sensitive scientists and scientifically literate humanists” (p. 44).

Macer (2005) suggested that a consideration of bioethical issues may assist students to develop bioethical maturity “which includes understanding a diversity of ideas and how to balance the benefits and risks of science and technology [as well as how to use] reasoned approaches in making decisions combining with scientific data with ethical concepts” (p. 83-84). Macer (2004) also explained how discussion of issues encouraged a range of specific skills.

Assessing the impact of moral decisions involves the ability to identify existing ideas and beliefs, listen to others, be aware of multiple perspectives, find out relevant information and communicate the findings to others. Students need to experience situations that will allow them to develop these skills through interacting with the teachers and each other. (p. 85)

Hermann (2008) concluded from his examination of evolution as a controversial issue that controversial issues should be included in science classrooms for a number of reasons. Firstly, he emphasised that by addressing controversial issues, students are able to arrive at their own defensible positions. Secondly, he suggested that including controversial issues gave students opportunities to examine validity and trustworthiness of science related claims. Thirdly, controversial issues

instruction gave opportunities for student to talk, discuss and argue, and fourthly, he concluded that students were able to think and reason about questions for which there are no clear answers.

Reiss (1999) suggested four aims of the teaching of ethics in science. Firstly, he considered that it might heighten the ethical sensitivity, and secondly, the ethical knowledge of students. Thirdly, he considered that teaching ethics might improve the ethical judgment of the students, and fourthly, he suggested that it might make students better people or more virtuous and “more likely to implement normatively right choices” (p. 127). Reiss (2007) discussed the aims and associated values of school science education and considered that a diversity of aims and values was appropriate, with different aims suiting different audiences.

In addition to these wide aims of teaching science issues, there are further reasons identified in the literature for addressing controversial science issues in our science classrooms. These include the development of scientific literacy and understanding of the nature of science, development of informed citizenry, development of science content knowledge, development of motivation and interest in science, promotion of critical thinking skills, development of ethical knowledge and ethical thinking and reasoning. The following section moves from the general aims discussed above to discuss in more detail some more specific reasons.

Development of scientific literacy and understanding of the nature of science

As the twenty first century moves on, many countries have recognised the importance of a vision of scientific literacy in science education that involves an awareness of moral and ethical development of students. The meaning of the term “scientific literacy” is widely debated (Hand, Alvermann, Gee, Guzzetti, Norris, & Phillips, 2003), but generally it is seen as a vehicle to enable individuals to understand scientific issues. The OECD Programme for International Student Assessment (PISA) had scientific literacy as a major domain in 2006 and defined it as referring to, firstly, an individual’s scientific knowledge and use of that knowledge to identify questions, the ability to acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues. Secondly, it referred to understanding the characteristic features of science as a form of human knowledge and enquiry and, thirdly, it referred to an individual’s awareness of how science and technology shape our material, intellectual, and cultural environments.

Finally it refers to an individual's willingness to engage in science-related issues and with the ideas of science, as a reflective citizen.

Goodrum et al. (2001), in their review of international trends of science education, concluded that scientific literacy should be an aim of school science education and proposed that scientific literacy (as cited in Rennie, 2005) could be defined as helping students (or people)

to be interested in, and understand the world around them; to engage in the discourses of and about science; to be sceptical and questioning of claims made by others about scientific matters; to be able to identify questions, investigate and draw evidence-based conclusion; and to make informed decisions about the environment and their own health and well being. (p. 10-11)

Norris and Phillips (2003) also offered a list of scientific literacy characteristics from the literature in which they included the ability to distinguish science from pseudoscience, and argued that a definition of scientific literacy should include an appreciation of the wonder and curiosity of science and the wish and ability to become a lifelong learner in science. Although there are different emphases in scientific literacy definitions, they are all consistent in that they focus on science education for future citizens, rather than for future science professionals. However, Layton, Jenkins, Macgill and Davey (1993) argued for scientific literacies, rather than for an undifferentiated scientific literacy, and Shamos (1995) proposed that the construct of scientific literacy is too poorly defined to be of use in driving curriculum reform and that it is an "unattainable myth".

Zeidler (1997) and Zeidler, Walker, Ackett and Simmons (2002) suggested that, in order to achieve scientific literacy, moral and ethical issues needed to be included in science curricula. Incorporating controversial science in science programmes is not the only way to develop scientific literacy, but such programmes are able to provide a strong vehicle for teachers to "stimulate intellectual and social growth of their students" (Sadler, 2004, p. 533). Reiss (2007) regarded that the basic notion of scientific literacy should be to "enhance an understanding of key ideas about the nature and practice of science as well as some of the central conclusions of science" (p. 18). Roth and Lee (2002) broaden the aim of scientific literacy and argued that it is an attribute of communities rather than individuals. Roth and Barton (2004), using a range of case studies, further argued that "critical scientific literacy is

inextricably linked with social and political literacy in the service of social responsibility” (p. 10). Dawson (2007) and Dawson and Soames (2006) suggested that scientific literacy can help students weigh up arguments about controversial science issues, use critical thinking skills, and make balanced, well informed decisions that they can justify.

It is widely accepted that an understanding of the nature of science is regarded as an important and key element in developing scientific literacy in our students (Driver, Leach, Millar & Scott, 1996) and there are many studies that support an explicit and integrated approach for effective teaching of the nature of science and controversial science issues (Abd-El-Khalick & Lederman, 2000; Craven, Hand, & Prain, 2002; Feldman, 2003; Hildebrand et al., 2008; Walker & Zeidler, 2007). Hipkins (2006) suggested a curriculum organisation model for teaching about the nature of science based on Latour’s (2004) idea that curriculum organisation needs to shift emphasis from “matters of fact” to “matters of concern”, and that these matters of concern incorporate ethical and social questions. She argued on the basis of classroom observations, that such a curriculum model could produce significant learning about nature of science as well as scientific concepts and investigative concepts.

Research literature supports the inter-relatedness between the nature of science and the teaching of controversial science issues (Bell & Lederman, 2003; Sadler et al., 2002) and several authors have suggested that the manner in which an individual responds to controversial science issues is affected by their understanding of the nature of science, particularly in regard to the social, tentative and empirical aspects of science (Kolsto, 2001a; Sadler & Zeidler, 2004; Zeidler, Walker, Ackett, & Simmons, 2002). Other studies have reported gains in nature of science understandings in interventions where the nature of science has been integrated explicitly with instruction in controversial science issues (Khishfe & Lederman, 2006; Lewis, Amiri, & Sadler, 2006).

Driver et al. (2000) summarised the inclusion of ethical issues as a major component of the nature of science.

There is an important argument that the school science, if it is to contribute effectively to improved understanding of science, must develop students’ understanding of the scientific enterprise itself, of the aims and purposes of

scientific work, and of the nature of the knowledge it produces. Such an understanding, it is argued, is necessary for students to develop an appreciation of both the power and the limitations of science knowledge claims, an appreciation which is necessary for dealing appropriately with the products of science and technology as informed citizens who can fully participate in a modern democracy. (p. 1)

The perspectives presented in this section suggest that addressing controversial science issues in science classrooms is an integral part of developing scientific literacy.

Development of informed citizenry

Informed citizenry (Jenkins, 1999) is linked closely to the notion of scientific literacy and understanding the nature of science. The term is used frequently in the literature, and especially mentioned as an aim in many curriculum documents both in New Zealand and internationally e.g. Australia, United Kingdom, USA, Canada, and South Africa. Jenkins (1999) suggested that achieving informed citizenry will require more than the reform of school science curricula. It is argued widely that controversial science issues education can enhance informed citizenry (Davies, 2004; Kolsto, 2001a; Van Rooy, 2004; Zeidler, Sadler, Simmons, & Howes, 2005) because the issues are relevant and can bridge school science and the students' lived experiences (Cajas, 1999; Sadler et al., 2007). Berkowitz and Simons (2003) stated that

Science education must serve as a foundation for the education of an informed citizenry who participate in the freedoms and powers of a modern, democratic, technological society. With the rapid development of scientific knowledge and the advent of new technologies, all members of society must have an understanding of the implications of that knowledge upon individuals, communities and the "global village" in which we now live. (p. 117)

Advances in biotechnology present society with ethical issues and dilemmas which require informed citizens capable of contributing to public debate (Dawson, 2001; Levinson, 2003) and it is in schools that much of the public's understanding of science is nurtured (Lock & Miles, 1993). As future citizens, students will need to make informed decisions on issues that affect them, not only personally, but at the level of the family, community, nationally and globally. Although it is clear that ethical decisions need to be based on sound science (Lewis & Leach, 2006; Oka & Macer, 2000), it is important that good decision-making skills are fostered if students

are to become citizens capable of making informed personal decisions (Dawson, 2001; Dawson & Soames, 2006). Levinson and Reiss (2003) suggested that in terms of informed decision making, the more informed we are, the more difficult it can be to make a decision.

Fien and Fien-Williamson (1996) and Kolsto (2001a) suggested that an increased knowledge about issues may enable students to make more informed social and political decisions that lead to action. However Kolsto stated that the making of informed judgments is difficult unless sufficient information is available. The links between decision making and science content knowledge in the literature are discussed in the following section.

Development of science content knowledge

One of the main goals for science education has been the promotion of science content knowledge (Jenkins, 1990; Laugksch, 2000) and a common assumption in the literature about the teaching of controversial issues is that there is a link between content knowledge about an issue, and the ability to negotiate and resolve the socioscientific issue. Jenkins (1999) stated that “a citizen who wishes, individually or as part of a group, to engage seriously in a debate about an issue which has a scientific dimension sooner or later has to learn some of the relevant science” (p. 704). He argued, however, that it is not usually as straight forward as simply seeking scientific knowledge, as it may not be in a form that can be used or it may be unavailable (Wynne, 1996), or there may be debate about the methods used to obtain the information.

Dawson and Schibeci (2003), Fleming (1986b), Patronis et al. (1999), Pedretti (1999), and Tytler, Duggan, and Gott (2001), in their studies, drew the conclusion that a lack of understanding of content material hindered the ability of students to demonstrate argumentation and reasoning skills of a high quality. Other research by Hogan (2002) and Zeidler and Schafer (1984) suggested that science content understanding improved informal reasoning about controversial science issues. Similarly, Zohar and Nemet (2002) in a study about human genetics and associated issues, found that when particular attention was paid to increasing students’ understanding of science content as well as the skills of argumentation, they were able to use their science content knowledge to improve the quality of their

arguments about bioethical issues. The findings also indicated that the intervention group performed better than the control group in testing of genetic content knowledge. Sadler and Zeidler (2005b) examined the influence of genetics content knowledge on informal reasoning about genetic engineering issues with science and non science students and found that “differences in content knowledge were related to variations in informal reasoning quality” (p. 71). They also found that students with better content knowledge used that knowledge to explain and present less flawed arguments. Another study by Sadler and Fowler (2006) found by increasing science content knowledge, preferably by the use of discussion, not only did argumentation skills improve, but more positive attitudes to science were developed.

Such studies suggest that another reason for teaching controversial issues is that by introducing a science concept through a socioscientific issue, students’ interest and knowledge of the science can be enhanced, together with their decision making skills. This also suggests that science educators could use controversial issues to bring about conceptual change (Posner, Strike, Hewson, & Gertzog, 1982) and engage in meaningful learning of the science concepts that background the issues. As the students connect their existing ideas to the new information through dialogue with other students and with their teacher, we are reminded that this is a focus of a social constructivist approach to teaching.

Walker (2003) presented a case study in which students worked through a web-based unit on genetically modified foods and the findings of the study indicated improvements in high school genetics understandings. Similarly, Barab, Sadler, Heiselt, Hickey, and Zuiker (2007) and Applebaum, Barker, and Pinzino (2006) documented statistically significant improvements in science content knowledge related to environmental and human biology based issues, respectively.

Solomon and Thomas (1999) queried whether students should learn the science of current issues, especially when the “story” is changing rapidly, and Simonneaux (2000) similarly asked, “how should the content of biotechnology information be developed for the purpose of teaching today’s students?” (p. 619). The findings from interviews with students were that more, rather than less, science content was needed for effective learning. Levinson (2003) suggested that the questions to consider in terms of science content are when to feed in the science and what level of science is required. He suggested that the level of science may be

minimal, or complex, depending on the issue and considered that after introducing the issue, the science could be fed in on a “need-to-know” basis.

However, studies by Fleming (1986a) and Bell and Lederman (2003) suggested that students’ decision making is driven by the affective domain (personal opinion and belief systems) and not by science content knowledge. Findings from Sadler, Chambers, and Zeidler’s study (2004) were similar. Other studies that questioned the importance of using science knowledge when making decisions on controversial science issues have been carried out by Levinson (2003) and Lewis, Leach, and Wood-Robinson (1999). Oulton et al. (2004) argued that it was not sufficient to consider solely the scientific elements, as rationality alone was not a suitable basis for discussion because it avoided the consideration of values and personal experiences.

Development of motivation and interest in science

A further reason for the inclusion of the teaching of controversial issues in science is that such an approach may be motivating for those students who perceive science to be boring, difficult and irrelevant. As the science is placed in contexts that students can relate to it becomes more relevant to their lives (Cajas, 1999; Pedretti, 1999). Wood (1997) suggested contexts that are personally relevant to students and issues that included situations that were current and authentic, interested and motivated students more in their science lessons (Heath, 1992; Patronis et al., 1999; Sadler, 2004; Ramsey, Hungerford, & Volke, 1990; Van Rooy, 1993a, 2004). Wood argued that, while recognising that controversial science issues are a means for making science relevant, it appeared to be important that the issues selected were local ones. Zeidler and Sadler (2008) agreed with this view and stated that “social and ethical issues provide avenues for students to attach personal meaning to science concepts, theories and processes and enable investigations that are closer to students’ daily existence” (p. 801).

Conner (2000, 2002) also reported on increased motivation as well as a broadening of students’ views after teaching a unit on cancer. She further observed that students developed an intrinsic interest in learning if a context has personal relevance, and gave examples of how students in a study of cancer considered the issues to have relevance.

Participating in discussions about bioethical issues can be motivating for some students, enabling them to see science as stimulating, and controversial issues as relevant in their lives rather than just a set of facts and theories. Van Rooy (1994) stated:

Here is an opportunity for science teachers to challenge students who all too often view science as a mere collection of undisputed facts which the teacher holds to be true, rather than science being a collection of disputed facts, rich in controversy and in a state of flux. Science might then be seen by more students as dynamic, exciting, controversial issues and relevant to their world and so worthy of academic study rather than being sterile and of no particular relevance. (p. 27)

Van Rooy also mentioned the energy that students have for controversial science issues, and suggested that secondary teachers harness this to enhance science learning.

Levinson (2003) suggested that interest in, and knowledge of, the biology can be enhanced by introducing a biological concept through an ethical perspective. Students want science to be exciting (Finegold, 2001) and engagement with contemporary and relevant issues can often stimulate interest from students in science, for example, issues such as genetically modified foods and cloning/stem-cell research (Cerini, Murray, & Reiss, 2003; Driver et al., 1996; Osborne & Collins, 2000; Osborne, Driver, & Simon, 1998).

Promotion of critical thinking skills

Because controversial science issues offer no “right” or “wrong” answers, or simple solutions, they can help students to think critically by encouraging an understanding of the importance of reasoning in regard to the issues. Longbottom and Butler (1999), in their argument that science education should make a contribution to creating a “more truly democratic society” (p. 487), concluded that

If citizens have some knowledge of the natural world and the process of gaining that knowledge, then they may be empowered to view critically the social world. Citizens who are critically minded, and who can analyse and challenge social structures will be better able to implement democratic ideals. In this way, science education ... can play a valuable part in equipping citizens with knowledge for action. (p. 489)

Oulton et al. (2004) identified that teachers and learners need to reflect “critically on their own stance and recognise the need to avoid the prejudice that

comes from the lack of critical reflection” (p. 420). Reiss (2007) argued that Oulton et al. (2004) showed a stance that moved beyond critical thinking to “criticality”, which he defined as using the results of critical thinking to achieve social change. Huckle (1999) also examined criticality in the context of sustainability, where criticality enabled people to participate in action for social change in terms of sustainability of the environment. Reiss (2007) cautioned, however, that such action can be overwhelming to overloaded teachers, and he provided some classroom-based examples in the context of nuclear power that can contribute to criticality in science.

Conner (2003) suggested that the ability to critically evaluate bioethics issues was an important goal of bioethics education. She explained how an approach that supported and fostered critical thinking engaged the content knowledge and processes of real life situations where decisions have real consequences. Conner also commented that the inclusion of suitable contexts for problem solving and reasoning enabled students to develop skills to become independent, self motivated, critical thinkers who are more likely to take responsibility for lifelong learning. She concurred with Heath (1992) and suggested that these critical thinking skills included the weighing up of research evidence (synthesising and analysing), detecting bias in information, questioning the validity of sources and reasoned decision making, and the development of “independence of mind” by evaluating one’s own opinions and beliefs.

Van Rooy (2004) considered that use of controversial issues develops four main approaches to thinking in students. She suggested, firstly, that a civic and social thinking approach is supported by the case that controversy and discussion are part of the “social fabric” of society and as schools are part of society, controversial issues should be integrated into school science programmes. Secondly, she suggested that controversial issues develops a sociology of knowledge, as social construction of scientific knowledge is not necessarily objective or clear cut but must be a component of any controversy. The third thinking approach identified is that of the psychology of learning which Van Rooy considered promoted students’ content knowledge, discussion skills, decision making skills and the ability for rational judgement, and the motivation to learn to gain intellectual independence. The fourth approach outlined is that of ethical thinking in which students learn to take on other’s

perspectives, aware of the effect of their decisions on others and the environment. The development of ethical thinking is explored in the following section.

Development of ethical knowledge, ethical thinking and reasoning

Ethical knowledge can be considered as an understanding of the ethical frameworks that can help individuals to make reasoned and informed decisions. As discussed earlier in this chapter, there is no one universally accepted framework for ethical thinking and after much deliberation, I decided to work with the frameworks put forward by Reiss (2006) because not only did they include a rationalistic approach, but use of the virtue ethics framework allowed for the consideration of the affective domain and notions of care.

According to Heath (1992), reasoned decision making is one aspect of the larger notion of critical thinking. Sadler (2004) commented that if we want our students to think for themselves, there must be opportunities provided to engage in “informal reasoning including the contemplation of evidence and data and to express themselves through argumentation” (p. 533). Other research (Driver et al., 2000; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Patronis et al., 1999; Zohar & Nemetz, 2002) supported the statement that controversial science issues can provide an appropriate context for reasoning and argumentation. Simmons and Zeidler (2003) commented that if we wish to stimulate and increase our students’ reasoning and decision making skills, we must

provide students with rich and varied opportunities to gain and hone such skills...using controversial socioscientific issues as a foundation for individual consideration and group interaction provides an environment where students can and will increase their science knowledge, while simultaneously developing their critical thinking and moral reasoning skills. (p. 83)

Sadler et al. (2007) have argued that the most significant practices for decision-making are: recognising the inherent complexity of socioscientific issues (open-endedness, contentious and without simple solutions), examining the issues from multiple perspectives, appreciating that the issues are subject to ongoing inquiry and exhibiting scepticism when presented with potentially biased information.

Recently there has been some interesting discussion in the literature on the use of the term “socioscientific reasoning”. This term was originally proposed by

Sadler et al. (2007) as a “new analytic construct” to help understand student practice in relation to socioscientific issues, and one in which the levels of performance for individual students could be identified. Sadler (2008) critically analysed a study by Simonneaux and Simonneaux (2008a) and claimed that the use of the term “socioscientific reasoning” in this study varied from the initial conceptualisation. Sadler contended that Simonneaux and Simonneaux had “over-reached” in that they firstly considered socioscientific reasoning as a theoretical framework thereby expanding the construct to include a broader range of practices. Secondly, Sadler argued that they used the term to describe reasoning patterns emerging from a group of students, rather than the individual assessment of individual students. He did not endorse the researchers’ use of the construct. Simonneaux and Simonneaux (2008b) replied that they had not intended to identify performance levels of individual students, but used the construct to make reasoning with students as explicit as possible and considered that socioscientific reasoning involved a number of operational variants. These variants were based on Vergnaud (1994) and identified as recognition of the inherent complexity of issues, examination of the issue from multiple perspectives, appreciation that the issue is subject to ongoing inquiry, exhibition of scepticism, identification of risks and uncertainties and identification of values underlying the students reasoning. The debate is ongoing.

Zeidler and Sadler (2008) provided a broad statement that encompassed many of the areas addressed above when they stated that, in addressing controversial science issues, students cultivated a personal relationship with contemporary issues through active participation, developed argumentation skills, developed the ability to differentiate science from non science issues and developed the ability to recognise the importance of reliable evidence and data. They considered that one of the aims of addressing controversial science issues was “the epistemological development that enables scientific concepts to become connected to students’ values, sense of ethics and moral reasoning” (p. 801).

In this project I considered that decision making on controversial science issues required an understanding of common ethical frameworks for ethical thinking which students could use to make reasoned ethical decisions. Students need to be explicitly introduced to the common frameworks of ethical thinking so that, firstly, their ethical knowledge was increased and secondly, this ethical knowledge could be

used to make a reasoned ethical decision. Explicitly providing instruction involving students having to think about their reasoning involves a set of high level thinking skills or metacognition. I also regarded that using this ethical knowledge for ethical reasoning required the development of skills such as argumentation and this will be discussed in the section on pedagogical perspectives near the end of this chapter.

Constraints to teaching controversial science issues

The recent and rapid rise of scientific and technological progress has increasingly impacted on schools and the science curricula requiring consideration of the ethical implications raised by the development and application of new technologies. However it does not follow that science teachers have the expertise to address these implications. Controversy, debate and understanding of the tentative nature of science are not always a significant part of science teachers' pedagogical knowledge base. Further, the practical measures needed to implement issues-based teaching and learning are lacking (Macer, 2004a), with few guidelines for specific approaches within science contexts being provided (Conner, 2002). Hodson (2003) pointed out

Much that I have suggested is likely to be disturbing to science teachers, severely testing their competence and confidence....Accommodating to what some teachers will perceive as loss of teacher control and direction will be difficult. Indeed, to teach this kind of issues-based curriculum science teachers will need to develop the skills and attitudes more commonly associated with the humanities and language arts. (p. 664-665)

Hughes (2000) suggested that many teachers considered that addressing controversial science issues devalued the curriculum, alienated traditional science students, affected classroom control and could affect their status as gate-keepers of science knowledge.

In a discussion about the reasons for, and benefits of, teaching controversial issues in science classrooms it is important to ensure that the difficulties are not under-estimated. Although the study by Levinson and Turner (2001) in the United Kingdom indicated that 60% of all teachers (in all subjects) think there is too little coverage of issues related to bioethics, and that students should be exposed to such issues, the majority of science teachers considered it their role to present the "facts" of the subject and not to deal with the social and ethical issues. They perceived science to be value free, and not about values, ethics or the opinions of others.

Other teachers surveyed in Levinson's report felt that although it was important to address values in their science teaching, they had a lack of confidence and a lack of expertise in managing discussion and debate in the classroom, as well as the constraint of insufficient time in their teaching programmes. The report outlined how a change in classroom practice from content driven science lessons to asking questions that have no hard answers and where more questions may be raised than solved, can seem a cultural shock to students and teachers (Levinson & Turner, 2001). As Lock (2002) pointed out, "Science is a subject which is seen to be heavily cognitive; dominated by knowledge and involving extensive curriculum content" (p. 179), and Osborne, Simons and Collins (2003) argued that much of school science is regarded as being dull, difficult and not relevant to students or society as a whole. Consequently any change in pedagogy can be difficult for teachers and a study by Ratcliffe and Grace (2003) noted that teachers may experience tension as they move away from "normal practice" and promote discussion and ethical reasoning.

Approximately 90% of teachers surveyed by Levinson and Turner (2001) also believed that there was an urgent need for new, high quality resources that offer a balanced approach with up-to-date, accurate information. Similarly, Macer (1994), in his survey, indicated that 72% of biology teachers in Australia, New Zealand and Japan also felt that they did not have sufficient resources to teach bioethics. Other researchers have identified a lack of suitable resources as being a constraint to the teaching of controversial science issues (Dawson, 2001, Forbes & Davis, 2007; Reiss, 1999; Sadler et al., 2006).

Another constraint was identified by Hall (1998), who stated that many science teachers believed that it is not realistic for them to address moral and ethical aspects because science works with descriptions and explanations, whereas ethics examines how we ought to act given the knowledge we have. A teacher who believes that the nature of science is a search for knowledge and truth may consider the teaching of controversial issues, where there is no clear solution to an issue, to be inappropriate in science (Solomon, 1990).

In a study carried out by Simonneaux and Albe (2003) to identify the reasons why the introduction of controversial science issues is either promoted or resisted, the researchers reported that overall teachers were in favour of issues-based teaching, although it appeared that this type of teaching was rare and depended on the subject

being taught. Similarly to other researchers (such as Allchin 1999; Claxton, 1997; Levinson & Turner, 2001; Van Rooy, 2000), the teachers in Simonneaux and Albe's study felt that teaching science meant teaching facts and certainties, that addressing controversial science issues was venturing into areas that were not part of the science curriculum, and that conducting debates not only wasted precious time, but also placed teachers at risk. Findings of Simonneaux and Albe allowed them to identify attitudes and perceptions of teachers, but did not allow them to infer that the teachers would behave accordingly. They argued, as did Levinson (2001) and Hodson (2003), in favour of an emphasis to be placed on socio-epistemological training for science teachers as well as a multi-disciplinary approach to the teaching of controversial science issues.

Oulton, et al. (2004) also recognised that there are many barriers to curriculum development in this area and, citing work by Clarke (1992), McBee (1996), Thornton (2000), and Werner (1998), they listed these as being: complexity of the issue, teachers' lack of familiarity with and knowledge about the topic, lack of time to deal comprehensively with the topic, the pressure of more "accountable" aspects of the curriculum, and a fear that teachers may be accused of bias.

Curriculum perspectives

Controversial science issues and international curricula

Zeidler and Sadler (2008) stated "The decision-making skills necessary for living in a contemporary society present a need that science educators are advantageously positioned to fill; we simply need to redress science curricula in such a manner that opportunities for students to engage in activities that have ties to real-world practice occurs" (p. 800). However it is not as simple as the authors might imply.

In attempting to promote scientific literacy, new curricula have been introduced in several countries including New Zealand, Australia, UK, USA, Japan, China, India, South Africa, and many European countries (Dawson, 2001; Fensham, 2002; Macer, 2005; Malcolm, 2007; Zeidler et al., 2005). For example, Australian state and territory secondary school curricula raise controversial science issues (Dawson, 2001), and a national report by Goodrum et al. (2001) on science education in Australia identified the importance of science education to prepare

students for their future roles as citizens in an age of science and technology. In England and Wales, Key Stage 4 science (age 14-16 years) stipulated that students are to consider “the use of contemporary scientific and technological developments and their benefits, drawbacks and risks...how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions” (Department for Education and Skills, UK, 2006, p. 37). Wellington (2004) argued that by teaching socioscientific issues, teachers can make a unique contribution to the development of citizenship, which is another requirement in the English and Welsh curricula. However Osborne (2006) and Millar (2006) both cautioned on the difficulty in designing curricula which simultaneously address the scientific literacy of future citizens, but also provide for the training of future science professionals.

The most prominent reasons given for including such issues in science classrooms are the development of scientific literacy, and the need for scientific knowledge to help in decision making and sustain democracy (Levinson, 2008). The importance of such education is generally accepted, but the decision about which directions should be taken is debatable. Some argue that specialists need to be called on to resolve the issues created by science (Shamos, 1995), while others believe that citizens need to be able to participate in “socio technical” controversies and negotiate with the specialists (Bader, 2003).

Controversial science issues and the New Zealand curriculum

Wilmott and Willis (2008) noted that although ethics is more embedded in science education than anywhere else in the Northern Hemisphere, that the heritage is actually the longest in New Zealand where social and ethical issues have been a part of the senior biology curriculum since 1993. However, generally in New Zealand, science has traditionally been taught without addressing controversial issues and, although the two integrating strands of *Science in the New Zealand Curriculum* (Ministry of Education, 1993) “allude” to the development of thinking about issues in science, the content knowledge in the contextual strands still dominates science teaching practice in New Zealand schools. Bolstad and Hipkins (2005) identified a similarity between New Zealand teachers and many teachers internationally in making a content dominated interpretation of the curriculum, and this has also been identified by researchers in Australia (Goodrum et al., 2001) and

the UK (Millar & Osborne, 1998). Osborne and Collins (2000) identified an emphasis on large amounts of content, covered quickly, to be a major barrier to student enjoyment of and continuation of science.

Hipkins and Barker (2002) argued that there are a number of ways that *Science in the New Zealand Curriculum* (Ministry of Education, 1993) could be interpreted to introduce science teaching around controversial issues. However, even though interpretation of the science curriculum document may support the teaching of such issues, that does not mean that these issues will necessarily be addressed. And although the SiNZC (1993) showed that curriculum planners recognised the need for informed citizenry, this intended curriculum is not demonstrated in the taught or implemented curriculum (Bolstad & Hipkins, 2005; Loveless & Barker, 2000). Jorgensen and Ryan (2004) noted in their review of the New Zealand Curriculum Framework, that

At no point does it (NZCF) make clear how curriculum users can move from their personal values and attitudes, and that of the New Zealand Curriculum Framework itself, to the ethical implications of applying the multiplicity of values to solve universal problems. (p. 226)

New Zealand has very recently reviewed its curriculum documents which will require implementation before 2010. This new document (*The New Zealand Curriculum*, 2007) sets out the foundation policy for learning and assessment in schools by establishing values, competencies, learning areas and assessment principles. Critical thinking and bioethics education appear as a developing area in the science and technology learning areas. Within the science learning area, the science essence statement states that students will “explore how both the natural physical world and science itself work, so that they can participate as critical, informed, and responsible citizens in a society in which science plays a significant role” (p. 17). The introduction to the science learning area goes on to elaborate:

Science is able to inform problem solving and decision making in many areas of life. Many of the major challenges and opportunities that confront our world need to be approached from a scientific perspective, taking into account social and ethical considerations. By studying science, students ... use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment. (p. 28)

From this introductory statement, and under an over-arching strand titled the Nature of Science, four contextual strands are presented. The Living World strand states that students will learn about living things and how they interact with each other and the environment and as a result, they will be able to make more informed decisions about significant biological issues. This extends what already existed in the old senior biology curriculum document. Similarly, the Planet Earth and Beyond strand states that students will be able to appreciate the numerous interactions of Earth's four systems with the solar system and then, as a result, confront the issues facing our planet and make informed decisions about the protection and wise use of Earth's resources. The Physical World strand, unlike in previous curriculum documents, states that knowing about physics enables people to understand a wide range of contemporary issues and challenges and potential technological solutions. Similarly the Material World strand suggests that by using their knowledge of chemistry, students are better able to understand science-related challenges, such as environmental sustainability and the development of new materials, pharmaceuticals, and sources of energy.

In the New Zealand senior qualification of the National Certificate of Educational Achievement (NCEA) there is at Level 3 (Year 13) a biology achievement standard "Research a contemporary biological issue" as well as Level 3 science achievement standard "Research a controversial issue in science" that may be chosen by schools as part of their assessment programme for NCEA. For these achievement standards, students are generally expected to give one or two arguments in favour of a position on an issue, and one argument against a position. My discussions with teachers suggest that there is little "active" teaching of controversial issues or discussion of the principles and practices of ethical decision making, or debate of the ethical argument. For an increased level of scientific literacy, there is a need to provide students (and their teachers) with opportunities to analyse and work within ethical frameworks so that more informed and reasoned ethical viewpoints can be argued.

Although this senior assessment qualification has provided opportunities for some senior science students to explore, and be assessed on their understanding of a controversial issue, Hipkins (2001) has argued against leaving the discussion of controversial issues until the senior secondary years, and suggested that younger

students would find science personally relevant and stimulating by engaging in the debate that surrounds such issues. She has also argued for a “back to front” approach in which the issue became the context from which the traditional science content could be explored.

So *The New Zealand Curriculum* (2007), as with the previous curriculum document, has clear statements of intent regarding the teaching and learning about controversial science issues at a number of levels and teachers are expected to address these explicitly, but there are no guidelines on how they may be taught, or how ethical decisions are made. This has enormous implications, not only for in-service training, but also for pre-service training. As a result I decided that it was important to find out how New Zealand teachers were currently addressing controversial science issues in their secondary science classrooms and explore whether or not some form of support might be useful to assist teachers to meet these curriculum requirements.

Pedagogical perspectives

Pedagogical approaches to addressing controversial science issues

Although the importance of addressing controversial science issues is recognised in a number of curriculum frameworks, it is not enough for this to occur implicitly and expect that ethical decision-making will just happen in science classrooms. There is extensive literature about the reasons and aims of teaching controversial science issues, but there is little available for practicing teachers on how to effectively address teaching and learning about controversial science issues so that both ethical sensitivity and ethical knowledge are developed in order for students to make a personal and ethical judgment on the issue. I could find little literature for this in New Zealand schools except for a study carried out by Conner (2002) which reported students’ critical reasoning ability in a study set in the context of cancer. Teachers need to have pedagogical approaches and strategies to help them explore with confidence controversial science issues in their science classrooms and I argue that to match the intended curriculum changes required of science teachers, there needs to be explicit support in terms of new pedagogical approaches.

Some approaches have been put forward internationally. One of the early approaches was the Science-Technology-Society (STS) movement which was

developed in the 1980s in Canada and focused on the impact of science and technology on society. Guidelines for the teaching of STS have been provided by Aikenhead (1994, 2000), Cheek (1997), Cobern (2000, 2001), Fensham (1988), and Yager (1996, 1998). Yager (1996) commented that STS is a “context for curriculum” (p. 13) and described four main key phases of instructional strategies. The first phase was one of invitation which focused on students’ questions, concerns and ideas followed by a second exploratory phase which involved students working individually and in co-operative groups in a variety of activities designed to search for answers to questions or solutions to problems. This phase included designing or carrying out investigations, gathering and analysing information and data, and engaging in group discussion and debate. The third phase involved the proposing of explanations and solutions and the final phase encouraged students to take action at a personal or societal level.

Aikenhead (1994) described STS science teaching as an approach which “conveys the image of socially constructed knowledge. Its student oriented approach...emphasises the basic facts, skills and concepts of traditional science ...but does so by integrating that science content into social and technological contexts meaningful to students” (p. 59). However Ziman (1994), an original proponent of STS education, commented that “the fundamental purposes of STS education are genuinely and properly diverse and incoherent” (p. 22) and Zeidler et al. (2005) claimed it to be an incomplete and undeveloped pedagogical strategy. The lack of a theoretical framework has also been noted by Hodson (2003) and Jenkins (2007).

An extended STSE (Science-Technology-Society-Environment) approach was proposed for Canadian schools by Hodson (2003) which broadened the concept of STS to include environmental education. While it was considered an improvement over STS, it did not engage students in discourse and argument, nor did it develop the ability to make reasoned decisions based on ethical principles (Pedretti, 2003; Sadler, 2004; Zeidler & Keefer, 2003), although Pedretti, Bencze, Hewitt, Romkey, and Ashifa (2008) reported on the effective use of STSE approaches with multimedia case methods in a pre-service teacher programme.

The SSI (Socioscientific Issues) movement, meanwhile, had been proposed by Zeidler et al. (2002) in the United States. The stance taken in proposing this approach was that the STS approaches could be substantially improved and

remodelled by consideration of students' moral and ethical development (Zeidler et al., 2002). As they pointed out, SSI is a broader term that subsumes what STS has to offer, while also considering the "ethical dimension of science, the moral reasoning of the child and the emotional development of the student" (p. 344). Sadler (2008) considered that the STS label has been so widely used that its meaning is now diffuse and that the many strategies and approaches under its umbrella do not share a common framework.

Keefer (2003) proposed further conceptual frameworks for the SSI movement which were extended and combined into a single framework by Zeidler et al. (2005) that identified four areas of pedagogical importance central to SSI teaching. These were nature of science issues, classroom discourse issues, cultural issues, case based issues, and the researchers considered that promotion of these four pedagogical areas promoted functional scientific literacy.

Recently, Sadler et al. (2007) have reported from their work, four significant practices for decision-making of socioscientific issues. Firstly, recognition of the inherent complexity of SSI, and the importance of avoiding simplification of the issue by recognising that a progression from objectivity to relativism to "probalism" was to be expected. Secondly, Sadler et al. reported on the importance of examining issues from multiple perspectives, and thirdly that an appreciation that SSI issues is subject to ongoing investigation. Fourthly, the demonstration of scepticism was regarded as a significant practice for effective socioscientific reasoning. The researchers regarded these four practices as fundamental to the negotiation of socioscientific issues.

In the United Kingdom, a context based course, Salters-Nuffield Advanced Biology for 16- 18-year-olds, was introduced in 2005 for senior biology students. This course was introduced through a range of contexts and had a strong emphasis on social issues and the development of ethical reasoning. The approach taken in the course is that scientific concepts emerge from enduring, yet topical, contexts such as global climate change, genetic engineering, conservation biology, stem cell biology, cystic fibrosis and memory. The course provides opportunities to introduce students and their teachers to ethical principles that would help them to analyse biological issues in real life contexts (Reiss, 2006). The four ethical frameworks that were introduced in the course were rights and duties, consequences, autonomy and virtue

ethics. This course clearly focused on increasing ethical knowledge and ethical judgment of students (Hall, Reiss, Rowell, & Scott, 2003; Reiss, 2006).

Levinson (2006) recently presented an approach for teaching socioscientific issues in which three strands were proposed to provide a framework for teachers. These interconnecting strands were: categories of reasonable disagreement, the communication virtues or dispositions necessary to engage in reasonable disagreement, and narrative modes of thought and experience which can best illuminate the disagreement. Examples were provided to illustrate how the framework could be used by teachers. Although valuable, the complexity of this approach needs further translation in order to be useful for classroom practice. Levinson (2008) further justified the use of a model of personal narrative in the teaching and learning of controversial science issues. Levinson (2001) had previously discussed differences in pedagogical approaches between the humanities and science education. His suggestion that perhaps the humanities teachers could take on board the role of teaching controversial science issues brought about lively debate in the United Kingdom. Perhaps there are opportunities for an exploration of humanities and science teachers addressing these issues together?

Models and learning strategies for teaching controversial science issues

A number of models and learning strategies for teaching and learning about controversial science issues can be identified in the literature. Many of the models proposed relate to components of a bioethical model described by Burnham and Mitchell (1992) and recommended by Dawson (2001), with similar formats recommended also by Frazer (1986), Morris (1994) and Van Rooy (1994). The five stages in this model involved observation, questioning and hypothesising, information gathering, analysis and ethical deliberation, with the final stage being a decision or description of a solution. It is the fourth stage of analysis and ethical deliberation that is important in light of the current research and an aspect not fully developed in many approaches, including the STS approach described earlier. Such ethical deliberation requires the consideration of ethical principles and I contend that students need some form of scaffolding to assist them through this stage in ethical inquiry.

Another decision-making model for discussion of issues, related to the Human Genome Project, involved firstly definition of the issue, problem analysis according to ethical principles, debate of arguments and conclusions (Morris, 1984). Approaches in the teaching of issues have been described in ways such as a class room manager, and overseer (Hand & Prain, 1995), as well as a guide, diagnostician, innovator, motivator and researcher (Osborne & Freyberg, 1985). Conner (2004) went further and indicated how a teacher might enact these roles through establishing and maintaining respectful interactions, assisting group work and discussions and fostering independent learning when teaching in science contexts that have strong values components.

Oulton et al. (2004) proposed a pedagogical model that focused on awareness of various worldviews and the recognition that a person's stance on an issue will be affected by his/her worldview. They emphasised the importance of teachers and students reflecting critically on their stance and the need to provide students with the skills and abilities to identify bias and show a willingness to change a view as appropriate. They encouraged teachers to promote open mindedness and to share their views with students, making explicit the way in which they arrive at their own stance on an issue.

Keefer (2003) used case studies to examine ethical responses in students and as a result developed an "empirically derived model for decision-making" (p. 253). This model followed a process of

1. Identifying moral issues at stake
2. Identifying relevant knowledge and unknown facts
3. Providing a justification
4. Considering alternative scenarios that argue for different conclusions
5. Identifying and evaluating moral consequences
6. Offering alternative resolution

Zeidler et al. (2005) suggested that this model is "strikingly similar" to a model developed by Pedretti (2003) based on Ratcliffe (1997), in which Pedretti allowed her pre-service students to develop their own decision-making model.

Levinson (2003) suggested that one model for teaching controversial science issues is to start with a case study, enable articulation of the dilemma, and feed in the science on a 'need-to-know' basis. He suggested that groups of students could consider the interests of each of the parties involved through a list of focused questions and then the students could engage in debate, or construct an argument to support or justify the claim they are making. He considered that an important outcome following the debate should be that the students wrote a "discursive argument" that incorporated both an understanding of the science and the ethical issues.

Kolsto (2000) also reported on a model that incorporated case-based approaches and emphasised that science knowledge is formulated by consensus building via critical discourse among students. His consensus building model acknowledged four key attributes. The first one involved presentation and defence of data or conclusions, with the goal being consensus. Secondly, professional and nonprofessional views were examined for balanced recommendations, and this was followed by the consultation of experts to help students reach consensus. The final attribute required the production of a report by the students of their conclusions which was available to the public, politicians and policy makers. This approach required high demands of teacher competency and their role as a counsellor, consultant, critic and expeditor (Zeidler et al., 2005). The use of case studies has also been identified in the literature by Fullick and Ratcliffe (1996), Lock and Ratcliffe (1998), Sadler et al. (2006), and Sherborne (2004).

There are a range of strategies for teaching and learning about controversial science issues that have been reported in the literature, such as role play, scenarios, debate, group work, jigsaw discussion, forums, conferences, vignettes, oral presentations, case studies and debates, oral presentations and written reports (Jarvis, Hickford, & Conner, 1998; Van Rooy, 2004). Simonneaux (2001) described a study examining the pedagogy of role play and argumentation in promoting students' ability to make and justify their decisions in the context of genetic engineering in animals. She commented that the strategies described assisted in more than the acquisition of science content and that

Teaching students to identify and assess opinions and to form their own well thought out opinions on a complex problem of both scientific and

social importance should logically be considered an essential aspect of science education and the acquisition of scientific literacy. (p. 929)

Settelmaier (2003) used a dilemma approach, in which dilemma stories were used to introduce issues to secondary students. The results found that they were a useful tool to challenge students' thinking and provide individual reflection on personal values. However the study revealed logistical and planning problems of coverage of the curriculum content with the dilemmas, and matching the dilemmas to the students' interest. McCann (1997) suggested that

Perspectives and strategies that have been successful in the science, technology and society curricular movement, as well as the environmental education movement, will prove valuable resources for traditionally trained science teachers who are delving in to these. (p. 3)

It becomes clear from the literature that there are a number of models, and a number of teaching and learning strategies, that can be used in addressing controversial science issues. Although there is no single way to teach controversial science issues, there is a commonality through the literature emphasising that controversial science issues cannot be addressed effectively from a didactic, teacher centred approach, and that the process of ethical reasoning is more about a respectful exploration of all viewpoints, rather than about the final decision. As Levinson and Reiss (2003) stated, "It is how a decision is made, rather than what decision is made that...is core to teaching bioethics" (p. 8).

Facilitating argumentation

Argument, or the justification of claims, has a central role in addressing controversial science issues. The value of argument in the development of reasoning and argumentation in science classrooms has been "amply" demonstrated in the literature (Keefer, 2002). The case for argumentation as a form of pedagogy was stated by Billig (1996), who regarded that learning to argue is learning to think, and Osborne (2006) identified that argument and its evaluation is actually critical thinking which "is a core feature of science" (p. 4). He argued that a focus on examining ideas, evidence and argumentation has the potential to improve students' conceptual understanding of science, enhance their ability to reason and think critically, develop a deeper understanding of the nature of science as well as make the learning environment and learning experience more enjoyable. He suggested that the construction of argument and its critical evaluation are "discursive" activities,

central to the learning of science. Similarly, Levinson (2003) noted that addressing controversial science issues effectively involved discussion so that students can articulate the issue as they evaluate the associated viewpoints.

Patronis et al. (1999) and Zohar and Nemet (2002) also recognised that controversial science issues provided an appropriate context for argumentation and reasoning. Patronis et al. (1999) elaborated that argumentation holds a central role in the resolving of controversial science issues, and is “a social process, where cooperative individuals try to adjust their intention and interpretations by verbally presenting a rationale of their actions” (p. 747-748). Driver et al. (1996) argued that argumentation in school science assists students in appreciating the power and limitations of science claims and that this is necessary to develop an understanding of the scientific enterprise and to evaluate the use of the products of science and technology.

Osborne and Young (1998) considered that developing students’ ability to understand valid ways of arguing, and enable them to recognize the strengths and limitations of scientific argument, was an important task for science teachers. Students need to have an awareness of what constitutes a reasoned argument in a science context and to be able to construct and evaluate their own. Osborne, Simon, Erduran and Monk (2001) explored pedagogical practices that support argumentation in science classrooms. The significance of such practices was that they offered an avenue to improve the epistemic understanding of the nature of science that many would argue is an essential outcome of science education today (Millar & Osborne, 1998). To disseminate their work more widely, Osborne et al (2004) developed a pack, funded by the Nuffield Foundation, called the Ideas, Evidence and Argument in Science Education (IDEAS) pack. This showed teachers how to explicitly introduce argument to students, how to manage small group discussion, how to teach, model and evaluate argumentation, and resources for developing argument lessons. Simon and Maloney (2006) reported on the design and implementation of activities that supported teachers in the development of students’ argumentation skills. In their study, which was carried out with 10- and 11-year-old students, they found that good quality argumentation occurred when students were expected to give reasons for their choices in any activity in science, where students explained why

they rejected alternative options, and where students explored why scientists rejected ideas in the light of new evidence.

Dawson (2006), in her study on the argumentation skills of Western Australian high school students, concluded that students needed opportunities to practice these skills if they were to develop their scientific literacy. Sadler (2004) similarly commented that if we want students to think for themselves, there must be “opportunities for them to engage in informal reasoning, including the contemplation of evidence and data and to express themselves through argumentation” (p. 533). Driver et al. (2000) stated that “in our democratic society, it is critical that young people receive an education that helps them to both construct and analyse arguments relating to the social applications and implications of science” (p. 297). Ratcliffe, Harris, and McWhirter (2004) have shown from their studies that students base their arguments more on values and personal experiences than science concepts, and therefore decision making about controversial science issues is a complex process.

Zeidler (1997) and Chinn and Brewer (1998) identified that students have difficulty in developing arguments, especially in presenting opposing arguments or diverse views. Zeidler et al. (2005) suggested that teachers also found it difficult to confidently implement sustained student discourse because of the complex nature of argumentation, but argued for the importance of using argumentation and discourse to construct shared knowledge and develop students’ views about controversial science issues. They referred to the ability of students to internalise and articulate the arguments and positions of other people (i.e. stand in other people’s shoes), as “transactional discourse” and discussed how it can improve science learning. Similarly, Berkowitz and Simmons (2003) commented, “Whereas transaction can foster students’ logical development by focusing on scientific problems and issues, teachers can foster the development of social and moral reasoning by focusing on ethical and social issues” (p. 133).

However, although the concept of argumentation has been identified frequently in the science education literature, such pedagogical practice is rarely found in science classrooms, especially in New Zealand. Newton et al. (1999) had difficulty in finding evidence of argumentation in science classrooms, and Levinson (2003) found that the quantity and quality of such discussion was low. He found in his case study of senior science students exploring controversial science issues, that

teachers dominated the classroom discourse, and suggested that support for teachers from other curriculum areas, along with the professional development of teachers, could aid in facilitating improved discourse and argumentation.

Erduran, Simon and Osborne (2004) developed and tested sets of material for developing argumentation skills and discussed some of the difficulties in teaching argumentation skills in science classrooms. They identified these difficulties as students being more likely to generate explanations rather than evidence; arguments not often based on appropriate evidence; often a single piece of evidence is selected which may be distorted, or some evidence may be ignored in order to support claims. Subsequently, Simon, Erduran and Osborne (2006), drawing on their sets of materials, reported on a typology of pedagogical strategies that teachers adopted when implementing argumentation.

Albe (2008) explored how students elaborated on controversial science issues in small group discussions and identified several processes in which arguments in role plays were elaborated from science data, common ideas, and epistemological and strategic considerations. It appeared that students' social interactions influenced their patterns of argumentation, with students requesting others to justify claims on their positions.

Jimenez-Aleixandre et al. (2000) referred to two aspects necessary for effective argumentation. The first aspect was that of argumentative operations (the structure of an argument) and the second related to the epistemic operations (definitions, science context knowledge, use of analogies and exemplars). Zohar and Nemet (2001), in a twelve-week learning intervention, provided explicit instruction in both the understanding of the science concepts and in the use of argumentation skills to an experimental group within the context of human genetic dilemmas. Comparisons between the experimental and control groups revealed notable differences in the quality of argumentation as well as improved conceptual understanding of related science content knowledge.

Toulmin's argument model (1958) recognised there should be a claim (an assertion) based on data. A strong argument is supported by warrants (reasons for making the claim) which are in turn supported by backings (scientific laws or models). The claim can be challenged by counterclaims (alternative assertions) or a

rebuttal (reasoned rejection of the claim). This model has been used by many researchers (Bell & Linn, 2000; Dawson & Venville, 2008; Erduran et al., 2004; Jimenez et al., 2000; Osborne, Erduran, Simon & Monks, 2001). For example, Dawson and Venville (2008) analysed argumentation and informal reasoning in Australian high school students in a biotechnological context using the frameworks of Toulmin's argumentation pattern and informal reasoning patterns (rational, emotive and intuitive). Most students used no data or basic data to justify their claims. They also used intuitive and emotive informal reasoning more frequently than rational, which the researchers found was associated with more sophisticated arguments. Erduran et al. (2004) considered that levels of sophistication of an argument could be determined by the use of these components of Toulmin's argument model. However some researchers argued that this model does not fully identify quality, strength and weakness of the students' arguments (Zeidler, Osborne, Erduran, Simon, & Monk, 2003) and they suggested that a naive conception of an argument's structure affects the validity and core beliefs on argumentation.

Computer-based tools to develop argumentation

The challenge for classroom teachers is how to support students in their construction of arguments in science classrooms and one approach is through the use of computer-based tools. A web-based learning environment was used by Jorde and Mork (2007) to encourage students to explore in groups and debate the issue of wolves in the landscape in Norway. The context served as a vehicle for the teaching of science concepts and provided opportunities for students to develop their argumentation skills. The researchers identified four main categories of arguments: biological/scientific, economic, social and political, with biological/scientific and social arguments most frequently used. Use of scenarios, or case studies which were based on realistic situations, helped groups to work collaboratively, and using authentic and current information helped students to discuss and debate information. As they discussed new information and were presented with multiple views, students had opportunities to evaluate arguments as well as practicing their argumentation skills.

Kollar, Fischer, and Slotter (2005) reported on the use of a computer-based Sensemaker tool in the WISE (Web-based Inquiry Science Environment) programme and found that the structured and scaffolded environment assisted students to build

sound arguments. Other researchers have also reported on the development and evaluation of tools for web-based learning (Bell, 2004; Linn, Clark & Slotta, 2003; Slotta, 2004; Willis, 2000).

Bell's (2004) research scaffolded science content knowledge within a computer-based tool and students were encouraged to explore the background science. They used evidence to support their viewpoint then debated and discussed the issues before coming to an informed decision. In reporting on a constructivist instructional design model, Willis (2000) suggested that users of this computer-based model should play a role in its design, and that trialling and obtaining user feedback and suggestions was an evolutionary process of development.

Cho and Jonassen (2002) found in their study that computer-based tools can support students in constructing higher level argumentation and Bell (2004) also found that the use of technology supported high quality argumentation by incorporating knowledge representation tools which connect evidence to a claim. Sandoval and Reiser (2004) and Evagorou and Osborne (2007) also demonstrated from their research that technology enhanced learning environments can be used to successfully scaffold argumentation. Evagorou and Osborne combined a computer-based tool (Argue-WISE) based on the WISE programme with a discussion based platform designed by Linn at the University of California, Berkeley.

Walker and Zeidler (2007) used a web-based learning environment to promote discourse on a controversial science issue in the context of genetically modified food and they examined features of argumentation and discourse in the final classroom debate. Although students use of the tool reflected conceptions of "tentative, creative, subjective and social aspects" of the science, aspects of the nature of science did not enter in to the debate, and it appeared that students used factually based evidence that frequently led to "fallacious reasoning and personal attacks" (p. 1). They recommended that students receive explicit instruction on argument structure, either prior to engaging in the activities or during the activities themselves. This has implications for pedagogical content knowledge in that teachers need to be familiar with instructional techniques that emphasise argumentation.

A computer interactive tool was also developed and trialled by a research team at the University of Waikato, New Zealand (Jones, McKim, Reiss, Ryan,

Bunting, Saunders, de Luca, & Conner, 2007) which supported the teaching and learning of ethical reasoning to build a strong argument in a wide range of classroom programmes. Although it was only trialled with seven teachers, the case studies also highlighted the critical role of pedagogical content knowledge in terms of ethical reasoning in the teaching and learning about controversial science issues.

The literature shows that web-based learning environments and associated computer-based tools are potentially valuable vehicles that can scaffold and support students individually and collaboratively to develop science conceptual understanding and use evidence to construct high quality arguments in science. However teachers reported that they felt limited by lack of expertise and lack of time to develop these skills in their classrooms.

Assessment of issues

The assessment of controversial science issues can be problematic because what is assessed tends to drive teaching programmes. Traditionally, science knowledge and understanding have been assessed, so instruction has focused on this rather than controversial science issues, where assessments involving “nuance, judgment and weighing of alternatives” rather than “fixed answers” can be problematic (Conner, 2004, p. 45). The assessment to support new initiatives can be challenging as new assessment approaches are needed to support and reflect the new emphases of the curricular documents. Ratcliffe (2007) reported that there is a current lack of suitable measures for demonstrating student achievement in the area of science-based issues, and also commented that summative assessment is dominated by written assessment which may not capture the “nuances” of students’ abilities to reason, argue, and defend value judgments that they may have demonstrated in discussion. She goes on to discuss how valid test items are not easy to construct, especially if they are set in unfamiliar contexts, and she concluded that current summative assessment practices do not encourage or enable consistent assessment of issues in classrooms. She acknowledged however, that the use of SOLO (Structure Of Learning Outcomes taxonomy), devised by Biggs and Collis (1982), had potential to guide the assessment of students’ arguments.

As mentioned earlier in this literature review (p. 31), social and ethical issues have been part of the New Zealand senior biology curriculum since 1993. The

common pedagogical approach to this part of the curriculum involved teachers setting a topic, or a list of topics, from which students select one to research individually and then write an essay. There is traditionally little active engagement with the issue or co-operative learning strategies used as pedagogical approaches to this task. Assessment of the issue has been by an essay written to address a question in an external examination. Since 2005, essays have been assessed internally by teachers who follow specific criteria to make a valid assessment. The assessment is judged on three levels (achieve, merit and excellence) and based on the referenced description, explanation, or discussion related to the biological concepts and processes upon which the issue is based; the biological, social, ethical, economic and environmental implications related to the issue; and the differing opinions held by a range of people on the issue. Stating and justifying their own opinion, using supporting evidence, is required for a student to receive an “excellence” level of achievement. Teacher judgments on student work are checked on a regular basis by moderators and the New Zealand Qualifications Authority noted recently through moderator reports, that the ability of biology teachers to make sound judgments on students’ work is generally fair and valid.

Conner (2004) also used essays with senior biology students in New Zealand, and these were self and peer assessed, as an assessment task to provide opportunities for students to improve their essays. She also argued that categories for critical thinking aspects needed to be clearly defined as criteria in examination schedules for students as well as for teachers.

Based on his experience of setting and marking questions on ethical thinking in the SNAB programme over six years in the UK, Slingsby (2008) argued that assessing ethical thinking needs to recognise a progression and suggested one that might be useful, although he stressed that it is not grounded in research.

Several studies in argumentation have provided assessment schedules in which arguments are evaluated on students’ ability to communicate arguments with supporting evidence, a demonstration of science concepts associated with the issue and the recognition of multiple perspectives. A high level of sophistication involved the ability to analyse an issue from a range of perspectives and recognise challenges to one’s personal viewpoint, and a less sophisticated level involved the appreciation of some other perspectives after prompting, or an inability to think beyond a personal

viewpoint (Erduran et al., 2004; Sadler et al., 2007; Zohar & Nemet, 2002). Sadler et al. (2007) argued from their research that socioscientific reasoning was an assessable construct and developed a rubric to assess this construct. Their “emergent” rubric had four performance levels for each of the elements of recognition of complexity, ability to examine the issue from multiple perspectives, understanding that socioscientific issues were subject to ongoing inquiry, and the ability to exhibit scepticism.

Evaluating information

Some researchers have cautioned on the need for developing scepticism of information related to controversial science issues, and the evaluation of information can also be problematic for students. Sadler (2004) suggested that students find it difficult to evaluate information and also find it difficult to recognise bias and demonstrate scepticism of information relating to socioscientific issues.

Kolsto (2001b) worked with students in examining science-based claims and he encouraged students to answer questions which asked what the source was, was the source trustworthy, what was the evidence, might the sources have interests influencing their views, and was there consensus on this knowledge claim by the science community. He reported that most pupils in his study (16-year-olds) recognised the need to carefully assess the sources and the reliability of information related to the issue and stated that, “In addition to the science knowledge offered, one usually has to deal with the issue of trustworthiness of knowledge claims from other actors engaged in the issue” (p. 878). This relates strongly to one of the four significant practices identified earlier by Sadler et al. (2007), which recognised the importance of exhibiting scepticism when presented with potentially biased information. Hermann (2008) also considered that the interpretation of validity and trustworthiness of science-related claims was an important reason for including controversial issues in science education.

Teacher positions when addressing controversial science issues

The role of the teacher when addressing controversial science issues is a sensitive one and care needs to be taken that all ideas are valued, none are ignored or ridiculed and that a mutual respect is encouraged for all ideas. Van Rooy (2004) suggested that students need to be able to engage in debate in a positive learning

environment where they are free to voice beliefs without ridicule, and she emphasised that such a learning environment must “value tolerance, respect the opinion of others and be well resourced” (p. 196). Levinson (2003) emphasised that teacher awareness of the sensitivities of some students to particular issues because of their personal experiences or circumstances is essential and he suggested that such students be given an option to either participate, or work on another task.

Levinson (2003) considered that students may look to the teacher as an authority and it is important that students’ viewpoints are not influenced by the teacher’s viewpoints. Teachers can take various roles and these may be neutral, acting as “devil’s advocate”, or presenting balanced viewpoints, but there will be implications for whatever role is taken (Wellington, 1986). Levinson (2003) suggested that a neutral role may not be convincing to students as they will be aware that teachers have a point of view. However he made the point that if a teacher makes their opinion known, then it may be considered to be indoctrination. Wellington (2004) argued that science teachers, as part of the science profession, cannot be “neutral chair”, nor should they present a balanced set of viewpoints. He emphasised that they must have a position on an issue and that this position should present the “view of science”, as by presenting students with the scientists’ values and perspectives which are based on evidence and which has been opened to scrutiny and review by peers, teachers are making a stand against relativism. Van Rooy (2004) suggested that the roles teachers might take can be from a position of neutrality or a balanced role where all alternate views are presented, but she added commitment as another position. She elaborated on commitment as where the teacher view becomes known and explained and that this has the advantage of allowing for student criticism and therefore teacher credibility. However she cautioned that open discussion might be compromised because students may not be willing to argue with the teacher, or they may argue for the sake of contradicting the teacher. She concluded that the role taken will be dependent on the issue, the students and the school environment, and teachers need to weigh up the relative importance of each. She suggested that the most appropriate position is one that is “flexible and reflective to both the students and the controversial issue” (p. 201).

Bridges (1986) identified three possible approaches for addressing controversial issues. These were firstly, advocacy approaches to instruction which

occurred when the teachers argued from their personal viewpoint. The second approach was one of affirmative neutrality in which the teachers presented multiple views on the controversy without revealing their personal position. The third approach was one of procedural neutrality when information about the controversy and different points of view were elicited from resource material and from the students. Hermann (2008) suggested a fourth approach often taken by teachers was that of avoidance of instruction on issues and discussed this further in the context of the teaching of evolution.

So although there are no clear guidelines for teacher positions when discussing issues, the teacher's role needs careful consideration, with teachers modelling respect and making it explicit in discussion that there is no "right" answer.

Resources for teaching controversial science issues

Lack of resources and materials suitable for science teacher have been identified by many teachers as a constraint to addressing controversial science issues (Dawson 2001; Forbes & Davis, 2007; Macer, 1994; Levinson & Turner, 2001; Reiss, 1999; Sadler et al., 2006). As mentioned earlier, some resources and programs which help teachers to address controversial science issues have been developed for teachers (Erduran et al., 2004; Osborne et al., 2001), and in the last few years, web-based resources have gone part way towards meeting some of these needs. Sherbourne (2004) reported on a range of on-line resources developed by the Centre for Science Education at Sheffield Hallam University to support the ethical thinking of 14- 18-year-old students. Some recent web-based resources developed to support teachers in the teaching and learning about controversial science issues are described in Appendix A.

In general, the web-based resources present up-to-date examples of issues, often supported by student and teacher learning materials that provide in-depth information to background issues, video clips, interactive activities, animations and, in some cases, tools to assist students make decisions on controversial issues. However, despite some innovative issues-focused materials being available, teachers often end up assuming a passive role (Pedretti & Hodson, 1995) or are unwilling or able to find out how to make the most of the opportunities provided by the resources (Wishart, Baggot la Velle, Green, & McFarlane, 2007).

Summary

An exploration of the literature based around the theoretical perspectives associated with teaching and learning about controversial science issues provided a strong background from which clear definitions and understandings of values, morals and ethics could be established, as well as understandings of the kinds of thinking and reasoning that could be engaged to negotiate issues in the science classroom. Another factor that emerged was that although there is no one accepted framework for ethical thinking, consideration of those presented in the literature enabled a decision to be made on ethical thinking frameworks that would be relevant for use in New Zealand schools. These were the four frameworks presented by Reiss (2006): consequentialism (projected outcome of a decision), rights and duties, autonomy (making decisions for yourself), and virtue ethics (leading a virtuous life considering virtues valued in society such as honesty, truthfulness, integrity, compassion). It became clear that the addition of a fifth ethical framework could be justified for use in New Zealand classrooms as a result of the pluralistic nature of New Zealand society today.

A number of aims and reasons for addressing controversial science issues were examined in the literature, and these included general aims such as the development of scientific literacy and informed citizenry along with the development of other more specific skills, such as development of science content knowledge, critical thinking skills, motivation and interest in science, and development of ethical knowledge, thinking and reasoning.

Teaching about controversial science issues in science classrooms appears, from the international literature, to be difficult for teachers. The research suggested that a number of constraints, such as lack of guidance, lack of pedagogical knowledge, and lack of classroom resources and realities of constraints in the classroom, are all interacting factors that contribute to teachers' lack of confidence in addressing controversial science issues.

A review of curriculum perspectives both internationally and in New Zealand indicated that although curriculum planners recognise the need for informed citizenry and the development of scientific literacy, the intended curriculum is rarely demonstrated and the implemented curriculum is still largely content-dominated. *The*

New Zealand Curriculum (2007) has a clear statement of intent for the teaching and learning of controversial science issues, but there are no guidelines or intended professional development on how this might be done. The implications of this are that a professional learning programme might be able to provide support to assist some teachers in the meeting of these curriculum requirements.

Much of the literature on addressing controversial science issues focused primarily on students and how they make decisions on such issues. In contrast, little research has addressed teachers and teacher pedagogy, and yet teachers play a crucial role in the teaching of controversial science issues. Clearly, the extent of teachers' pedagogical knowledge will influence their teaching practices, which will subsequently determine the opportunities they provide for effective students' learning in this area.

A number of pedagogical approaches and models, assessment issues, teacher roles and strategies and approaches relative to teaching and learning of controversial science issues, can be identified in the literature, although only one study (Conner, 2002) had been carried out in a New Zealand context. General instructional approaches from the international literature were examined and discussed, but these provided little on specific frameworks or models that classroom teachers could follow and implement in their classrooms. The literature showed that the demands are high on teachers and that there are many practicalities to consider. These ranged from the choice of the issue, decisions on the role to be taken in discussion, effective teaching and learning strategies to employ, developing an understanding science concepts, understanding argumentation, resourcing for the issue, assessment of the issue, evaluation of information, curriculum constraints and how to promote critical thinking and the development of ethical knowledge and reasoning. The literature on teaching and learning about ethics and ethical thinking revealed a similarity between the informal reasoning approaches suggested by Sadler and Zeidler (2004) and the ethical reasoning frameworks put forward by Reiss (2006). This confirmed for me that a planned sequence of learning, used in conjunction with accepted ethical thinking approaches, may help teachers to develop effective pedagogical practices that will assist students to move from being intuitive decision makers where they lack a rationale for their views, to reasoned decision makers who can justify their decisions according to ethical thinking approaches.

It emerged from the literature on pedagogical practices that student-centred approaches to addressing controversial science issues are more effective than teacher-centred approaches. Further, an effective approach requires a facilitative role to be taken by the teacher so that, through a soundly based decision making model, students could be assisted to examine their own values, explore the science behind the issue, and through collaborative activities examine the controversial science issue critically using a range of ethical frameworks to provide justification of their personal views.

This review of literature provided a frame of reference from which the intended research project could be designed and developed. Firstly, it established a theoretical base that informed my knowledge base and which was essential to background the project. Secondly, it clearly showed that there was a lack of current literature on teaching and learning about controversial issues in New Zealand secondary science classrooms and that there was a need to examine how New Zealand teachers are addressing issues, including the teaching of decision making skills in their science classrooms. Given that the literature shows that teachers in other countries indicated that constraints to teaching controversial science issues were lack of suitable resources, materials, time, appropriate skills and confidence, it was important to investigate whether New Zealand teachers perceived similar or additional constraints. Thirdly, there should be an identification of the support that teachers indicated they needed to address the teaching of controversial issues in secondary science classrooms and, finally, it seemed likely that a professional learning programme would provide support to assist New Zealand science teachers to do this.

To this end, the main research questions that emerged for this project were:

- 1. How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*
- 2. What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*
- 3. In what ways will a professional learning programme support teachers to address controversial science issues in secondary science classrooms?*

Chapter 3 describes how the research project was designed and then developed to address these three research questions.

CHAPTER 3: RESEARCH DESIGN

Introduction

This chapter explains how the research was designed and implemented to answer the three research questions:

1. *How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*
2. *What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*
3. *In what ways will a professional learning programme support teachers to address controversial science issues in secondary science classrooms?*

Following the setting out of the theoretical paradigms or frameworks of the research project, Phase One of the project is described. This phase involved the development and administration of a survey to secondary science teachers with follow-up focused group interviews with some survey respondents. The chapter outlines the data collection techniques and how the quantitative and qualitative data were analysed to answer Research Questions 1 and 2. Next, for Phase Two, the chapter reports the development of a model for ethical inquiry and how the professional learning programme was structured to implement and evaluate the model. The following section documents Phase Three of the project, in which the model was trialed and evaluated in order to address the third research question. This section outlines the characteristics of the interpretive case study method chosen and then justifies the use of case studies to write up the data from the trials, and explains the procedures for analysis of the case study data. Finally, the procedures undertaken to ensure rigour and ethical concerns in the project are discussed.

Methodological paradigms for research

The aim of methodology is to describe the approaches to, and the kinds and paradigms of, research in order to assist our understanding not only of the product of scientific inquiry but the process itself (Kaplan, 1973). Kuhn (as cited in Cohen, Manion & Morrison, 2007) suggested that methodology is the theoretical framework

or paradigm on which the researcher draws as the basis of the study and Lather (1992) stated that methodology is the theory of knowledge and the interpretive framework within which a research project develops. It describes and analyses methods used for data gathering and guides the way interpretations, explanations and predictions are made.

Social sciences research is often divided into paradigms. A paradigm is defined by Bassey (1999) as a “network of coherent ideas about the nature of the world and of the functions of researchers which, adhered to by a group of researchers, conditions the patterns of their thinking and underpins their research actions” (p. 12). The two main paradigms described by Burton and Bartlett (2005) are positivist or quantitative, and interpretivist or qualitative.

Positivist researchers prefer structured methods of data collection, carried out on a large scale, with the data usually being quantitative and results presented as statistical tables in a way that enables others to see how the data have been interpreted. Usually data are compared, differences noted and explanations provided for differences between the groups.

Denzin and Lincoln (2000) provided a useful generic definition of qualitative research.

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretative, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings and memos to the self. At this level, qualitative research involves an interpretative, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of meanings people bring to them. Qualitative research involves the studies' use and collection of a variety of empirical materials – case study; personal experience; introspection; life story; interview; artefacts; cultural texts and production; observational; historical; interactional and visual texts – that describe the routine and problematic moments and meanings in individuals' lives. (p. 3-4)

This quotation implies that the interpretivist or qualitative paradigm is concerned with the interactions of individuals and recognizes that there is no objective reality of the situation. The researcher is trying to understand and portray participants' perceptions and understandings of the particular situation or event. The forms of data collected in this paradigm are more 'naturalistic' and make use of

observations, informal interviews, detailed descriptions and individual accounts. They are small scale and aim for detail and understanding rather than ‘statistical representativeness’. This achieves an in-depth understanding and detailed description of an individual case history or a group’s experience (Yates, 2004).

Although some researchers suggest it is important to follow methods identifiable with a certain methodology, I was encouraged by the advice of Cohen et al. (2007) with their discussion of ‘fitness for purpose’. Their guiding principle encouraged different research paradigms for different research purposes. I considered the different paradigms and selected the methods that seemed the best ways to answer the research questions, not because they fitted to a particular theoretical framework or paradigm. Clough and Nutbrown (2002) suggested that the issue is not so much a question of which paradigm to work within, but how to best dissolve that distinction so that the research is designed to best serve the investigation of the questions posed through that research.

I have borrowed from both of the major paradigms and used quantitative and qualitative methods as appropriate to enable an investigation of the three research questions. Consequently, this research project took a mixed-method approach and proceeded in three phases to address the research questions. The three phases of the project are shown in Figure 2, with the starting points of Phase One shown at the base, and then proceeding chronologically up through Phase Two and Phase Three.

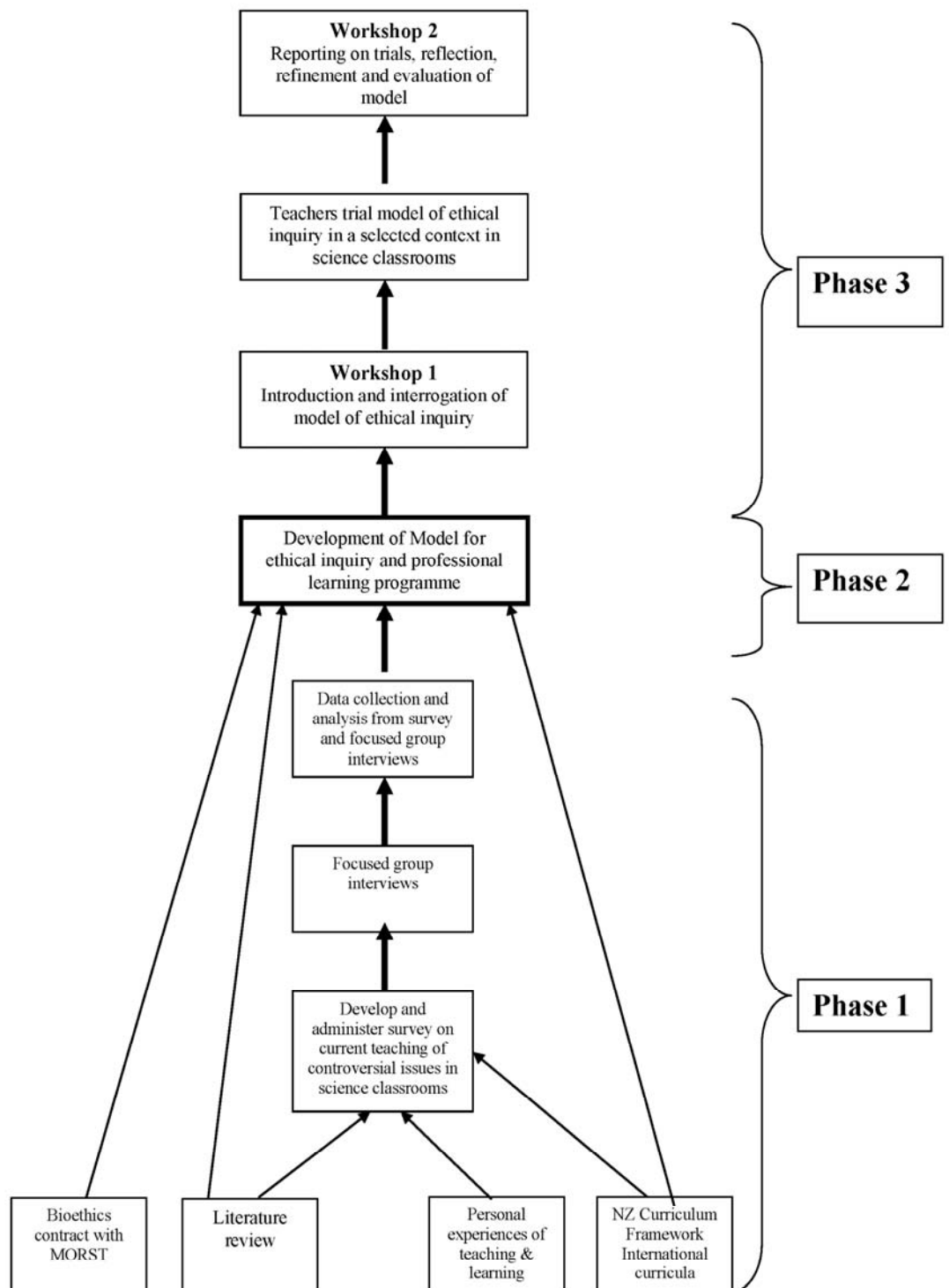


Figure 2. Thesis pathway

Phase One: The survey and the focused group interviews

This phase, which addressed Research Questions 1 and 2, involved the development and administration of a survey to find out first, how New Zealand teachers currently address controversial science issues in secondary science classrooms and second, whether they required support in order to do this. Following the analysis of the survey data, focused group interviews with some survey respondents were carried out to explore further the participant teachers' views and needs on the teaching of controversial science issues.

Firstly, the development and administration of the survey is described. The next section describes the data collection techniques and how the quantitative and qualitative data were managed and analysed. Finally, the focused group interviews are discussed.

The Survey

Development of the survey

A survey is a commonly used social research technique and its administration by post was considered a practical technique to collect data for Phase One of this study (Cohen et al., 2007). A postal survey was chosen as it has an economical advantage compared to telephone surveys and face-to-face interviews, and budget restrictions made this method of collecting data the most feasible choice. Teachers could complete the survey in their own time, providing comprehensive data in a relatively simple and inexpensive way over a short period of time (Anderson, 1990; Cohen et al., 2007).

In developing the survey, careful consideration was given to the kind of questions needed to be asked to address the first research question: "*How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*"

Some ideas were gathered from informal discussions with teachers at local and national science education association meetings, as a way of supplementing information gained from discussions with teachers in previous science advisory work. Other ideas for questions were sourced from literature examined from other studies, including work carried out by Levinson and Turner (2001) in their report to

the Wellcome Trust in the United Kingdom. This study indicated that the perception of many science teachers in the United Kingdom was that teaching of science was about the delivery of content and that the teaching of 'value-free' concepts was preferred. I wanted to determine whether, like teachers in the United Kingdom, New Zealand teachers felt that teaching science was value free, that they did not have the skills for controversial science issues-based discussions, that they lacked confidence to teach such issues, and that time and resourcing for teaching issues were problems.

The draft survey contained 23 items grouped into three sections. The first section of the survey addressed the demographics of the sample. These questions were developed by an examination of sociographic variables in other surveys. It involved ten restricted choice questions to cover information about the respondents, their professional experience and information about the respondents' schools. Questions were asked about their sex, age, ethnic origin, school type, years of teaching and qualifications and position held with subjects currently taught. These restricted choice questions asked respondents to select an option from possible choices and also included a space for other responses to be specified.

The second section of the survey employed a combination of eleven restricted choice, list, ranking and open-ended questions that covered the teachers' experiences in teaching of issues; issues-based topics taught; teaching strategies or approaches used; resources used; how confident teachers felt about addressing controversial science issues; their perceived constraints to the teaching of issues; resources that would be useful in teaching of issues and finally professional development support accessed or required. The open-ended questions provided an opportunity for respondents to express honest and personal comments, and this added "richness, depth and authenticity to the empirical data" (Cohen et al., 2007, p. 255).

In the third and final section of the survey, teachers were given an opportunity to comment on any additional aspects of teaching and learning about controversial science issues that was of concern or important to them. They were also asked if they were prepared to participate in a follow-up interview related to the teaching of controversial issues in science classrooms.

Some of the survey questions required the respondents to recall information, such as controversial science issues taught or types of strategies or approaches used. To assist in obtaining full information about these, a list was provided to aid recall. Items in the lists were mainly identified from the international literature as well as my personal experiences. Respondents were requested to check those on the list that they had taught or used. Such questions also included “Other (please specify)” to provide an opportunity for additional responses to be recorded.

Field testing the survey

The purpose of the field testing was to ensure that the survey and its instructions were understandable and unambiguous. Such a field test can help to increase the reliability, validity and practicality of the survey (Morrison, 1993; Oppenheim, 1992). It was also important to establish face validity to ensure that the survey appeared, at face value, to measure what it was designed to test (Cohen et al., 2007). Sapsford and Jupp (1996) offered a more precise definition as they discuss that validity means the “design of research to provide credible conclusions; whether the evidence which the research offers can bear the weight of the interpretation that is put upon it” (p. 1).

The draft survey was examined by four local experienced science teachers who agreed to review the survey. They were asked individually to complete the survey in order to check that the instructions and layout were clear, and then to provide feedback on the questions to eliminate ambiguities and difficulties with words. Their suggestions were all incorporated, and changes were made to simplify one question about subjects and levels taught by respondents. Emphasis was given to state that the senior science level encompassed Years 11-13. Consistency of terminology was also discussed and the term “addressing controversial science issues” was finally used throughout the survey. Suggestions were made in relation to a response list from one question being used to answer another. Other suggestions accepted were that the survey be divided in to three sections and that the inclusion of closing instructions for the return of the survey be given at the end of the third section, reinforcing those in the explanatory letter.

The revised version of the survey was field-tested and completed individually by another two teachers who concluded that the survey had face validity and that

they believed it did test what it set out to test. A copy of the final survey is included as Appendix B.

Administration of the Survey

It was not feasible to sample all the secondary science teachers in New Zealand schools so it was chosen to target the sample towards secondary science teachers in a readily accessible geographic area. It was decided finally not to sample but to send the survey to all 50 secondary schools across the central North Island of New Zealand. This involved the regions of North and South Waikato, Bay of Plenty and the King Country. The region provided a range of public and private schools; a range of deciles;² co-educational and single-sex schools; and included a range of urban, suburban and rural settings within the region. A mailing list for all these schools was obtained from the current secondary science adviser based with School Support Services of the University of Waikato.

An explanatory letter (Appendix C) was developed to accompany the survey. This introduced the researcher and then provided the background to the survey, why the questions and their responses were relevant to science education in New Zealand and what would be done with the results. It also provided instructions on how the survey should be completed, what to do with it when completed and the due date for return. Confidentiality of responses was assured and the purpose of the numbering on the surveys was explained as a way of ensuring receipt of completed questionnaires from the different school types. A stamped addressed envelope was included for the return of the survey. The survey and accompanying explanatory letter were mailed to the Head of Science in the fifty schools, who had the option to complete it and/or to hand it to as many staff as they felt appropriate. They were given 4 weeks to complete and return the survey.

Follow up procedures were employed after 6 weeks (2 weeks after the due date) for those who did not respond. These involved personal phone calls being made by the researcher to the schools with the dates of the phone calls being recorded on the spreadsheet.

² Deciles are a socio-economic rating from 1-10 allocated by the Ministry of Education in New Zealand with 1 being the lowest socio-economic rating and 10 being the highest.

Data collection techniques

A spreadsheet was constructed of all the schools that the survey was mailed to and each school was allocated a number that was also marked on the top left hand corner of the survey. Records were kept of the dates of the mail out and receipt or non receipt of the completed surveys. Willingness to participate in a follow up interview (in which case respondents provided their contact details) was also recorded.

The survey generated both quantitative and qualitative data. To enable analysis, the survey data were coded. Miles and Huberman (1994) identified codes as “tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study. Codes are usually attached to ‘chunks’ of varying size – words, phrases, sentences or whole paragraphs, connected and unconnected to a specific setting” (p. 56).

Ezzy (2002) defined coding as a way in which data are disassembled and reassembled. He discussed how data are disassembled when they are broken apart into lines, paragraphs or sections and then how these fragments are rearranged, through coding, to produce a new understanding that explores similarities and differences across a number of different cases. Coding of the survey was carried out by assigning a code number to each of the restricted choice, list or ranking questions. The open-ended responses were read several times and recurrent themes were noted. A coding framework for the themes was devised and a frequency tally of each theme was made by hand. This enabled the qualitative data to be converted into numerical data for analysis.

Computer software (Statistical Packages for the Social Sciences – SPSS) was used to process the coded survey data and this produced statistics for frequency distributions and Chi square tests to determine whether there were statistically significant relationships between some of the variables concerned with the teaching of controversial science issues. Cross tabulation using SPSS also enabled a matrix of one variable being present in relation to another. Statistical analysis hinges on the idea of statistical significance and, as Kirk (1999) noted, “a statistically significant result is one for which chance is an unlikely explanation” (p. 337).

Focused Group Interviews

The purpose of the focused group interviews was to enable further exploration of the views of survey teachers in the teaching of controversial science issues, along with a discussion of the specific support and the needs that they might require to implement the teaching and learning of controversial science issues in their classrooms (Research Question 2).

In the early stages of planning the research, both focus groups and interviews were considered to explore further the views of the respondent teachers from the survey. Focus groups were initially considered. Anderson (1990) defined a focus group as a “group of individuals with certain characteristics who focus discussion on a given issue or topic” (p. 241). Cohen et al. (2007) suggested that focus groups operate more successfully if they are composed of relative strangers and that it is from the interaction of the group that the data emerge. Morgan (1988) discussed the need for more than one group and that the size of the group is an important decision. He suggested between four and twelve people per group as a group that is too small has dynamics that exert a disproportionate effect. If a group is too large it can be hard to manage and can fragment. A focus group was considered for this research project in that such a group may be useful in providing a situation where the synergy of the group provided more depth and insight (Anderson, 1990).

Interviews were then examined and this method gave opportunity to probe for further detail from each individual. There are a number of different types of research interviews. Cannell and Kahn (1968) defined a research interview as a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information. I wanted to develop a more open-ended, unstructured form of interviewing that was exploratory, but that involved more than a two-person conversation. Oppenheim (1992) discussed exploratory interviews and noted that they frequently cover emotionally laden topics and that they provide an opportunity for respondents to talk freely and emotionally and to have candour, richness, depth, authenticity and honesty about their experiences. I was getting closer to what I was looking for.

I then explored group and focus interviews. Watts and Ebbutt (1987) explained how group interviews are useful to allow discussion to develop and can

yield a wide range of responses. They consider that such interviews are useful when a group of people are working towards a common purpose, or where it is seen as important that everyone in the group is aware of what others in the group are saying. Such interviews can also be time saving compared to individual interviews.

The work of Merton and Kendall (1946) reported on focus interviews and explained that they differed from other interviews in that the persons interviewed are known to have been involved in a particular situation and the elements of that situation have been previously analysed by the researcher. A distinctive feature of the focus interview is this prior analysis by the researcher of the situation and they suggested that using the analysis as a basis, the interviewer can construct an interview guide. They discussed the need for “significant data” and established a set of criteria for focus interviews as being ones that are non directional, where the interviewer guidance is minimal and that the interview should bring out affective and value-laden implications of subjects’ responses. It should elicit relevant, personal contexts, beliefs and ideas. Burns (2000) also discussed focus interviews and commented that they can be used to corroborate facts already “gleaned” from other sources and that questions were open-ended with a conversational tone. These criteria, particularly those of Merton and Kendall (1946), were close to what I was looking for, but I did not want individual interviews. I wanted a situation where participants could build on each other’s thoughts and ideas.

So after consideration of the advantages of both focus groups and group and focus interviews, my criteria were developing. I wanted the interviews in this phase of the project to focus, build on and probe the prior analysis of the survey; establish a synergy so that people’s thoughts and comments might build on another’s; enable participants in each interview group to be in pairs and comfortable with each other as sensitive issues (and personal views on these) were being discussed; use open-ended questions with a conversational tone to bring out the value laden implications of participants responses, their personal contexts, beliefs and ideas; allow non directional probes; provide the opportunity to talk freely and emotionally and to have candour, richness, depth, authenticity and honesty about their experiences.

I finally decided that interviews would be used that were not individual ones, but interviews in pairs from the same schools who were comfortable with each other. It was decided that two groups of two teachers would be sufficient to explore the

issues at depth. This would allow the above criteria to be met and I called these interviews “focused group interviews”.

Planning the focused group interviews

The focused group interviews were planned to be informal situations over a cup of coffee. Contact was established initially with the teachers by a phone call in which the purpose of the discussion was described. The teachers, and their Principals, were then sent an information letter along with an invitation to participate in the project (Appendices D and E). Informed consent for permission to use the conversations for research purposes was also obtained.

Selection of the four teachers to receive an invitation was based on those respondents to the survey who had indicated a willingness to be involved in further exploring ideas about the teaching and learning of controversial issues and who also indicated that they would be comfortable discussing together sensitive issues. In the final selection, parameters such as school types, locality, accessibility and teaching experience were also considered in order to obtain representation of these variables.

Data collection techniques

The focused group interviews involved using open-ended questions (listed in Appendix H) that allowed for unstructured factual and opinion responses with few restrictions placed on participants’ replies (Cohen et al., 2000). The schedule for the questions was flexible and the questions were asked with a flow and sequence so that each interview appeared to be an overall, informal discussion that lasted for about thirty minutes. It was not an “ordinary, everyday conversation” (Dyer, 1995, p. 56) as it had a specific purpose, there was opportunity for clarification and elaboration of any responses by all participants, including the researcher, and there was an opportunity to raise and pursue other issues and matters (Denzin, 1970; Silverman as cited in Cohen et al., 2000, p. 147). Non directional probes were used such as, “What do you think?” and “What happened next?” Words and terms used by the researcher were often those used by participants.

The responses were audio-taped and the qualitative data from these were analysed interpretively and the trends compared and added to those from survey Question 17 (teaching strategies and resources utilised) and Question 20 (identifying useful support). The participants’ understanding of ethical thinking and decision

making was also explored in the focused group interviews. Re-reading of the transcribed notes allowed the researcher to become familiar with the data (Cohen et al., 2000, p. 149) and allowed trends to be detected to complement the survey data. These data from the survey and the focused group interviews were used to inform Phase Two of the project in which a pedagogical model of ethical inquiry was designed to support teachers in addressing controversial science issues in secondary science classrooms.

Phase Two: Development of a pedagogical model and planning the professional learning programme

Phase Two of the research involved the development of a pedagogical model of ethical inquiry followed by the introduction of the model to teachers for trialling and evaluation in their secondary science classrooms.

As shown in Figure 2, the model for ethical inquiry was informed by the literature review (Chapter 2), the data from the survey and focused group interviews (Chapter 4), an examination of national and international curricula, my work as part of a research team on a bioethics contract with the Bioethics Council of New Zealand, and my personal experiences in teaching and learning and as a regional adviser in secondary science for the University of Waikato. An initial version of the model (Version 1) was developed (see Appendix I) and presented to four teacher-researchers at Workshop 1. The teacher-researchers' critique and trialling of the model were to provide refinement of the model in Workshop 1 and lead to the development of a version that could be trialled in science classrooms (Version 2).

Following the development of the model of ethical inquiry, the professional learning programme was designed. This programme involved two research teacher workshops with the development of these workshops being informed by literature in professional learning and my experiences in the professional development of teachers as a regional adviser in secondary science for the University of Waikato for six years. Data from the survey and the focused group interviews (Chapter 4) were also considered in the design of the professional learning programme.

The development of the model of ethical inquiry and the design of the professional development programme are discussed in more detail in Chapter 5 which describes how the literature, development work with the Bioethics Council of

New Zealand, international curricula, *The New Zealand Curriculum (2007)*, outcomes of the survey and the focused group interviews and my personal experiences informed the model development and the design of the professional learning programme.

Phase Three: Implementation and evaluation of the model

Phase Three of the project involved two professional learning workshops to introduce, implement and evaluate the model for ethical inquiry. The findings of the two workshops were intended to address the third research question: *In what ways will a professional learning programme, with support, assist teachers to address controversial science issues in secondary science classrooms?*

Interpretative research design

This phase of the project utilised an interpretative approach (Merriam, 1988; Stake, 1995) in which, rather than provide quantitative data, the situation is seen through the eyes of the participants. Interpretative research is a process of deliberate inquiry (Miles & Huberman, 1994) and builds a complex holistic picture in natural settings (Creswell, 1998). Creswell suggested that the intent is to uncover and understand details so that a detailed view of the context (in this case secondary science classrooms) is presented. Bryman (2001) commented that the interpretivist epistemological position is one in which “the understanding of the social world is through an examination of the interpretation of that world by its participants” (p. 264). He also suggested that an interpretivist approach seeks empathetic understandings of participants’ actions and thinking, and that it attempts to interpret these from the participants’ point of view. Seeing through the eyes of the participants is valued and helps gain deeper meanings of the different situations (Cohen et al., 2007). As stated by Alton-Lee (2001), the “researcher’s voice does not become the sole authoritative commentary on a frozen piece of educational practice” (p. 90).

Denzin and Lincoln (1994), in their *Handbook of Qualitative Research*, outlined the criteria for effective interpretative or qualitative research and these included the consideration of a number of theoretical paradigms; use of an appropriate genre; rich description; appropriate and sensitive forms of data collection; critical reflection and interpretation; close engagement between the researcher and research participants and acknowledgement of the participants’ point

of view. These criteria were strongly influential as I planned this phase of the research and they are further expanded as I discuss and justify the use of a case study approach in this phase of the project.

As mentioned at the beginning of the chapter, I decided that the project moved between two research paradigms – those of positivist and interpretivist and consequently the project would be taking a mixed-method approach. There were multiple sources of data collection and these contributed to the trustworthiness of the project. Data collection and the interpretation of these data are addressed later in this chapter, as are the genre and a discussion of the relationship that built up between the teacher-researchers and myself.

The teacher-researchers and the workshops

The four teachers who had participated in the focused group interviews indicated a willingness to be involved in the professional learning programme. They, and their Principals, had earlier received information letters, an invitation to participate in the project and consent forms (Appendices D and E).

Workshop 1 was to background, introduce and provide the teachers with expertise, including introducing them to ethical frameworks for decision making and a range of strategies, to implement the stages of the model. A Power Point presentation was developed to guide and scaffold the sessions (Appendix J). There was an initial critique of the model and this information was used to modify the model into Version 2 which was supplied to the teachers for use in their trialling in teaching programmes in their classrooms. Teachers were provided with a range of resources such as video clips, prepared strategies, professional readings and templates on a CD ROM to support them in their trials. The discussions from the workshop were audio-taped with permission and later transcribed.

The teachers returned for Workshop 2. Each teacher presented his/her classroom trials and these were discussed. The teacher-researchers interrogated, re-critiqued and reflected on the model. The audio tapes of the teachers' presentations were transcribed, and used to develop a series of case studies of each of the trials. The teacher-researchers reviewed all workshop transcripts and verified the case study as it developed for each trial.

Following a within-case analysis of each trial, a cross-case analysis was then made to explore relationships and patterns between the individual cases, and this analysis was used to further evaluate the model of ethical inquiry.

Use of a case study approach

There was a wealth of information obtained from the transcribed tapes of the individual teacher presentations of their trials and their accompanying documents. The difficulty that I found was how best to present and write up the data from the trials. I wanted the trials to read like a number of interesting stories but stories from which I could determine some findings. After much deliberation I found that there were a number of reasons to justify the use of a case study. Each trial provided a “unique example of real people in real situations” and the “teacher accounts, personal constructs and explanations were valued and actively sought” (Hitchcock & Hughes, 1995, p. 317). They considered that a case study was concerned with a “rich and vivid” description of events and that it provided a chronological narrative of relevant events, blending a description of events with an analysis of them. They explained how a case study focused on “individual actors or groups of actors” and sought to understand the event and attempt to portray the “richness of the case” in writing up the report (p. 317).

Case studies attempt to show what it is like to be in a particular situation and provide a “thick description” of each “case’s own issues, contexts and interpretations” (Denzin & Lincoln, 2000, p. 439). They aim to understand the participants’ lived experiences of, and thoughts and feelings for, a situation. Both Neuman (1991) and Sturman (1997) used the term case study as a generic term for the investigation of an individual, group or phenomenon, with a case being described as an individual, group, organisation, movement or geographic unit. Miles and Huberman (1994) described the case as a “phenomenon of some sort occurring in a bounded context” (p. 25).

Stake (1997) considered that a case study tells the story of a bounded system and that each case worthy of study is a complex and dynamic system. Merriam (1988) described the end product as a “holistic, intensive description and interpretation of a contemporary phenomenon rather than a quantifiable result” (p. 9). It is the preferred strategy when “how, who, why, what and where” questions are

being asked, when the researcher has little control over the events or when a real life context is being used for the research (Burns, 2000, p. 460).

Robson (2002) identified that there is an individual case study; a set of individual case studies; a social group study; studies of organisations and institutions; and studies of events, roles and relationships, all of which find expression in the case study method. He also argued that a “unique case can provide a test bed” (p. 181) so that a new approach can be trialled to gain further insight into its operation before being taken to a wider audience. In this phase of the project I proposed an approach to the teaching and learning of controversial science issues which I wanted to be trialled before making it available to a wider range of science educators. As stated by Cohen et al. (2007), case studies are a “step to action” (p. 256) and people who want to contribute and take some action can be guided by, and put to use, the findings from a case study.

Yin (1994) identified three types of case studies, each determined by their outcomes. The first is exploratory and acts as a pilot to other studies or forms of research. The second is descriptive, which provides a narrative account, and the third is explanatory, in which theories are tested. Yin’s classification is similar to that of Merriam (1988), who also identified three types: descriptive or narrative accounts; interpretative, in which conceptual categories are developed to examine initial assumptions; and evaluative, which provides explanation and judgment. I found myself considering a descriptive case study method which provided a narrative account of the unfolding events of each trial.

Case studies have several claimed strengths and weaknesses. There are limitations with case study research in that much more information is gathered than is required. Firstly, such overload can provide information that becomes difficult and time consuming to analyse (Burns, 2000; Lincoln & Guba, 1985). Secondly, critics of case study research suggest that there are opportunities for subjectivity in implementation, presentation and evaluation of the case study because such an approach relies on the personal interpretation of data (Tellis, 1997). Tellis also argued that consideration needs to be taken of the integrity, sensitivity and possible prejudices of the investigators.

The strengths of case study research were summarised by Nisbet and Watt (1984) who suggested that case studies are immediately intelligible, understood easily by a wider audience, strong on reality, catch the unique features that may be lost in larger scale data such as surveys, and they can be undertaken by a single researcher. After consideration of these strengths and weaknesses, I found that the strengths outweighed the weaknesses. However, I would need to keep in mind the weaknesses and limitations of case study research as I gathered and analysed the data to tell each story.

Using Hitchcock and Hughes' (1995) criteria, I determined that the case in this project was the individual classroom and its purpose was to confirm, challenge and extend a model of ethical inquiry to assist teachers and students in the area of ethical decision making.

As mentioned earlier in this chapter, I also worked with the criteria for interpretivist research, established by Denzin and Lincoln (1994), which paid attention to the use of an appropriate genre, methods of data collection, consideration of the researchers and research participants' relationship and interpretation of data. These are discussed in more detail below.

Use of an appropriate genre

Denzin and Lincoln (1994) in their criteria for interpretivist research commented on the use of an appropriate genre. Robson (2002) suggested six forms of organising the writing up of a case study. From these, I considered two ways. Firstly, that of a narrative report (a prose account which is interspersed with figures, issues, quotes and analysis) and secondly, a chronological structure in which a simple sequence is used as the "organising principle" and has the strength of an ongoing story. It can contain sections with explanations, interpretations, and summaries of issues that are interspersed.

Some case studies can be divided into two main parts (Willis, 1977); the data reporting and then the analysis, interpretation or explanation. This appeared to be another way in which I could structure the writing of the findings.

The case studies were written in a narrative genre. Clough (2002) argued that stories in a narrative methodology must speak for themselves and that "critical discussion must fit around the stories" (p. 6). He implied that although narrative

provided a freedom from traditional academic frameworks, it did not allow freedom from every dilemma. And he reminded us of Richardson's quote: "Although we are freer to present our texts in a variety of forms to diverse audiences, we have different constraints arising from self-consciousness about claims to authorship, authority, truth, validity and reliability" (Richardson, 1994, p. 523). Clough also suggested that narrative opens up a deeper view of familiar context, and does not depend on any one form of data.

A narrative genre as a style of writing seemed to be the most appropriate writing style to represent the voices of the teacher-researchers in this project. Clandinin and Connelly (1994) asserted that narratives can take us forward in our search for meaning and understanding. Richardson (1994) put forward the criteria of verisimilitude (plausibility), coherence and interest and commented that these need to be satisfied for the researcher, the teacher-researchers and readers of the thesis.

Lincoln and Guba (1985) also provided several guidelines for the writing up of case studies. These included making sure that the writing captured the informality, reporting the facts and ensuring sections where interpretation, evaluation and inference were explicit, drafting the report for over inclusion rather than under inclusion, honouring the ethical considerations and being clear on the data giving rise to the report so that reliability and validity can be checked.

I finally decided that I would identify each trial as a case study and the most appropriate form of writing up and reporting the events of each individual case study would be to write a narrative account which was sequenced chronologically. This "provided a sense of immediacy of an event unfolding before the reader's eye" (Bassey, 1999, p. 88). I drew on a range of data types and interspersed quotes, explanations and interpretations.

Data collection

Denzin and Lincoln (1994), in their criteria for interpretivist research, asserted the need for appropriate, sensitive forms of data collection. Burns (2000, p. 460) suggested that the main techniques of data collection are interviewing, observation (participant and nonparticipant) and document analysis. In this phase of the study there were multiple sources of data with much of this being qualitative and unstructured. Transcripts were made from the audio tapes of the sessions, including

each teacher's presentation, and direct quotations were used from these to describe some of the teacher-researchers' experiences. There were a number of documents for analysis that included student and teacher evaluations which the teachers brought together in their presentations, documents of completed teachers' planning proformas, and reflective journals of the participant teachers. Teacher reflective journals were used by three of the four teacher-researchers. Such journals were described by Hobson (1996) to be a powerful tool in qualitative research and these teachers used it to reflect on their planning, the teaching sessions, their action and the actions of the students. Other data that were generated were a video of classroom work and student work in the form of reports and essays. All of these were pulled together to understand the event or trial.

Researcher and research participants' relationship

Another of the criteria outlined by Denzin and Lincoln (1994) was the importance of close engagement between the researcher and the research participants and the acknowledgement of the participants' point of view.

In an attempt to act in a way that was caring and alert to teachers' needs, I was influenced by the work of Noddings (1984, 1992). Adopting an ethics of care involves one being empathetic and concerned that the relationships between participants, and between participants and researcher, are responsive and alert to the feelings of others. Her notion of responsiveness referred not just to the 'agent' who cared, but also the response of the 'cared-for'. This project had some potentially sensitive issues being discussed between and with the participants, and avoidance of potential harm, and tolerance or respect of other viewpoints was important to consider. All views needed treating with dignity and respect and this was a strong commitment and obligation that I made as the researcher. It was important to empathise with the teacher-researchers so that we developed respectful relationships and it was important to listen actively and offer support, encouragement, affirmation and resources when required (Flinders, 1992). Consciously adopting an ethic of care, empathy, and trust, I believe enabled the establishment of mutually respectful and collaborative relationships within our focused group interviews and workshops. I agree with Erikson (1986) that a "non-coercive, mutually rewarding relationship with key informants, is essential if the researcher is to gain valid insights in to the

informants' point of view" (p. 142). As a result of a more mutual focus, a sense of rapport and a more reciprocal research relationship develops (Alton-Lee, 2001).

In this phase the findings were constructed by myself as researcher, and the teacher-researchers, so that together we created meaning and understanding. The teacher-researchers and I worked co-operatively during Phase Three of the project to interrogate, critique and trial and then re-critique the model. We continued this co-construction of the model until we had a shared understanding. The joint construction of meanings and action were continuously negotiated and influenced by the context (Denzin & Lincoln, 1994). The eyes of the participants were valued and assisted in gaining deeper understandings of the different situations (Cohen et al., 2007). Consequently, critical feedback from the teacher-researchers was a crucial factor in the development and co-construction of the model of ethical inquiry.

Interpretation of data

Denzin and Lincoln (1994) also acknowledged the need for critical reflection, analysis and interpretation in their criteria for effective interpretative research. Eisner (1991) described interpretation as "to interpret is to place in context to explain, to unwrap, to explicate...If description deals with what is, interpretation focuses on the why and how" (p. 97-98).

In this project, a two-stage analysis of the data was undertaken. Firstly, a within-case analysis was carried out as each classroom of students and teacher was a separate case itself. Although I noted similarities and differences between the five cases³, analysis was left until all case write-ups had been completed so that independence for each case was maintained. Once the analyses of the individual case studies were complete, a cross-case analysis, relying on the methods suggested by Miles and Huberman (1984), was completed. This analysis was used to synthesise the information gained from the case studies and the insights gained were used to enable themes and patterns to be identified and conclusions synthesised in order to address Research Question 3. Initially, cases were compared to identify common themes and to identify any unique aspects from each case. A matrix was created using the emerging themes from the case studies and this was then used to facilitate comparisons between the cases. Attempts were made to build general explanations

³ One of the four teachers carried out two trials.

and abstractions across cases (Merriam, 1988) and to make sense beyond the specific cases (Miles & Huberman, 1994). Such integration of data and interpretations of meanings provided a more holistic understanding of people in the settings (Creswell, 1998), as well as attempting to test the validity of the model of ethical inquiry.

The case studies were sent back to the teachers with relevant transcriptions for each to be reviewed and to ensure that the interpretations were consistent. This follows the recommendations by Lincoln and Guba (1985) that member checks allow participants to read how researcher has interpreted what happened.

In review, case study research was the methodology used for Phase Three of the project in order to address Research Question 3. Within-case analyses were carried out for each trial and these were written as a narrative account. Finally, a cross-case analysis was conducted to synthesise the information from the five case studies.

Rigour in the Research Design

Common social science research procedures were undertaken to ensure rigour of the research project. Validity was ensured by field testing the survey along with validation by the participants; and reliability was achieved by consistency in data collection methods. Confidence in the findings of the study was established by triangulation. Each of these procedures is discussed in the following sections.

Validity

As cited by Cohen et al. (2007), “threats to validity and reliability can never be erased completely; rather the effects of these threats can be attenuated by attention to validity throughout the piece of research” (p. 133). They also suggested that reliability is a necessary, but insufficient condition for validity; reliability is a necessary precondition of validity, and validity may be a sufficient, but not necessary, condition for reliability.

Validity is a requirement for both quantitative and qualitative research and in this project both these aspects needed to be considered in terms of validity. Validity is the extent to which the research findings are what they claim to be (Bassey, 1999). Lincoln and Guba (1985) suggested that credibility in naturalistic inquiry or qualitative data is addressed by a number of ways. For internal validity this includes

triangulation of methods and sources, and member checking, in which respondents check accuracy of the analysis of data. These were addressed in Phase Three of the project in which there was a strong chain of evidence in transcriptions and verification of case study analysis by teacher-researchers.

External validity refers to the degree to which results can be generalised to the wider population, other cases or situations. In this project, a cross-case analysis between the five cases made generalisation possible. Lincoln and Guba (1985) suggested that for external validity to occur, the researcher should provide sufficient “rich data” with “thick description” for readers to determine whether transferability is possible. Content validity was demonstrated in Phase One, where the survey instrument needed to show that it fairly and comprehensively covered the domain or items that “it purports to cover” (Cohen et al., 2007, p. 137). This, together with face validity where, superficially, the survey appears at face value to survey what it is designed to survey (Cohen et al., 2007), was addressed in Phase One of the project where field testing of the draft survey was carried out by teachers before posting to schools.

To further ensure validity of the survey in Phase One, steps were taken to avoid the non return of the questionnaire by the inclusion of a stamped self addressed envelope and follow-up personal phone calls to request return. Validity was also ensured by the coding being carefully done, and rechecked, especially that of qualitative data.

Reliability

Reliability is the extent to which “a procedure produces similar results on all occasions under constant conditions” (Bell, 1999, p. 103). Reliability differs in quantitative and qualitative research. In quantitative research, it is a synonym for dependability, consistency and replicability. For the survey, the same questions were sent to all participants and data was systematically collected in standardised form (Borg, Gall, & Gall, 1983). There was a reliance of participants answering the questions honestly and with care, but as a researcher, one can only work with what participants write, which is often less than what they know, although the focused group interviews provided an opportunity to probe for more depth.

Reliability, in terms of qualitative research is often debated. Guba and Lincoln (1989) replaced the term reliability in qualitative research with terms such as credibility, confirmability, dependability and trustworthiness. I established dependability and confirmability by using an approach which results in thick description (Guba & Lincoln, 1989). This allows a reader to make his or her own interpretations in agreement or disagreement with the patterns that the researcher describes in the data. These patterns were based on the researcher's analysis and interpretations of the collected data.

Many critics of the case study method argue that it lacks reliability. However the case studies in this project incorporate multiple data sources and triangulation of these data was used to interpret converging evidence and search for diverging evidence so that clear findings could be reported.

Reliability in qualitative research can be problematic and some would argue that it is unworkable and not relevant in qualitative studies (Le Compte & Preissle, 1993). Bogdan and Biklen (1992) argued that reliability in qualitative research should be regarded as the fit between what researchers record as data and what actually occurs in the natural setting. Two researchers studying a single situation might develop different findings, but both sets of findings might be reliable. Brock-Utne (1996) argued that qualitative research strives to record multiple interpretations and meanings of events and this is construed as dependability by Lincoln and Guba (1985). They identified dependability as involving member checks or respondent validation, and triangulation. In Phase Three of the project, member checks of case studies were carried out, along with clear audit trails in terms of the process and the product to address confirmability.

Triangulation of data

Rigour in data analysis relies heavily on a process known as triangulation. Triangulation is the term used when two or more methods of data collection and/or sources of data are used in a research project (Cohen, et al., 2007). Triangulation also helps to eliminate bias, increases trustworthiness and reliability and can help detect errors or anomalies in a researcher's findings. Triangulation methods attempt to explain the richness and complexity of the research by studying it from more than one standpoint and make good use of both quantitative and qualitative data.

Campbell and Fiske (1959) commented that it is a powerful way of demonstrating concurrent validity, especially for qualitative research, and Gorard and Taylor (2004) discussed the value of combining quantitative and qualitative research. Adelman et al. (1980) suggested that triangulation can be a powerful technique when using case studies. Triangulation contributes to verification and validation of qualitative analysis by checking the consistency of findings generated by the different data collection methods and consistency of the different data sources within the same method (Burns, 2000).

This project used methodological triangulation (Denzin, 1970) as it used different methods to answer each research question. Triangulation methods employed to ensure the accuracy of the findings of the project were derived from collection methods such as the survey and focused group interviews, audio-taped discussions from workshop sessions, teacher planning and resource material, teacher reflective journals, student work and teacher and student evaluations. Other triangulation methods included confirmation of the data and data analysis by the teacher-researchers as they reviewed all workshop transcripts and verified the case study as it developed for each trial.

In summary, triangulation in this project was satisfied by the collection of data from multiple sources, use of a variety of data collection methods and the combination of quantitative and qualitative approaches.

Ethical considerations

The main ethical concerns in the project were related to informed consent, access to schools, avoidance of potential harm to participants and confidentiality and anonymity. An ethics of care is also discussed.

Informed consent

The principle of informed consent arises from a participant's right to freedom and self determination (Cohen et al., 2007). It has been defined by Diener and Crandall (1978) as "the procedures in which individuals chose whether to participate in an investigation after being informed of facts that would be likely to influence their decisions" (p. 52). This definition implies four elements which indicate competence, or the need to engage individuals capable of making correct decisions given relevant information; voluntarism, where participants choose freely to take

part; full information as far as it is possible to do so; and comprehension, where participants fully understand the nature of the project. Researchers can be assured that if these four elements are present, the subject's rights will have been given appropriate consideration.

Cohen et al. (2007) also suggested that informed consent requires explanation and description of purposes, contents and procedures of the research, benefits that might be derived from the research, right to voluntary non-participation, rights to confidentiality, opportunities for participants to ask questions about any aspects of the research, and signed contracts for participation.

All of these aspects were covered in the project. In Phase One of the study, an explanatory letter accompanied the survey sent to the schools (Appendix C). This was sent to both Principals and science teachers and outlined the title and purpose of the study, the background to the research and the research questions. The significance of the research was presented along with an assurance of confidentiality and a description of what would be done with the provided information. The degree and affiliated institution was also supplied along with contact details of the researcher so that Principals and science teachers could make contact and discuss any aspect of the research. Similarly, information letters and consent forms were sent to the school Principals and the four teachers taking part in Phase Three of the project (see Appendices D and E).

Consent was gained from all involved in the study including students and caregivers as necessary (see Appendices F and G). Consent to use the information obtained from the survey was indicated by voluntary return of the questionnaire. Participants taking part in the focused group interviews and the two workshops in Phase Three were asked to give written consent after receipt of the information letter, as were their Principals (see Appendices D and E). This included consent for audio taping and transcription of interviews and workshops.

All participants were informed of the nature and type of data to be collected, the ways data were to be collected and the use to which the data would be put. It was made explicit that they were free to withdraw from the research at any time. Teachers had the right to inspect, change and withhold any data at any stage of the research process.

Access to schools

The principle of informed consent in the initial stage of the project was important because it allowed access to the schools for the focused group interviews. This permission was gained early in the project when fully informed consent was gained for Phase One of the project. This followed the advice of Bell (1991) which was to gain permission for access early on, when informed consent was gained.

Avoidance of potential harm

A primary consideration in ethics is that no harm be done to the participants because of their involvement (Fontana & Frey, 1994). Bell (1991) indicated there is a need to ensure that the research process or findings do not damage or harm any of the participating teachers or students. This was ensured in a number of ways and in this project these included the use of fictitious teacher names and classes, giving participants full information about the research and checking the interpretation of evidence with the teacher-researchers. In addition, Bell proposed that, to minimise any uncomfortable aspects in the teacher change process, the researcher may have to become an adviser when requested. I took this role when asked and anticipated that it can grow out of the dialogue between teachers and myself during the professional learning process. Such reciprocal dialogue is the result of the active development of sound ethical relationships that are seen by Brickhouse (1992) as leading to an improvement in the quality of teaching, learning and research. It is important that as a researcher, sight is not lost of the obligations owed to those who are helping in the project.

Confidentiality and anonymity

Participants were also protected by anonymity and confidentiality. The essence of anonymity is that information provided by participants should in no way reveal their identity (Cohen et al., 2007). Privacy and confidentiality were assured to teachers and the school and anonymity in the final report and any publications that could result from the survey, the focused group interviews and the case studies. The principles of anonymity and confidentiality were ensured in this project by not using names of participants and this was done in Phase One, by each survey being coded to allow the researcher to audit returns. Respondents were informed of this. Names of respondents were necessary for those teachers agreeing to be part of the focused

group interviews and the workshops, so in the second and third phases, the true names in all transcriptions and written records were removed and replaced with false names.

These issues were discussed with the participant teachers prior to the beginning of the project. There were a small number of participants in Phases Two and Three and this reassurance to teachers was important in the educational environments of today that have an increasing emphasis on staff appraisal. Tolich (2001) raised an important principle in his discussion of the Antipodean angle on ethics and suggested that New Zealand must be treated as if it was a small town. Even if schools were not named, New Zealand is such a small place that individual schools, and hence the people involved in them, may be identifiable.

Confidentiality is another way of respecting the right to privacy of the participants. This means that although the researcher knows who has provided the information, no connection would be made publicly. Privacy is more than confidentiality. It also means that a person has the right not to participate in research, not to answer the questions, not be interviewed and not to answer phone calls or email (Cohen et al., 2007).

Summary

This chapter has described how the research was carried out to answer the three research questions. Phase One of the project, in which the development and administration of the survey to secondary science teachers and the carrying out of focused group interviews with some survey participants, was described. This included a description of the data collection techniques and how the data were analysed to answer Research Questions 1 and 2. Next, Phase Two was described and this explained how the model for ethical inquiry was developed along with a description of how the professional learning programme was designed to implement and evaluate the model. The chapter then described Phase Three of the project in which the model was trialed and evaluated in two workshops in order to address the third research question. A justification for the use of case studies to write up the data from the trials was presented and the analysis of the data across cases was discussed. Finally the procedures undertaken to ensure rigour and ethical concerns were explained.

The following chapter describes the results of the postal survey and focused group interviews that were developed in order to accomplish Phase One of the study and answer the first two research questions.

CHAPTER 4: PHASE ONE - THE SURVEY AND FOCUSED GROUP INTERVIEWS

Introduction

This chapter describes the results of the postal survey and focused group interviews that were developed in order to accomplish Phase One of the study and answer the first two research questions.

- 1. How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*
- 2. What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*

The first section reports the findings of the survey. These findings are complemented with further information gathered from the focused group interviews with four teachers who had completed the survey. The final section provides a summary of the findings from the survey and the focus group discussion and leads into the following chapter which describes Phase Two of the study.

Findings of the survey

As described in Chapter 3, the survey was field tested and then sent to 50 secondary schools. Responses were received from 23 schools, with 4 of the 23 schools responding as a result of follow up procedures. Twelve schools chose to send responses from more than one teacher in the science department. From the 23 schools, a total of 40 responses were received. One teacher responded in 11 schools, 7 schools sent a response from 2 teachers and 5 schools sent a response from 3 teachers.

Of the 23 (of 50) schools that responded, 21 were state high schools and there were 2 integrated/private secondary schools. There were 15 urban schools and 8 rural schools in the sample. The sample was not representative of the school types within the sampled area as the region showed a ratio of 42:8 state schools to integrated/private schools whereas the sample showed a ratio of 21:2. Neither was the sample representative of the school distribution, with a regional ratio of 27:23 of urban schools to rural schools whereas the sample showed a ratio of 15:8 for these

schools. The demographic characteristics of the sample reported by teachers in Questions 1 to 8 of the survey (see Appendix B) are shown in Table 1.

Table 1. *Demographics of the Survey Sample*

Demographic characteristics	Male (n=21)	Female (n=19)	Total (n=40)
Age groups			
25-35 years	4	3	7
36-45 years	2	6	8
46-55 years	11	8	19
55+ years	4	2	6
Ethnicity			
Pakeha / European	19	15	34
Māori	2	-	2
other	-	4	4
Years of teaching			
1-2 years	-	2	2
3-5 years	2	2	4
6-10 years	3	5	8
11-20 years	1	4	5
20+ years	15	6	21
Position in school			
Subject/assistant teacher	2	7	9
Teacher in charge of subject	1	3	4
Head of Faculty/Department	16	9	25
other	1	-	1
School type			
State high school - urban	12	6	18
State high school - rural	5	8	13
Integrated high school - urban	2	5	7
Integrated high school - rural	1	-	1
Area school (years 1-13)	1	-	1
School roll numbers			
201-500	3	-	3
501-1000	5	11	16
1001-1500	6	2	8
1500+	7	6	13

The demographic characteristics show that out of the 21 male and 19 female respondents, 62.5% were over the age of 45 years and 52.5% had been teaching for more than twenty years. Beginning teachers (less than 5 years teaching) accounted for 15% of the sample. The demographic data in Table 1 show that age clearly correlates with years of teaching so only years of teaching will be used in reporting of the findings.

Teaching subjects and levels

An analysis of the teaching subjects and teaching levels of the respondents (see Question 9 on the survey) is given in Table 2.

Table 2. *Subject Levels in Science Currently Taught*

Subject	Year level	Male (n=21)	Female (n=19)	Total (n = 40)	Total %
Junior science	9-10	20	19	39	97
Senior biology	11-13	12	14	26	65
Senior physics	11-13	5	1	6	15
Senior chemistry	11-13	6	2	8	20
Senior science	11-13	6	8	14	35
Horticulture	9-13	2	1	3	7.5
Environmental Education	9-13	2	1	3	7.5

Note. Most teachers taught more than one level

All of the teachers, except for one, taught junior science classes (Years 9-10). Sixty-five percent of the teachers taught senior biology with the 74% of females and 57% of males teaching in this area. Physical science (chemistry and physics) specialists made up 35% percent of the teachers with noticeably more males than females in this area; 15% of the teachers were teaching physics and 20% were teaching chemistry, with 3 teachers teaching both physics and chemistry. Three of the teachers were involved in horticulture and environmental education and 20 of the

respondents taught in more than one specialty science area in senior classes (Years 11-13).

Teaching of controversial issues

All 40 teachers responded that they thought that controversial science issues should be discussed in science classrooms and all indicated that they did discuss controversial science issues with their students (see Question 12). Question 13 asked teachers to indicate the subject area in which these discussions took place and Table 3 shows these responses set along side the data from Table 2 (number of teachers teaching in each subject level).

Table 3. *Comparison of Teachers within Specific Subject Levels Who Discuss Controversial Science Issues*

Science levels	Science currently taught (Question 9)			Teachers discussing controversial issues (Question 13b)		
	Male (n=21)	Female (n=19)	Total (n=40)	Male (n=21)	Female (n=19)	Total (n=40)
Junior science	20	19	39	12	14	26
Senior biology	12	14	26	11	13	25
Senior physics	5	1	6	4	0	4
Senior chemistry	6	2	8	5	0	5
Senior science (Yr 11-13)	6	8	14	9	7	16*
Horticulture	2	1	3	1	1	2
Environmental Education	2	1	3	2	2	4*

Note. * These numbers are greater than the number of teachers currently teaching the subject because Q13b did not specify current year.

Biology teachers were more likely to discuss controversial science issues than teachers of chemistry and physics (25 of the 26 biology teachers, compared to 5 of the 8 chemistry and 4 of the 6 physics teachers). This is possibly because addressing a controversial issue in biology, but not in chemistry or physics, is an internally assessed achievement standard in the National Certificate of Education (NCEA) national qualification system in New Zealand.

Of the 39 teachers teaching junior science, 26 (66%) addressed issues within their teaching programmes. These results in Table 3 show that the proportions of male and female teachers discussing science issues were similar in all subject areas except for in the physical sciences (physics and chemistry), where none of the female teachers, but all of the male teachers, discussed controversial science issues within their classrooms.

It is noticeable for senior science and environmental education that there are some anomalies within the two total columns. Fourteen teachers indicated that they taught senior science, yet 16 said they discussed controversial science issues in senior science classes. Likewise, 3 teachers indicated they taught environmental education, yet 4 said they discussed controversial issues in environmental education classes.

It is likely that responses to Question 9 were based on currently taught science subjects and Question 13 may have been interpreted by teachers as their teaching in other years as well as the current year.

Reasons for discussing controversial science issues

Question 11b asked teachers about their reasons for discussing controversial issues in science classrooms. These comments were read several times and recurrent themes were noted. These are shown in Table 4, with the numbers of teachers who mentioned them.

Table 4. *Teacher Reasons for Discussing Controversial Science Issues Grouped into Themes*

Theme	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Awareness of different perspectives	6	5	11	29
Critical thinking/higher level thinking	5	5	10	26
To help make informed decisions	2	8	9	24
Provides facts /current information, science knowledge	3	5	8	21
Relevant/part of everyday life	3	3	6	16
Discussion/debate to form own opinions	3	1	4	11
Demonstrates aspects of the nature of science	3	1	4	11
High interest	2	0	2	5

Note. Some comments contained ideas that related to more than one theme.

One theme, mentioned by approximately 30% of the respondents, was that students gained an awareness of different perspectives of an issue through discussion. Some examples of such comments follow.

Generates discussion and awareness of perspectives/points of view. As long as it is a balanced approach and that students are aware that it is controversial and that different sides need to be touched on. (701a, male)⁴

Students need to be exposed to different points of view. (712a, female)

Students need to be aware of both the issues and the different sides to the issues; that there is not one or two, but many stances applicable (815a, male)

⁴ Responses are coded according to identification number for school (3 digits), teacher within the school (alpha character), and sex of respondent.

Twenty six percent of the responses commented that discussing controversial science issues promoted critical thinking skills:

We need to promote open mindedness and critical thinking skills. (103a, male)

[There is a] need for students to think critically; make judgments on fact not emotion, nor be swayed by pseudoscience; understand both sides of issue and make valid choice based on facts. (502a, female)

[There is a need] to teach students critical thinking so they are informed citizens; so they have some knowledge of the controversy and can contribute in a constructive way. (702b, female)

These are issues that the students will strike when they leave school - they should be introduced in an informative environment where they are taught to think critically i.e. look at both sides, evaluate sources. (709a, male)

If they are not taught, how can they think critically? (815a, male)

Another theme included by 24% of the teachers (8 female and 1 male) was that discussing controversial science issues assisted students to make informed decisions:

To help students make informed choices. (501c, female)

Students need to] be part of the current debates and see how issues can change/be resolved over time. Be part of the process and form opinions that are informed (all sides). (712b, male)

Young minds need to discuss, analyse, debate all issues to make them aware of the issues to enable them to formulate their own opinions and views. (103a, male)

It gets students thinking at a higher level; questioning what they know or family values. Gives them more knowledge to make an informed choice about what they do think about an issue or topic. (812a, female)

Some comments (21%) related to the acquisition of science knowledge and understanding. Some examples of these were:

So that students have a factual basis from which to make informed decisions. (806b, female)

[It is important to] give students knowledge so that they can think about them[issues] and form opinions. 810b, female)

People need to know facts upon which they can base their decisions. (806a, female)

Other comments (11%) showed that the teachers considered the discussing of controversial science issues reinforced concepts about the nature of science:

Controversial issues engage students and demonstrate the tentative nature of science. (706a, female)

It is the very nature of science to explore/search etc. Whether controversial or not, we should address it. (708c, female)

Students need to learn that science doesn't have all the answers and there are complex issues that don't have right or wrong answers to them. (715a, male)

Sixteen percent of the comments also mentioned the relevance of such issues in the everyday life of the students:

Science is relevant to today's society; students need to have this displayed to them. (812b, female)

It's in the news. (716a, female)

We are part of the real world, not an academic ivory tower. (502b, female)

Controversial science issues addressed in teaching programmes

Question 14 asked teachers to choose from a list of controversial science issues, those topics that had been part of their teaching programmes. A list was provided to aid recall and space was provided to give opportunity for additional responses to be recorded. The issues addressed by science teachers in teaching programmes are shown Table 5, ranked in order of the frequency with which teachers addressed them.

Table 5. *Controversial Science Issues Addressed in Teaching Programmes*

Science Issue	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Cloning	17	18	35	88
Genetic engineering in animals and plants	18	16	34	85
Genetically modified foods	16	17	33	83
Reproductive technologies	13	17	30	75
Genetic engineering in humans	16	14	30	75
Introduced species	14	16	30	75
Global warming	18	11	29	73
Human gene therapy	16	13	29	73
Genetic engineering in microbes	14	15	29	73
Stem cell research	13	14	27	68
Ozone depletion	14	12	26	65
Human genome	11	13	24	60
Genetic screening	11	12	23	58
Pest control	12	11	23	58
Organ transplantations	11	12	23	58
Xenotransplantations	8	12	20	50
Waste disposal	10	8	18	45
Nuclear power	10	8	18	45
Pesticides	8	9	17	43
Energy production	9	7	16	40
Surrogacy	9	6	15	38
Animal testing	4	5	9	23
Euthanasia	5	2	7	18
Ecotourism	2	2	4	10

Note. All teachers identified more than one controversial science issue

Issues associated with biotechnological techniques such as cloning, genetic engineering, gene therapy and stem cell technology were the topics that teachers most commonly chose to address with their classes. Discussion about introduced species featured strongly, as did other environmental issues such as global warming

and ozone depletion. Teachers also indicated a range of other controversial science topics that were part of their teaching and learning programmes. Eleven teachers responded that evolution, including human evolution, intelligent design and creationist views, were addressed in their classrooms as controversial science issues in the teaching and learning programme. Other topics mentioned were issues around immunization (2 teachers) and other environmentally based issues, such as water quality, fish stocks, recycling, over population, and bioremediation (7 teachers).

When asked to indicate their priorities for the most important topics to address in their classrooms, teachers listed genetic engineering and cloning issues as a first priority, followed by energy issues and thirdly, global warming.

Confidence levels in addressing controversial science issues

Question 16 asked teachers to choose from “very confident”, “confident” and “tentative” as their level of confidence in teaching controversial science issues and to provide an explanation for their choice. These responses are summarised in Table 6.

Table 6. *Confidence Levels for Addressing of Controversial Science Issues*

Confidence levels for addressing controversial science issues	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Very confident	7	4	11	27.5
Confident	13	13	26	65.0
Tentative	1	2	3	7.5

About one quarter (28%) of the teachers responded that they felt very confident in addressing controversial science issues in the classroom, with 64% of these being male teachers and 36% being female teachers. Two thirds of the sample (65%) felt confident and in this group the numbers of male and female were the same. Only 3 (8%) of the teachers, one male and two females, indicated that they felt tentative in addressing controversial science issues. Comments explaining their levels of confidence were examined. Those who felt very confident provided comments such as:

I read widely and like to encourage students to think and see both sides of issues. Emotional detachment is difficult for students. (702a, male)

I have a wide interest in science, so controversial issues are part of what's happening in science today. How can students become informed citizens if they do not know how to evaluate the science behind a controversy? (705a, female)

[I have] sound background knowledge. (705b, female)

I don't see it as an issue - just facts. (806a, male)

I am continually updating the research. (201a, male)

I am facilitator only; set up discussion, refine, play devil's advocate. To set the students on a path of their own research for both sides of the issue and critique their sources. They must come up with their own decision and justify. (501c, female).

If we say an issue is any subject with two or more opposing points of view, then all teachers do is to present the two points of view. This makes the topic more interesting. (706a, male)

Open to new ideas, so not intimidated; it's OK for different opinions. (501b, female)

Those teachers who expressed that they were confident in addressing issues in science classrooms supported their level of confidence with statements such as:

Depends on the issue - have confidence if have subject knowledge. (701b, female)

Years of exposure to issues. (702b, female)

As part of senior science AS level 3 there is an internally assessed research project on a controversial issue topic. This requires research by me to be able to assist and mark assignments accurately. (702c, female)

I am aware of the possible controversies surrounding the introduction of new technologies, particularly those that affect humans. There are also cultural and religious issues other than biological ones. (103a, male)

[I am confident] providing I make the time to be well informed. (708a, female)

I teach the science and let students discuss and make up their own minds on subjects. (501a, male)

Confident when materials are easily available. (806b, female)

I ensure when I am teaching the issues that I do not put my opinion over, but will be the devil's advocate when students start to do this. I always ensure I finish mentioning the ethical problems and the fact that each person's thoughts on the issue are their own. (716b, male)

I have the knowledge base to tackle such issues and feel that I am able to bring across many viewpoints and not be subjective. It also allows me an opportunity to develop critical thinking in my students. (810a, female)

It's about getting the students discussing a topic either in groups and feeding back e.g. jigsaw etc... or as a class - management so everyone is heard. Providing even information so it shows all sides of the argument. (812a, female)

The three teachers that indicated they felt tentative about addressing issues in their science classrooms responded with the following comments:

I am aware of the best approach to present issues in an unbiased, focused manner; however I do not understand the issues myself to the degree I would like. (103a, male)

Too hard to know what the "facts" are - depends so much on the opinion of scientists. (712a, female)

Don't get enough information. (712b, female)

Teachers' levels of confidence were further analysed according to the demographic characteristics of years of teaching, school type and current teaching subjects. These results are reported in Table 7.

Analysis of the confidence levels related to years of teaching showed that teachers with more years of teaching (11+ years) expressed a higher confidence level in addressing controversial science issues. However a Chi square test indicated that this difference was not statistically significant. School location and size of schools show that the smaller schools and rural schools have more teachers with lower confidence levels than those teachers in urban and larger schools. In terms of subject teaching areas, no clear patterns emerged.

Table 7. *Confidence Levels for Teaching Controversial Science Issues Related to Demographic Characteristics*

Demographic characteristics	Confidence level			
	Very confident (n=11)	Confident (n=26)	Tentative (n=3)	Total (n=40)
Years of teaching				
1-2 years	-	2	-	2
3-5 years	1	3	-	4
6-10 years	2	5	1	8
11-20 years	2	2	1	5
20+ years	6	14	1	21
School type				
State high school - urban	5	13	-	18
State high school - rural	2	9	2	13
Integrated high school - urban	3	4	-	7
Integrated high school - rural	1	-	-	1
Area school (Yrs 1-13)	-	-	1	1
Current teaching subjects				
Junior science (Yrs 9-10)	11	25	3	39
Senior biology (Yrs 11-13)	6	19	1	26
Senior physics (Yrs 11-13)	-	5	1	6
Senior chemistry (Yrs 11-13)	1	2	-	3
Senior science (Yrs 11-13)	5	9	-	14
Horticulture (Yrs 9-13)	2	4	2	8
Environmental Ed (Yrs 9-13)	1	2	-	3

Teaching strategies and resources

Question 17 asked teachers about the resources and teaching strategies that they used in their teaching programmes when addressing controversial science issues. A list of these resources and teaching strategies, analysed according to sex of teacher, is shown in Table 8.

Table 8. *Resources and Strategies Used by Teachers in Addressing Controversial Science Issues*

Resources and/or strategies used	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Teacher talk	19	19	38	95
Classroom discussion	20	17	37	93
Newspapers/magazine articles	18	16	34	85
Videos/video clips	18	13	31	78
Textbooks	14	11	25	63
Case studies	8	11	19	48
Values continuum	8	10	18	45
Guest speakers	7	8	15	38
Small group discussion	8	6	14	35
Debates	7	6	13	33
Prepared teaching Packages/kits	8	4	12	30
Role play	4	5	9	23
Think, pair and share	1	2	3	8
Writing frames to assist decision-making	-	2	2	5

Note. Most teachers used more than one resource or strategy.

An overwhelming number of teachers used teacher talk (95%) and classroom discussion (93%) as strategies to address controversial science issues. Newspaper articles, videos and textbooks were also commonly used. Student centered activities and co-operative learning strategies were in the minority. Writing frames for structuring argument were used by two senior biology teachers as they addressed an NCEA achievement standard for national qualifications. Other resources and strategies used by teachers showed that five teachers used Internet resources and on-line information; another found current affairs programmes from TV to be useful.

Constraints to addressing controversial science issues

Teachers were asked in Question 18 about the problems or constraints that were found in addressing controversial science issues in their classrooms. Their responses were collated and analysed according to frequency of the constraint. The pattern of responses is shown in Table 9.

Table 9. *Teachers' Perceived Constraints to Addressing Controversial Science Issues*

Constraints/barriers in addressing controversial science issues	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Lack of time in current programme	13	14	27	68
Lack of personal background knowledge	8	12	20	50
Lack of time to plan	6	8	14	35
Lack of teaching resources in the school	7	7	14	35
Knowledge of effective teaching and learning strategies	3	6	9	23
Lack of interest by the students	5	3	8	20
Inability to handle discussions about values	4	3	7	18
Insufficient funding for purchasing of teaching resources	3	4	7	18
Remaining unbiased and non-judgmental	4	1	5	13
Lack of confidence to try different strategies	2	1	3	8
Not knowing how to assess the teaching of issues	1	2	3	8
Lack of personal interest and motivation	1	1	2	5
Other	2	2	4	10

Note. Most teachers identified more than one constraint.

Sixty eight per cent of teachers identified lack of time in teaching programmes as a major concern in addressing controversial science issues. Comments similar to, "Time to fit in issues is a major problem" (701a, male), recurred throughout the data. Lack of personal background knowledge was identified

by 50% of the teachers, and once again comments similar to, “Remaining up to date with the research” (201a, male), were recurring. Lack of time to prepare and the lack of teaching resources were each identified by 35% of respondents. Another issue of concern, identified by 23 % of respondents, was based around teaching strategies and approaches, including the inability to lead discussions based around values and attitudes.

Some teachers did not identify any constraints to teaching of controversial science issues, for example, two teachers responded as follows:

I have not experienced any problems - everyone's opinions e.g. religious, creationism are respected, handled sensitively. All issues are open for teaching at senior levels if they relate to the curriculum content. (705a, female)

No problems. Usually fun to teach as it makes them think. (701b, female)

Further analysis of the perceived constraints in relation to the teachers' confidence levels showed that those who reported themselves as very confident or confident cited lack of time in teaching programmes, followed by background knowledge and lack of resources in the school. In contrast, those who reported their confidence level was tentative found that both background knowledge and lack of resources, followed by lack of time, were the most important of the constraints.

Support for addressing controversial science issues

Question 19 asked respondents about previous support they had received in addressing controversial science issues and the results are summarised in Table 10.

More than half of the teachers (60%) reported that they had received no support or training in the teaching issues in science classrooms. Ten percent mentioned their pre-service education and 25% had experienced relevant in-service training support.

Table 10. *Support Received for Addressing Controversial Science Issues*

Support received for addressing of controversial issues	Male (n=21)	Female (n=19)	Total (n=40)	Total %
None	12	12	24	60
Pre-service	0	4	4	10
In service	6	4	10	25
Other	6	4	10	25

Note. Some teachers identified more than one form of support.

Other kinds of support teachers considered important were prepared resources (4 teachers), discussion with colleagues (3 teachers), attending conferences (1 teacher) and use of the Internet (2 teachers). Question 20 asked teachers to choose from a list of suggested resources which ones they would find useful. Table 11 shows their responses to the kinds of support listed in the question.

Table 11. *Useful Support for Addressing Controversial Science Issues*

Support to help in the teaching of controversial science issues	Male (n=21)	Female (n=19)	Total (n=40)	Total %
Pre-prepared teaching packages /kits	14	14	28	70
Professional development to update science background knowledge	13	13	26	65
Professional development in effective strategies	10	12	22	55
Networking/sharing resources	10	8	18	45
Visit by science adviser	4	9	13	33
Other	1	2	3	8

Note. Most teachers identified more than one form of useful support.

These responses show that teachers selected prepared teaching packages/kits to be the most useful form of support (70%), followed by professional development in the updating of science knowledge of the issues (65%) and professional development in effective teaching and learning strategies and approaches (55%). Teachers also commented that “specialized speakers” and “free *New Scientist*

publications” would also be considered useful. When the above results were further examined in relation to demographic characteristics, it emerged that teachers in rural schools, in contrast to urban schools, all indicated that networking and sharing of resources would provide useful support.

A number of Chi square tests were carried out across the survey responses using SPSS software to determine whether there were statistically significant relationships between some of the variables related to the teaching of controversial science issues. These tests examined relationships between useful support (Question 20) and confidence levels (Question 16) with variables such as sex, years of teaching experience and subjects taught. There were no statistically significant differences found suggesting that teachers, regardless of whether they were male or female, varying levels of teaching experience and subjects taught, had similar patterns of confidence and needs for support.

In the final question (Question 21), teachers were asked to make additional comments on any aspect of teaching and learning of controversial science issues that were of concern to them or that they felt were important. Twenty one teachers responded and these additional comments were analysed into themes. Four of the emerging themes were similar to the themes noted in Question 11; that teaching and learning about controversial science issues demonstrates aspects of the nature of science, develops critical thinking, assists in informed decision making, and encourages an awareness of different perspectives. Seventeen teachers commented on the themes from Question 11, four teachers commented on the constraint of time available in teaching programmes and four other teachers commented on the increasing visibility of intelligent design. Some teachers made more than one additional comment. The theme that occurred in these final comments with the highest frequency related to aspects of the nature of science. A number of these comments were based around the teaching of evolution:

I am concerned about the rise of ID as alternative to teaching evolution by natural selection. This is not a controversial science issue. (713a, male)

I am worried about conservative/religious swing against evolution evident in US (Intelligent Design). Will it be imposed here? (702a, male)

[I do not want] creationism and intelligent design to get any foothold. (502b, female)

However the science is separate e.g. human evolution is science, ID is not (save for the theology classroom). (811a, male)

Other nature of science aspects that were mentioned were:

It is important that it [issues] is taught - pseudoscience through the media, sensationalism is rife; students need the skills to evaluate and form opinions based on science. (705a, female)

...unreliable sources of information on Internet; students unable to judge validity. (502a, female)

Another theme occurring with relatively high frequency was that of the importance of up-to-date or current science knowledge:

Make sure you are up to date on your information. (806a, male)

[Teacher information must be] relevant, up to date. (702c, female)

Some of the final comments reinforced the ideas of critical thinking:

The most important aspect is that students are exposed to "grey" issues that force them to think critically. (709, male)

Time as a barrier to teaching of issues was reinforced:

Generally the courses we teach do not allow a great deal of time spent on issues. (811b, male)

There was a comment relating to lack of student interest:

Few students consider issues to be of interest to them. (714a, male)

and finally

They are vital - understanding these issues is vital to humanity's future on the Planet! (708c, male)

Findings from the Focused Group Interviews

Following an examination of the results of the survey, two groups of two teachers were interviewed in an informal situation, over a cup of coffee, to further explore the survey results.

After the introductions, the discussion turned to controversial science issues and teachers were encouraged to share their experiences. Those they had addressed with their classes ranged from cloning and genetic engineering “mentioned in passing” in science lessons, to topics such as sustainability (energy alternatives),

global warming and introduced species as major parts of both junior and senior biology topics. The discussion then moved on to the preparation of students by two of the teachers for the writing of an essay on a controversial issue in science and biology for assessment for internally assessed achievement standards for NCEA (AS 3.2 for both biology and science). This involved about 3-4 weeks of class time during which students individually researched their chosen issue.

The teachers commented on their positive or otherwise experiences:

Our school got sprayed for painted apple moth a few years ago. Staff and students debated the issue in many forums – some staff and students got sick. One student wrote his essay for Achievement Standard 3.2 on it and found out exactly what was in the spray (other than the bacteria). Six carcinogens were found according to his research – something the Government departments could not tell us. Great debate followed. (Teacher A)

Another teacher commented:

The individual essays produced by senior students are well balanced and informative and have been a learning experience for me. (Teacher C)

One teacher (Teacher B) considered that a factor that contributed to the success of her experiences, was having class time legitimately available to discuss the issue as “the NCEA platform was the vehicle.” Another teacher commented that the experience was successful because

There was “freedom to express their ideas – open encouragement of discussion – letting students express their ‘gut’ feelings. (Teacher C)

The teacher, Teacher D, that earlier discussed his “mention in passing”, explained that his addressing of issues was limited by his lack of up-to-date information on the topic.

When discussing the benefits of issues-based learning associated with science for students, the teachers gave similar responses:

[teaching issues] should be the pinnacle of our science teaching – producing an informed population is the best way to positively deal with issues in society. (Teacher A)

They are “real”. Students can listen to all sorts of arguments – quite enlightening for them as they see peers in a different light. Values are challenged – this I believe is healthy. (Teacher B)

They are/will be exposed to these issues during their lifetimes. They need balanced background information in order to make reasoned decisions that may affect them and the wider community. (Teacher C)

Teaching and learning strategies and approaches were then discussed and teachers described some that they had used. These included the use of a continuum, debate, role play, video, DVDs, full class discussion, teacher talk and the use of newspaper articles. One teacher needed an explanation of what a continuum⁵ was, and also commented that role plays took time in class and time to prepare and such time was not available.

Two teachers only were able to describe how they worked with students to enable them to make a judgment. The first teacher (Teacher A) talked about how the students watched a video and then discussed how a grain company had inserted a “terminator” gene in grain seeds. The same teacher also had a full class discussion on DNA profiling of the population for crime detection. For both issues students were asked to write a personal statement on their view. The second teacher (Teacher B) talked about the presentation of different theories, e.g., Darwinism and Creationism, and how she allowed students to debate and provide evidence to support their stance on the issue.

When the teachers were asked about the types of resources they thought would be useful, all indicated that they were unaware of any useful resources to assist in addressing issues in classrooms, except some websites that could background the science behind an issue. They considered that access to appropriate videos, DVDs, websites, interactive tools and quality teaching packages would be useful.

The teachers were asked about their understanding of ethical decision making and the different ways of ethical thinking and two of the teachers indicated that they had no understanding of ethics, except that they thought it involved making a decision about what was “right” or “wrong.” A third teacher commented:

*Ethics means principles or values that govern rules of human behaviour.
There are number of them e.g. democracy, Hippocratic, libertarian,*

⁵ A line along which views or ideas are ordered in a continuous series from one condition to another, e.g. acceptable to not acceptable.

utilitarian, stewardship, precautionary principle. When considering or deciding, the scientific community does it within this framework and often must balance one against another. (Teacher A)

Although the teacher was able to mention something about ethical frameworks, further detail could not be elicited. Another teacher commented:

Ethical decision making is when decisions are made with consideration and a consultative process with viewpoints of all parties involved. Being inclusive and aware of the complexity of an issue and the positive views others hold when decisions are made is important. (Teacher B)

The discussions in both focused group interviews concluded with teachers discussing the relationship of the teaching of issues to *The New Zealand Curriculum* (2007), especially the science learning area. All the participants of the focused group interviews were concerned that the teaching of issues was a part of the core, overarching Nature of Science strand, and that they felt poorly equipped to do this. All commented that there was a lot to be done to prepare and support teachers to effectively address controversial science issues in science classrooms.

Discussion of survey and focused group interview findings

This section discusses the findings of the project and identifies how controversial science issues are currently addressed in New Zealand secondary science classrooms, including the constraints identified by teachers (Research Question 1) and the support that teachers indicated would be useful (Research Question 2).

Current status of controversial issues teaching and learning in New Zealand

The survey and focused group interviews have revealed the current status of teaching and learning about controversial science issues in science classrooms in New Zealand. Analysis of the findings showed that all teachers surveyed in the project thought that controversial science issues should be discussed in secondary science classrooms, and all indicated that they were doing so.

Although only 66% of New Zealand teachers of junior science addressed issues in teaching programmes, all senior science (Years 11-13) did so. In specialist science subject areas at senior levels, biology teachers (96%) were more likely than chemistry (62%) and physics teachers (66%) to do so. Curriculum documents for senior science and biology and the associated achievement standards for national

assessment make reference to controversial issues and consequently teachers of these subjects were directed by assessment opportunities.

The main reasons teachers gave for discussing controversial science issues in their classrooms were to give students an awareness of different perspectives or other people's views (30%), to develop critical thinking in students (26%), and to provide opportunities to make informed decisions (24%). Slightly fewer teachers related reasons for discussing controversial science issues to the acquisition of science knowledge and understanding. The controversial issues commonly addressed in teaching programmes were those associated with biotechnological techniques (cloning, genetic engineering, stem cell technology). Other issues that also featured strongly in classroom discussions were global warming and ozone depletion.

In the teachers surveyed, just over a quarter (28%) responded that they felt very confident in addressing issues, with nearly twice as many males as females in this group. Most teachers who felt very confident were teachers of senior science and senior biology. About two thirds of the teacher respondents (65%) indicated that they felt confident and 8% were tentative in their confidence level.

Although New Zealand teachers indicated that they were teaching controversial science issues in their classrooms, this was usually carried out in a predominantly teacher centred way, using a narrow range of teacher centred strategies and without an understanding of frameworks of ethical thinking. The most common strategy used by teachers when addressing controversial science issues was for teachers to briefly introduce the issue and ask students to research the issue and then justify their personal viewpoint. There was no explicit teaching or discussion and the task was often done by students individually and in isolation. The result was then presented as an essay for assessment.

The main constraints to teaching issues perceived by both the survey respondents and the focus group participants were organisational barriers, and these were lack of time to address controversial science issues in current programmes (68%) and lack of time to plan topics (35%). Implementation of NCEA, and the ongoing related assessment, has been a high priority for secondary teachers and much of their energy and time has been directed towards this.

Lack of personal background science knowledge and understanding of science concepts associated with the issues as well as keeping up to date with the rapid change in technologies in science was a major problem identified by 50% respondents to the survey. This conceptual barrier was also reinforced by the participants in the focused group interviews.

Pedagogical barriers were also identified as a constraint to teachers addressing issues. These included a lack of knowledge of effective teaching and learning strategies and lack of teaching resources. As mentioned earlier in this section, teachers were using a narrow range of teaching and learning strategies which were predominantly teacher centred.

It also was clear that there has been little professional development in this area as the focus has been on implementation NCEA and few teacher education providers give opportunities for pre-service teachers to develop skills in this area. Consequently, beginning teachers move out into teaching positions with little pedagogical knowledge of skills and strategies to engage students in critical thinking about issues.

Overall, it appears from the findings that there is a lack of expertise among many teachers to utilise a range of student centred, collaborative teaching and learning strategies as they address controversial science issues in their classrooms.

Support required

Support is a broad term and both the survey and the focused group interviews generated useful data related to this concept. In examining these data further, in order to address Research Question 2, some key areas were identified in which both the survey respondents and the focused group participants felt that they needed support.

Lack of teaching resources, both printed and electronic guides and teaching materials, was indicated by both survey respondents and focused group interview participants as a constraint and was considered an area for support. There are many teaching resources available, especially on-line ones, although teachers indicated that lack of time to find and modify these is a problem and so they remain unaware of what is available. Some teachers commented that a lack of funding to purchase

resources and teaching materials was a constraint. Others felt that networking would provide an opportunity for such resources to be recommended and shared.

Lack of time was also a significant constraint and teachers regarded that support could be provided in terms of more time to plan or prepare teaching units, and search for resources and time to attend workshops and courses as training opportunities.

Pedagogical constraints were identified by teachers and they commented that they had little professional development in this area either as in-service or as pre-service teachers. They identified a strong need for support in this area as the *The New Zealand Curriculum* (2007) identifies informed citizenry and making decisions on controversial science issues as important outcomes for science students. Teachers need to have access to professional development to assist them in developing pedagogical approaches, including an understanding of ethical frameworks for ethical thinking, so that curriculum requirements can be addressed.

Summary

This chapter has presented the findings of the survey and the focused group interviews. In summary, the survey and focused group interviews have revealed the current status of the teaching of controversial science issues in secondary science classrooms in New Zealand (Research Question 1) and have identified the support that teachers indicated they need in order to address the teaching of controversial science issues in their classrooms (Research Question 2).

Overall the survey and the focused group interviews showed that there was a need to move teachers away from a focus on content, towards a pedagogy that focused on processes such as ethical thinking, argumentation and appropriate use of strategies and approaches to support these. I considered ways in which teachers might best be supported and decided that a professional learning programme would be developed for a small group of science teachers in which they would be introduced to a range of available resources for teaching and learning about issues, and also in which their pedagogical approaches could be extended to assist them in addressing controversial science issues. The main focus of the professional learning programme would involve developing, and then presenting to the group of teachers, a model of ethical inquiry as a pedagogical approach to support them to scaffold

their teaching and learning about controversial science issues. Such a professional learning programme would also need to release them from teaching commitments and provide the time to examine literature on teaching and learning about controversial science issues, explore possible approaches and resources as well as provide the time to plan a resource in the form of a unit of work that addressed a controversial science issue for one of their classes. Their success or otherwise in the teaching of the issue could then be analysed in order to evaluate the model of ethical inquiry.

The following chapter describes Phase Two of the project in which a teacher professional learning programme was planned and a model of ethical inquiry was developed as a pedagogical tool to provide support and assistance for science teachers in addressing controversial science issues.

CHAPTER 5: PHASE TWO - DEVELOPMENT OF THE MODEL FOR ETHICAL INQUIRY AND PLANNING THE PROFESSIONAL LEARNING PROGRAMME

Introduction

This chapter describes Phase Two of the thesis pathway which developed a model for ethical inquiry and planned a professional learning programme to introduce the model for trialling and evaluation in secondary science classrooms.

Firstly, it describes the development of the model for ethical inquiry, including further discussion of the literature that played a key role in the model design. The next section describes the professional learning programme by outlining the structure of the first workshop which backgrounded and introduced the model in preparation for trialling in secondary science classrooms. This is followed by a description of the structure of the second workshop which reported on the trials and evaluated the model for ethical inquiry.

The final section discusses how the professional learning programme considered and built the key principles for professional learning from the literature in to the design of the programme.

Development of the model for ethical inquiry

The research purpose was to develop a pedagogical model that provided a pathway to support teachers in teaching controversial science issues in New Zealand secondary science classrooms. I considered that the development of a model could assist teachers in addressing more explicitly controversial science issues, and that a planned sequence of learning in conjunction with the ethical reasoning frameworks could help move students from being intuitive decision makers, where they lacked a clear rationale for their views, to logical decision makers who could justify their own decisions and show tolerance for other people's viewpoint.

Influence of the survey and focused group interviews on the design of the model

The results of the survey and focused group interviews carried out in Phase One of this project indicated that New Zealand teachers tended to use a narrow range of teaching and learning strategies with full classroom discussion, teacher talk,

newspapers, videos and textbooks being the most commonly utilised strategies. Although teachers indicated that they were confident in leading full class discussions, co-operative and collaborative strategies were seldom mentioned. A common strategy used was for teachers to briefly introduce the issue and ask the students to research and then justify their personal viewpoints on the issue. There was no explicit teaching or classroom discussion of the issue and the task was done individually. The research was then presented as an essay for assessment.

These results reinforced the findings in a study by Newton et al. (1999) that indicated secondary science classrooms are strongly teacher-centred and that there is little opportunity for small group or whole class discussion. The researchers observed that where it did occur, there was little instruction on how to go about carrying out and participating in such discussions. When Newton et al. interviewed the teachers about their teaching strategies, they commented that, although they saw the value of discussion, they had few strategies for structuring discussion in both small groups and with a whole class.

From the survey and focused group interviews, it was clear that extending teacher use of strategies, especially for group and class discussion, was needed. It was planned to incorporate some potential strategies within the structure of the model.

Influence of the literature on the design of the model

Awareness of the existence of an ethical issue requires moral sensitivity (Rest, 1984) and this was an important starting point in model of inquiry as some students were unaware of the existence of an issue. Reiss (2006), drawing on the work of Davis (1999), suggested that teaching ethics can increase ethical awareness and sensitivity of students. He also acknowledged the importance of ethical knowledge in which students learn to distinguish between different ways of ethical reasoning and how teaching of ethics improves the ethical judgment of students and might make them more virtuous or “better people”. The terms of ethical sensitivity, ethical knowledge and ethical judgment were considered for use in the model and can be identified in some stages of the model. Dawson (2003) similarly identified ethical decision making as involving the three stages of ethical sensitivity (identifying the dilemma), ethical reasoning (identifying and weighing arguments for

and against the issue) and ethical justification (reaching and justifying a decision). I considered these to be key terms that could overlay parts of the proposed model. However, I wanted more detail in the pathway for teachers than these three constructions allowed.

Osborne (2006) argued that education for citizenship balances the following four elements of learning. The first is having a conceptual knowledge of scientific facts. The second element is the acknowledgment of epistemic learning which involves understanding the methods and processes of science so knowledge is secure and reliable. Thirdly, Osborne discussed the importance of a cognitive element in the development of an individual's ability to reason and think ethically, and emphasises that learning to argue is learning to think. He stressed the need for students to have the opportunities to listen, evaluate arguments of others and construct counter arguments. The final and fourth element presented was that of social and affective aspects, so that the learning is facilitated through social interactions and discourses. These four elements are incorporated within the proposed model.

Reiss (1999) discussed how confidence about validity of an ethical conclusion requires three criteria. The first of the criteria is the importance of arguments being supported by reason and the second criterion is that arguments need to be conducted within one or more established ethical frameworks. The third criterion proposed by Reiss is the need to exist, from genuine debate, a "significant degree of consensus" about the validity of the conclusions. Traditionally religious beliefs provided a strong framework for the making of ethical decisions, but there is less acceptance today for this to be the sole authority. All three of the above criteria identified by Reiss were integral in developing the model. Reiss also discussed the problem of conducting ethical debates in today's "plural" society. I wanted to consider the idea of pluralism carefully and I discuss this idea later in this section.

Morris (1994) presented a decision making model, in the context of the Human Genome Project, which involved definition of the issue, problem analysis according to accepted ethical principles or rules, debate of the arguments, and conclusion. It is similar to a five stage model developed by Burnham and Mitchell (1992) and recommended by Dawson (2001), which developed through stages of observation, question and hypothesis, information gathering, analysis and finally ethical deliberation. The final stage involved a decision or description of solutions

with an awareness that no single answer may be possible. The aspects of questions, information gathering, and ethical deliberation were considered for incorporation in the model. Dawson and Taylor (1999) made it clear that students need opportunities to develop, reflect on and justify their bioethical values, and these I thought were some other key aspects to consider.

Levinson (2006) presented a model for teaching socioscientific issues in which three strands were proposed to provide a framework for teachers. These interconnecting strands were: categories of reasonable disagreement, the communication virtues or dispositions necessary to engage in reasonable disagreement, and narrative modes of thought and experience which can best illuminate the disagreement. Levinson provided examples to illustrate how the framework could be used by teachers. I found this model commendable, but it was too complex and challenging for teachers as an initial introduction to the teaching of bioethics. The findings in the survey and the focused group interviews showed that there was little understanding of ethical decision making and I required more simplicity than this model provided.

Principles and frameworks for ethical reasoning

I am in agreement with Levinson (2003, p. 9) that *how* a decision is made, rather than *what* decision is reached, is core to teaching controversial science issues. The main difficulty in developing the model for ethical inquiry for this project concerned frameworks of ethical thinking or reasoning – the area involved in *how* the decision is made. The survey results and focused group interviews emphasised that the teachers had very little understanding of established frameworks of ethical thinking.

After examining and comparing the contributions and challenges of the main ethical perspectives – deontological ethics (duty or rights-based), virtue or care-based (Gilligan, 1982; Noddings, 1992), principles (Beauchamp & Childress, 1983, 1994, 2008) and outcomes-based (consequentialism) – I came to the decision that I would further develop the one presented by Reiss (2006), which combined some of the deontological principles of Beauchamp and Childress with the teleological emphasis of consequences, which considers what will happen if something is done. Reiss's four ethical frameworks consisted of consequentialism (projected outcome of

a decision), rights and duties, autonomy (making decisions for yourself), and virtue ethics (acknowledges virtues valued in society such as honesty, truthfulness, integrity, compassion). I regarded these four frameworks as being potentially workable in New Zealand schools as they had been successfully trialled in secondary science classrooms in the United Kingdom.

An additional framework – Pluralism

To Reiss's four frameworks, I added a fifth framework to the model for ethical inquiry. This framework was that of pluralism and the concept of pluralism has been discussed in general terms in Chapter 2. In New Zealand society, cultural beliefs, values and attitudes play a large part in people's responses to science and technology developments but there is often tension between traditional beliefs, especially of Māori people, and the benefits offered by the new biotechnologies.

If an awareness of pluralism is to be fostered in New Zealand, opportunities must be provided to discuss a full range of views on relevant issues (Snook, 2000, cited by Conner, 2002). It is important to note that in New Zealand, Māori people are not a small ethnic minority and that the indigenous view is given significance by the Treaty of Waitangi. As explained in Chapter 2, this treaty means that the Crown, as a treaty partner, is required by law to protect *te ao Māori* (the Māori world) and heed Māori advice. Acknowledging and exploring a Māori world view is central to government and government agencies, including the role of the Bioethics Council of New Zealand under the Treaty of Waitangi. The government regards that one of the Treaty responsibilities is to ensure that Māori voice is heard and that the wider New Zealand population gains an understanding of Māori issues and *te ao Māori*. This means that they engage in dialogue and consultation with a wide range of Māori, seek out the plurality of Māori voices in New Zealand and incorporate Māori perspectives in communications to the New Zealand public, ensuring that decisions acknowledge wishes of Māori.

Hipkins and Du Plessis (2004) focused their work on research strategies that enabled engagement of both Māori and non Māori in dialogue on genetic testing and biobanking. Lyver, Lyver, Hayes and Horne (2004) also discussed how conversation, or *korero*, could be facilitated with Māori in the context of developing acceptable pest control strategies.

A study by Roberts and Fairweather (2004) of Māori perceptions of the new biotechnologies, emphasised the need for cultural risk assessments to be grounded in culturally appropriate *tikanga* (knowledge), and also included acknowledgment of spiritual values as well. The authors of the study commented:

A purely scientific risk/benefit framework is not sufficient for Māori. For some the alternative was envisaged as based primarily on whakapapa, which could be used as a guide to make culturally safe decisions about new technologies. ... Knowledge of whakapapa reveals the historical origin, record and relationships of things; in this way it provides a cultural risk assessment framework for Māori. (p. 72)

Whakapapa refers to genealogy but it is a complex concept. Hudson, Ahuriri-Driscoll, Lea, and Lea (2007) described it as:

Ancestry, genealogy or family tree, describing the layers of generations built upon another. In te ao Māori (the Māori world) whakapapa is a familiar term and as the 'ultimate catalogue' it defines not only relationships between people, but with all other things. Trees, birds, mountains, rivers and even events can be said to have and perhaps even share whakapapa....It also creates a framework for managing information about the entire environment and place of people within it. Matauranga Māori (Māori knowledge) thence, is organised through whakapapa. (p. 43-44)

Māori have concerns about the use of biotechnologies and their implications not only for *whakapapa* but also personal *tapu* (sacredness) and *mauri* (lifeforce). Many believe that the new biotechnologies can irreparably interfere with the relationships between humans and the natural world and that these biotechnologies are a serious misconduct of *tikanga* (protocols). Māori also have a strong sense of *kaitiakitanga* or responsibility and guardianship for the environment and all of its life forms. The collective viewpoint is frequently emphasised over the individual viewpoint. As stated in a report by the Bioethics Council of New Zealand (2005) on Xenotransplantation:

The indigenous view of Māori cannot be voiced anywhere else in the world. As such it is vital that this world view not only be taken in to account in Aotearoa/New Zealand, but also be given significance. (p. 17)

Another report by the Bioethics Council of New Zealand (2006) on “Choosing genes for future children: regulating pre-implantation genetic diagnosis”, devoted one chapter out of five (Chapter 3) to Māori views on pre-implantation genetic diagnosis. Māori perspectives and consultation with Māori were significant

aspects of this project because, as mentioned above, such consultation is matter of right, not expectation, under the authority of the Treaty of Waitangi. The report identified issues of “equality of access to health services, discrimination and the potential erosion of cultural and spiritual values” with regard to the “biotechnology explosion in the last ten years” (p. 71). Such explanations acknowledge the different ways of knowing, although Durie (2004) in his discussion of scientific knowledge and indigenous knowledge as independent knowledge systems, pointed out that some Māori researchers were trying to “synchronise the interface between science and indigenous knowledge” (p. 1141).

A recent literature review on values in the New Zealand Curriculum by Keown, et al. (2005), commented that Māori values “transverse the whole range and breadth of Māori cultural experience,” and that for Māori,

values imply intrinsic beliefs and ways of doing and knowing things that inform how and why certain practices and approaches are followed. (p. 17)

Migrant groups are also contributing to New Zealand’s growing diversity and, as Brodwin (2000) commented, on the importance of effective responses to cultural pluralism,

Just as bioethics demands good facts, effective responses to cultural pluralism demands detailed knowledge of particular migrant groups, their recent history, and their own ethical commentaries. (p. 8)

I argue that the incorporation of pluralism in the proposed model for ethical inquiry enables specific acknowledgement of the cultural and spiritual differences within New Zealand society, especially Māori world views which are required to be acknowledged under the Treaty of Waitangi partnership articles. New Zealand teachers working with students in exploring controversial science issues, especially those involving the new biotechnologies, need not only to acknowledge traditional Māori cultural and spiritual values, but also require a framework of ethical thinking that enables them to meet the obligations of the Treaty.

I also argue that, after consideration of the findings from the survey in Phase One of this project and the requirements of the newly released *The New Zealand Curriculum* (2007), there is an obligation for teachers to address controversial science issues in their science classrooms from a stronger theoretical base and the model incorporates opportunities for such a base to be established.

Criteria for the design of the model

The criteria therefore were established for the development of a model for ethical inquiry. I considered that the model needed to include the following eleven criteria.

- An opportunity to develop an understanding of the science concepts backgrounding the issue.
- An opportunity for engagement and awareness of the issue (ethical sensitivity).
- An opportunity for individual reflection on personal values related to the issue.
- An opportunity for participation in classroom discussion, conducted within agreed parameters, e.g. no winners or losers, respect for different viewpoints, no interruptions, critiquing the viewpoint not the person.
- Awareness of how to phrase an ethical question.
- Awareness of ethical reasoning using a range of ethical frameworks. It was important to move students away from “gut” thinking to reasoned decision making (ethical knowledge).
- Decision making frameworks to assist students to scaffold or organise their thoughts and ethical reasoning to enable ethical judgment or justification.
- An opportunity for students and teachers to evaluate the learning (metacognition) and take action if appropriate.
- Awareness of a variety of appropriate strategies and approaches to consider at various stages of the model, especially those for group and classroom discussion.
- Awareness of focus questions and prompts that could facilitate and challenge critical thinking in students.

Using these criteria, the model was developed as a visual representation which showed the steps in the process of inquiry, together with some useful strategies to consider at various steps in the process. Appendix I shows the initial version of the model (Version 1) that was presented for critique to the teachers on the first day of the professional learning programme.

Planning the professional learning programme

The planning of the teacher professional learning programme involved designing two workshop days for four teacher-researchers. The two days would be separated by eleven weeks, with the first workshop backgrounding and introducing the model for ethical inquiry, and then preparing the teacher-researchers for trialling the model in their classrooms. The second workshop day would be based around teachers' reports on the implementation and evaluation of the model.

The workshops were carefully planned with clear objectives, specific sessions, interactive activities and opportunities for discussion. In order to implement an ethical inquiry approach into the teaching and learning about controversial science issues and to be able to provide students with guidance and support, I wanted the teachers to participate in the full ethical inquiry process, and experience the same knowledge and thinking skills as their students would. Each session would be recorded on an audiotape and transcribed.

Workshop 1- Backgrounding and introducing the model

The first workshop was to address five objectives through seven sessions. These objectives would be

- to review the current situation in the teaching of controversial issues in science classrooms in New Zealand,
- to explore and interrogate a model for ethical inquiry for introducing controversial issues into science classroom programmes,
- to explore five frameworks to assist ethical thinking for students,
- to identify strategies and resources to support the teaching of bioethics/controversial issues in science classroom programmes, including trialling of a computer-based tool, and
- to develop ideas for planning an issues-based unit to trial in a science classroom.

The intended timetable for the day is shown in Table 12. Appendix J shows the details of the Power Point slides that would scaffold the workshop sessions.

Table 12. *Timetable for Workshop 1*

Time	Session
9.00am	Introduction Introductions, Introduction to Research Project, Workshop 1 objectives
9.15am	Session 1: Researcher's survey results on the teaching of controversial science issues in New Zealand schools
9.30am	Session 2: Sharing experiences of teaching and learning about controversial science issues
9.45am	Session 3: What does the literature say? Jigsaw activity using a relevant professional reading
10.15 – 10.30am	Morning tea
10.30 – 11.30am	Session 4: Introducing ethical frameworks
11.30 – 12.30pm	Session 5: Introducing the model for ethical inquiry
12.30 – 1.15pm	Lunch
1.15pm – 2.00pm	Session 5 continued: The model for ethical inquiry
2.00 – 3.00pm	Session 6: Reality check – applying the model to a context
3.00 – 3.45pm	Session 7: Preparing for the classroom trials
3.45 – 4.00pm	Reflection and Evaluations on Workshop 1

After introductions, the pathway for the research project would be presented to the teacher-researchers (Figure 2), followed by the specific objectives for Workshop 1. The first session was planned to present the general findings of the survey that was carried out in 2006 as Phase One of this project. All four teacher-researchers had contributed to this survey. The use of the survey findings was to reinforce the background to the project with a review of how New Zealand teachers currently address controversial issues in their science classrooms.

The second session was to provide the teacher-researchers with opportunities to share their experiences of teaching and learning about controversial issues with the rest of the group. They would be encouraged to discuss the contexts, strategies, approaches and resources that they had used in their teaching experiences.

The third session was planned to introduce the teacher-researchers to some international literature on teaching and learning about controversial science issues.

The first eight pages of an article, *Bringing controversial issues into science teaching* (Van Rooy, 2004), would be explored using a “jigsaw strategy”. Each person would have five minutes to read one of four sections of the article and report back to the others. The sections of the article chosen for modelling this strategy were “Introduction”; “What is a controversial issue”; “Justifications for using controversial issues in science teaching”; and “The role and responsibility of the teacher”. A template would be provided for the teachers to record the main points of their section of the article, and then the main points as reported back from the others. Other key articles would be provided for further reading and these readings are listed in Appendix K. Following the jigsaw activity, links would be made to where the teaching and learning about controversial science issues was emphasised in *The New Zealand Curriculum* (2007) in the values, key competencies and the science learning area.

The purpose of the fourth session was to introduce the ways in which people make ethical decisions. The focused group interview responses prior to Workshop 1 had indicated that the teacher-researchers had very little knowledge of ethical frameworks and ways of ethical thinking. Consequently, this session would introduce the five ethical frameworks for ethical thinking to them. It was important to develop their expertise in understanding these frameworks of thinking so that they could confidently use them to help students appreciate the range of different ethical frameworks that could be used to develop a reasoned argument as well as evaluate the ethical arguments of others. To achieve this, discussion and activities would be based around three short video clips entitled *Ethics versus morals* (Reiss, 2006c), *Common ethical frameworks* (Reiss, 2006b), *Which ethical framework?* (Reiss, 2006d). The first activity, which was to follow the showing of the first video clip *Ethics versus morals* (Reiss, 2006c), was a continuum strategy, “Sorting priorities”, in which the different views that people hold on genetically engineered food could be discussed. This activity is shown in Appendix L.

The second and third video clips, *Common ethical frameworks* (Reiss, 2006b), and *Which ethical framework?* (Reiss, 2006d), would then be used to introduce four frameworks of ethical thinking: rights and duties, consequences, autonomy and virtue or care ethics. Following the viewing of the two video clips, a fifth framework based on pluralism was then to be introduced to the teachers.

A second activity was designed to follow the screening of the above video clips. This was based around the issue of pre-natal genetic screening. In the activity, a definition and a statement about pre-natal genetic screening are provided as an introduction to the activity. Then a range of ethical arguments related to genetic screening, each on individual cards, would be introduced for the participants to consider in pairs and they would have to decide which of the five ethical frameworks best supports each argument. They would also be encouraged to write some additional statements for each ethical framework. This activity is shown in Appendix M.

Session 5 was planned to introduce the model for ethical inquiry (Version 1) that had been developed by the researcher (Appendix I) and which incorporated the five frameworks of ethical thinking. Opportunities would be provided to examine and interrogate the stages of the model and the associated sidebars of strategies and question-prompts.

A potential strategy for ethical decision making would also be introduced in the form of a computer-based tool. This tool was developed by a research team, including the researcher, at the University of Waikato, working on a project commissioned by the Bioethics Council of New Zealand (see www.biotechlearn.co.nz)⁶. It provides an interactive to explore and scaffold the principles of ethical thinking in a selected science or technology context. The toolkit draws on a unique New Zealand metaphor, in that the toolkit is imaged as a *kete* (a Māori woven flax kit bag) with the woven strands representing the intertwining of ethics, the nature of science and key competencies as represented in the *New Zealand Curriculum* (2007). Each of the key ethical ways of thinking about a controversial issue is symbolised by a stone, which once selected from the *kete* is cast in to the “pond” (the issue). As the pond ripples with each framework “stone”, generic questions appear that can be explored. Students use these questions as support to write responses related to each ethical thinking framework. The responses are saved

⁶ Biotechnology Learning Hub provides up-to-date examples of biotechnology in New Zealand, with unit plans, classroom activities, worksheets and other teaching resources. This site is a collaboration between educators and the biotechnology industry – providing cutting edge biotechnology ideas in student-friendly ways.

in the interactive for later use when students consider the options and then make, with justification, their decision on the issue.

As a reality check, session 6 was planned to allow the application of the model in a context to be chosen by the teacher-researchers. This would then allow further interrogation and critique of the model and enable modifications to be made so that Version 2 of the model could be co-constructed. Writing frames would also be trialled in this application phase of the model to assist in scaffolding ethical decision making and justification.

Session 7, the final session, was planned to support the preparation for trialling of the model in the classroom. Some useful websites would be introduced as well as other support materials on a CD ROM to assist teachers in their trials. These materials would include the video clips from the workshop for use with students (Reiss, 2006); useful websites; the model of ethical inquiry (Appendix I); the computer-based bioethics tool and planning proformas (Appendix N). Planning proformas were to be provided as a tool to support teachers in the planning and teaching of their units and would focus the teachers' science content knowledge and pedagogy. Because of uncertainty in teaching this approach it was important for teachers to organise and plan in a similar way to that in which pre-service and beginning teachers are supported and scaffolded. The planning proformas would also provide a logical sequence for the teaching and learning by beginning with elements of planning, such as curriculum links and specific learning outcomes or learning intentions and success criteria, and then lead to the teaching and learning activities, with space for teacher and student moves to be indicated. The proformas would enable the teacher-researchers to clearly develop the frameworks for ethical thinking within the teaching and learning sequence and allow this knowledge to be organised and easily accessed. The expectation of the proformas was not to pre-determine the learning, nor was it a rigid document, but it was to be considered as a guide. They were not expected to follow the pathway blindly or jump to premature conclusions. Rather, the proformas were to encourage self awareness and flexibility in the teacher-researchers' approach (Sternberg & Horvath, 1995). The teacher-researchers would also be asked to be aware of unexpected learning so that they could be responsive to the students' needs.

A range of writing frames to help scaffold students' ethical thinking was also to be included on the CD ROM (Appendix O). These would have been trialled in Session 6, where the model had been applied as a reality check in a chosen context. Reflection templates for students and the teacher- researchers were also to be included on the CD ROM (Appendix P) as were templates for the teacher- researchers' reflective journals as a tool for mapping progress and thoughts during the trialling (Appendix Q). The researcher would undertake to send the teachers the re-constructed version of the model of ethical inquiry (Version 2) for use in the classroom trials. Professional readings in addition to the one examined in Session 3 would be included on the CD ROM as worthwhile articles to further extend their thinking on the teaching of issues in science education (Appendix K).

At the end of the final session, time would be provided for the teacher- researchers to discuss and reflect on the workshop.

Workshop 2 – Implementing and evaluating the model

The second workshop was to be held eleven weeks after Workshop 1 with three objectives to be addressed over three sessions. These objectives would be:

- to share and evaluate trialled classroom-based resources for bioethics education,
- to evaluate some tools for introducing ethical thinking to students, and
- to critique and reflect on the model for ethical inquiry.

The intended timetable for the day is shown in Table 13, and Appendix R shows the details of the Power Point slides that would guide the workshop sessions.

The introduction would reinforce the pathway of the project with an emphasis that the workshops and trials had focused on Phase Three of the project. The first session would involve a series of presentations led by the four teacher- researchers as they each in turn reported on their classroom trials using the model for ethical inquiry. Each teacher-researcher would be asked to scaffold their presentation using a Power Point template that would enable them to describe the task sequence, analyse the individual lessons and present students' work. The teachers' and students' evaluations were to be discussed and conclusions were to be drawn for each trial by the teacher on how the teaching unit impacted upon student outcomes.

Table 13. *Timetable for Workshop 2*

Time	Session
9.00am	Introduction: Re-visiting the project pathway and the model (Version 2) Workshop 2 objectives
9.15am	Session 1: Presentation of the class room trials
10.15 – 10.30am	Morning tea
10.30 – 12.30am	Session 1 continued: Presentation of the class room trials
12.30 – 1.15pm	Lunch
1.15pm – 2.00pm	Session 1 continued: Presentation of the class room trials
2.00 – 3.00pm	Session 2: Evaluation of the model of ethical inquiry
3.00 – 3.30pm	Session 3: Reflection on the project Evaluations

Following the presentation and discussion of the trialled units, Session 2 would involve a final critique and evaluation of the model. From this critique, further refinements would be made to the model to produce Version 3.

The final reflective session (Session 3) would ask the teacher-researchers to consider and comment on how the students' learning had been enhanced, challenged, or reshaped. They would also be asked how their own knowledge about ethical thinking and decision-making had been developed over the time of the project, and whether any unexpected learning had occurred for either them or their students. Finally, the pathway of the project would be reviewed and discussion would be facilitated on the sustainability of the project and "where to next?"

Consideration of models and key principles for professional learning in the design of the programme

Design of the professional learning programme was informed by the large amount of literature in this area (for example, Bell & Gilbert, 1994, 1996; Fishman Marx, Best, & Tal, 2003; Guskey & Huberman, 1995; Hewson, 2007; Hiebert, Gallimore & Stigler, 2002; Hoban, 2002; Loucks-Horsley, Hewson, Love, & Stiles, 2003; Showers, Joyce & Bennett, 1987; Timperley, Wilson, Barrar, & Fung, 2007; Tytler, 2007a). Firstly, the terms professional learning and professional development are discussed, and secondly, the models and frameworks for professional

development put forward by Bell and Gilbert (1994, 1996), Loucks-Horsley et al. (2003) and Fishman et al. (2003) are outlined with discussion on how they were considered in the design of the professional learning programme. Thirdly, the key principles identified from the literature for successful professional learning are discussed in terms of how they were integrated into the programme design.

Professional learning and professional development

Professional learning and professional development are often used synonymously. Guskey (2000) defined professional development as

those processes and activities designed to enhance the professional knowledge, skills and attitudes of educators so that they might, in turn, improve the learning of students. (p.16)

He argued that the term professional development implied the delivery of some kind of information to teachers in order to influence practice, whereas professional learning implied more of an internal process through which professional knowledge is created by the participants.

Hannay, Mahony, and MacFarlane (2004) acknowledged that the two terms are closely intertwined and that any well constructed professional development should be designed to promote professional learning, for without professional learning, professional development is unlikely to have any impact. Timperley et al. (2007) promoted the idea that professional learning is an umbrella term under which professional development (the delivery) is just one part.

I have used the term professional learning for this project, as it involved more than just delivery of information to influence teacher practice, and it promoted teachers internalising and creating professional knowledge to influence student outcomes.

Models of professional learning programmes

In line with the model of teacher development of Bell and Gilbert (1994, 1996), reflective sessions in the workshops asked teachers to reflect on their personal, social and professional learning.

The professional learning framework outlined by Loucks-Horsley et al. (2003) was incorporated with four inputs from their framework being acknowledged. Firstly, the design process was informed by my knowledge and beliefs about aspects

of professional learning, especially my knowledge bases of learners and learning, teachers and teaching, and teaching and learning about the nature of science. All of these are strong underpinnings of my teaching programmes in my work as lecturer of science, biology and environmental education at the University of Waikato.

Previously to that position, I had been a secondary science adviser for eight years with School Support Services, whose core function was professional development for teachers. These experiences have developed and refined my personal knowledge, beliefs and orientations on professional learning.

Secondly, the design process showed an awareness of critical issues with time and equity being taken into account. There was a period of eleven weeks taken for trialling between the two workshops and equity was considered in that the selection of the invited participants (two men and two women) came from two schools that varied widely in their decile rating. Thirdly, the context of the project was important in that there needed to be relevance for the teachers. The responses to the earlier survey and the responses in the focused group interviews indicated that the teacher willingness to be involved stemmed from the recent reform and requirements of *The New Zealand Curriculum* (2007). There was also a willingness to improve their knowledge and practice of teaching and learning strategies and resources both generally as well as in the context of the study. This also linked to the fourth and final input of the design framework proposed by Loucks-Horsley et al. (2003) that identified the importance of discussing strategies and approaches. In line with this final input there was considerable opportunity in the programme design for feedback and reflective evaluation from both the researcher and the teacher-researchers to the model for ethical inquiry and its associated strategies, and approaches and question-prompts.

Acknowledgement was also given to the design elements proposed in a model of professional learning put forward by Fishman et al. (2003). This model was similar to the one put suggested by Loucks-Horsley et al. (2003) but also considered a “media” element. Use was made in this professional learning programme of newspaper clippings, news media, video clips, other video clips, computers, interactive tools and the use of the Internet to access relevant and useful websites.

Key principles for successful professional learning

A number of key principles were identified from the literature for successful professional learning and those integrated into the programme design are discussed below.

Reflection and tools to support reflection

Reflection was viewed by Furlong, Barton, Miles, Whiting and Whitty (2000) as coming to know by capturing practical experience in order to learn from it. It involves “doing, thinking, looking back and looking forward, and is concerned with learning in order to be a better practitioner” (Simon & Johnson, 2008, p. 3). Reflection, both individually and within the community of learning, was planned as an integral part of the programme. Opportunities for the teacher-researchers to reflect on their teaching and the students’ learning were provided for in the structure and development of individual portfolios, and time for reflection was provided within the workshops.

Green and Smyser (1996) suggested that constructing a portfolio encouraged reflection which they regarded as essential for teachers’ professional development. A portfolio can be defined as a collection of evidence (Paulson & Meyer, 1991) and previous research that supported portfolios as a tool to enhance professional learning has been widely documented (for example, Dinham & Scott, 2003; Orland-Barak, 2005). As a result, each of the teacher-researchers would be asked to develop portfolios of evidence and would be provided with some tools to assist the collection of evidence such as templates for reflection, and templates for teacher and student evaluations. The portfolios would contain a collection of artefacts which teachers recognised as useful evidence from their trials. The teachers would use these for discussion, reflection and presentation of their trials to the other teachers. It was to be emphasised that the compilation of the portfolio was their responsibility and this selection of evidence was an important aspect of their reflection on practice. The questions and feedback from the other teachers in Workshop 2 was intended to strengthen this reflective process and, as Orland-Barak (2005) noted, teachers become more dialogic as they collaborate. Shulman (1992) also recognised the importance of discussing teaching and learning with colleagues as a critical aspect in the development of professional learning portfolios. Grant and Huebner (1998)

suggested that reflective commentaries, as a result of conversations and discussions with colleagues, were an important component of portfolios.

Professional learning takes time

Time is needed for professional learning, not only making time for teachers to participate in a programme, but time for teachers to implement activities or resources in to their classroom programmes and then time to engage with the new ideas and reflect on their effectiveness in their teaching and in promoting students' learning (Loucks-Horsley et al., 1998; Hall & Hord, 2001; Hoban, 2002; Joyce & Showers, 1995; Timperley et al., 2007; Tytler, 2007a). The eleven week timeframe was intended to enable the teacher-researchers to step back from their work, analyse and reflect on the results. Reflection emphasises the importance of metacognitive processes and there was an expectation on teachers to reflect and use this opportunity to build their competence and knowledge (Sternberg & Horvath, 1995). Time also allowed for a chance to prepare presentations of their trialling of an issues-based unit to other teachers and colleagues. The presentations and subsequent feedback would enable ideas to be discussed and challenged and this would encourage deeper thinking, along with opportunities to engage in professional conversations. The feedback they received from other participants would give an opportunity for refinement of the teaching unit (Bell & Gilbert, 1994).

Teachers willing to change

Hoban (2002) stated that “educational change is a complex process involving many interconnected elements that have a dynamic effect on one another” (p. 29). He identified a combination of conditions that supported teacher change and one of these was that there needed to be not only a desire to change but also the realisation that change may involve uncertainty.

Teacher collaboration and participating in a learning community are important

Teaching is viewed as a social practice (Poulson, 2001) and change requires mutually supportive interaction amongst teachers. The building of such a co-operative and supportive learning community was an important goal in this project and as McGee (1997) stated: “Change is more likely in schools where teachers interact with one another and personnel outside the school who are also involved in the change” (p. 292). This is supported by Hall and Hord (2001) and Joyce and

Showers (1995), who argued that change requires teachers to ground new ideas in their own personal experiences, which are situated in the school context and are sensitive to the levels and structures within which teachers and the school communities are interacting.

The group of teachers was one in which participants' ideas, experiences and challenges were shared to support and encourage each other. There were two teachers from each school which meant that the teachers could collaborate in planning and implementation as well as talk with each other about their findings. Stein, McRobbie and Ginns (cited in Rennie, 2001) found that teachers who worked in isolation during the implementation of a new curriculum area (technology) were less successful than those who worked in collaboration. Building this sense of community (Bell & Gilbert, 1994; Jones, Mather, & Carr, 1994; Hoban, 2002) as they share experiences and interrogate the model of ethical inquiry, then plan, trial, reflect and then refine the model, was a central aspect of the professional learning programme. The conversations were intended to be open and respectful of the perspectives of others (Rogoff, Matusov, & White, 1996), yet the teacher-researchers could challenge their own and others' thinking.

Provision of and modelling how activities and strategies may be used

The programme was planned to provide a variety of activities which included examples of approaches implemented in a simulated classroom situation. Modelling of activities and strategies can show how resources may be used to support new approaches and demonstrate how this new approach can engage learners and promote their thinking and learning (Kahle, 1999; Loucks-Horsley et al., 2003). The professional learning environment needed to provide the teacher-researchers with opportunities to learn through a range of activities so that they were assisted to integrate the new learning into a new form of practice (Timperley et al., 2007).

The researcher would model some strategies that teachers could then use in their own classroom practice, such as a continuum strategy, a jigsaw strategy and card sorting. After each activity, participants would be encouraged to discuss the effectiveness of the strategy and suggest other contexts related to the teaching of controversial science issues where it could be useful.

Materials and resources would be provided for the participants on a CD ROM to support implementation of various stages of the model of inquiry as well as to assist in their planning and reflection. They would have access to masters of the workshop activities, planning proformas, writing frameworks, reflection sheets, video clips and the interactive tool in a form that they could trial with their students. These materials were not sufficient in themselves and would need further discussion in the workshop programme. Engaging with a professional reading (Van Rooy, 2004) was another activity considered in the design of the programme.

The researcher would not always take the lead and, as Rogoff (1994) suggested, people undertake different roles at different times. Sometimes the researcher would take the lead where there were explanations to be made or approaches to be modelled, and at other times, especially during Workshop 2, the teacher-researchers would lead as they reported on and led the discussion on their trials.

Making the pathway explicit

Hewson (2007) suggested that in considering professional learning it is important not only to consider the outcomes of the programme but also the pathway by which the outcomes are achieved. Hewson put forward the metaphor of a pathway to enhance the success of the programme. He considered that the pathway metaphor not only draws attention to starting and endpoints and ways in which they are connected, but also that it highlights the journey and the resources and time needed to complete the journey. The professional learning programme in this study followed such a pathway (Figure 2) and this was to be made explicit to the teachers in the introductory session in Workshop 1 and reinforced again in Workshop 2.

The professional learning needs to have usefulness and relevance

On a day to day basis, teaching is demanding and teachers will only become engaged in new learning experiences if these are realistic, relevant and useful to their professional lives. There need to be direct implications for practice, in particular links between teaching and its impact on student learning, as well as links to new policy trends such as the overarching Nature of Science strand in the science learning area of *The New Zealand Curriculum* (2007). This strand, as well as the key

competencies and the contextual stands of the science learning area, specify that students need to be informed decisions makers about issues facing society today.

Prior to the workshops, the focused group interviews indicated that the four teachers had little awareness of ethical frameworks that could be used to support ethical thinking and decision making. This professional learning programme intended to extend the teacher-researchers' knowledge and understanding in this area and engage them with new learning on ethical frameworks and teaching and learning strategies and approaches that would help them to address the requirements of the new curriculum.

Guidance and support

Bell and Gilbert (1994) found that successful teacher development programmes included support and feedback. Encouraging conversations between teachers and between teachers and researcher was to be an integral part of the programme. At times this would be organised formally in the framework of the workshops as different aspects were targeted, but informal conversations would also have a place in the workshops, via telephone and email, and within schools. The workshops were to be conversational where people built on each others' ideas and were guided by the researcher's leadership (Rogoff et al., 1996).

Awareness of student outcomes

Information about student learning was to be gathered from student work, student feedback and evaluations. The teacher-researchers would be asked to discuss the impact of the teaching and learning programme on students' outcomes in academic (knowledge and understanding, engagement in tasks), social (behavioural interactions with peers and teachers) and personal aspects (identity, self concept and self esteem).

Sustainability

Century and Levy (2002) asked the question '*How do we ensure the programmes we are implementing will last?*' First thoughts indicated that it is the programme or the pedagogical approaches promoted by the professional learning that last, but Century and Levy went on to define sustainability as

the ability to of a program to maintain its core beliefs and values and use them to guide program adaptations to changes and pressures over time. (p. 4)

Timperley et al. (2007) suggested however that any definition of sustainability needs to be judged also on the basis of continuing improvement of student outcomes. They found few studies to provide this information.

Sustainability was not neglected in the literature, but was tested as an article of faith rather than a condition subject to empirical verification. (p. 219)

In this project, sustainability was to be discussed in the final reflective session of Workshop 2 of the professional learning programme, where the teacher-researchers would have an opportunity to talk about the long term impact of the programme and what the professional learning might mean, not only for their future teaching and learning programmes, but for other teachers and schools.

In summary, conditions for successful learning and aspects of models and frameworks for professional development identified by Bell and Gilbert (1994, 1996), Fishman et al. (2003), Hoban (2002), and Loucks-Horsley et al. (2003), and identification of key principles from the literature were important considerations in the design of the two workshops of the professional learning programme.

Summary

This chapter provided an account of the planning of the professional learning programme to develop, trial and evaluate a model for ethical inquiry for teaching and learning about controversial science issues in secondary classrooms. It described how the model was informed from the literature, the data from the survey in Phase One of this project, examination of *The New Zealand Curriculum* (2007) and international curricula, and my work as part of a research team for the Bioethics Council of New Zealand, which developed and trialled a computer-based tool to assist students in making ethical decisions.

The chapter described how the research of Beauchamp and Childress (1983, 1994, 2008), Dawson (2001, 2003), Levinson (2003, 2006), Osborne (2006), Reiss (1999, 2006), and others was considered, to propose a model that incorporated four ethical frameworks of consequentialism, right and duties, autonomy and virtue or care ethics. It then justified the inclusion of a fifth framework of pluralism on the

basis of the importance for acknowledgement in today's diverse societies of cultural, spiritual and other voices that are out of the mainstream. The argument is strong for New Zealand society because of the acknowledgment required by the partnership articles of the Treaty of Waitangi between Māori and the Government in New Zealand.

The criteria were established for the development of the model for ethical inquiry and a visual representation was created that showed the steps in the inquiry process. This was accompanied with sidebars containing suggestions for teaching and learning strategies and question-prompts that could be utilised at the various stages of the model.

Finally the chapter described how a professional learning programme was designed incorporating key principles and models for successful professional learning from the literature, informed by the survey and focused group interviews, and then used to introduce the model for ethical inquiry to four teacher-researchers in preparation for its trial, critique and evaluation.

The following chapter reports on the findings from the professional learning programme. Firstly it reports on the teacher-researchers' discussion and responses to Workshop 1 of the programme. This is followed by the reporting in Workshop 2 of the teacher-researchers' trials in the use of the model for ethical inquiry in their classrooms. Finally this chapter will discuss the critique and evaluation of the model for ethical inquiry with a final reflection on the project.

CHAPTER 6: INTRODUCTION, IMPLEMENTATION AND EVALUATION OF THE MODEL – THE FINDINGS

Introduction

This chapter reports on Phase Three of the thesis pathway which introduced, implemented and evaluated the model for ethical inquiry. Firstly, it introduces the teacher-researchers participating in the programme and then it presents the findings of the professional learning programme. It provides a narrative account of the teacher-researchers' discussion and responses to Workshop 1 in which the model for ethical inquiry was backgrounded, introduced and interrogated. This is followed by the reporting from Workshop 2 of the four teachers' classroom trials in their use of the model. Each trial is presented as an individual case study. The chapter then reports on the critique and evaluation of the model followed by reflection by the teacher-researchers on the project. The chapter finishes with a cross-case analysis of the case studies to explore the relationships and patterns from the individual cases and this analysis is used to discuss validation of the model for ethical inquiry.

The teacher-researcher group

There were four teacher-researchers all of whom had been respondents to the original survey on the teaching of issues in New Zealand classrooms carried out in Phase One of this project. All four invited teachers had demonstrated interest and enthusiasm for new educational developments and had offered in the survey to be further involved in working in this area. They had consequently participated in the focused group interviews. The four teachers were from two schools so there was support between the colleagues from each school as their trialling of the model progressed. Offers of invitation and permission to participate in the project had been sent to all teachers and their Principals and consent forms had been signed (see Appendices D and E). The composition of the teacher-researcher group is shown in Table 14.

Table 14. *Composition of the Teacher-Researcher Group*

Teacher	School type	Decile rating of school	Years teaching	Current taught subjects
Harry	State co-educational high school; urban	5	35	Junior and senior science; senior chemistry
Trina	State co-educational high school; urban	5	30	Junior and senior science; Senior biology
Aimee	Private co-educational school; rural	10	18	Junior science; senior biology
Ross	Private co-educational school; rural	10	5	Junior science; Senior chemistry

Note. The teacher-researcher names are pseudonyms but indicate gender.

Findings of Professional Development Workshop 1: Backgrounding, and introducing the model

The first workshop introduced Phase 3 of the pathway of the project (see Figure 2) to the workshop participants and the five objectives for the workshop were:

- to review the current situation in the teaching of controversial issues in science classrooms in New Zealand,
- to explore and interrogate a model for ethical inquiry for introducing controversial issues into science classroom programmes,
- to explore five frameworks to assist ethical thinking for students,
- to identify strategies and resources to support the teaching of bioethics/controversial issues in science classroom programmes, including trialling of a computer-based tool, and
- to develop ideas for planning an issues-based unit to trial in a science classroom.

The objectives were addressed through seven sessions. The timetable of the day was outlined in Table 12, and Appendix J shows the details of the Power Point presentation that guided the workshop.

The first session was a presentation of the responses to the survey that was carried out in 2006 as Phase One of this project and the second session encouraged the teacher-researchers to share their experiences of teaching and learning about controversial issues with the rest of the group. The third session provided a brief introduction to what the international literature says about the reasons for teaching controversial issues in science classrooms. The fourth session introduced the way in which ethical decisions are made and Session 5 then introduced the model for ethical inquiry (Version 1) that had been developed by the researcher. Session 6 involved the application of the model for ethical inquiry as a reality check to a selected context and Session 7, the final session, prepared the teacher-researchers for the trialling of the model in the classroom and concluded with teacher evaluations and reflections on the workshop. The sessions were recorded on audiotape, with permission, and later transcribed.

Session 1: Presentation of the survey results

Following the introductions and presentation of the project objectives, the teachers discussed the results of the survey carried out in 2006, in the first phase of the project, and to which they had all contributed.

All the teacher-researchers agreed that the constraints identified by the survey respondents were significant and they emphasised that lack of time in teaching programmes, lack of time to plan topics and examine resources were major barriers to teaching and learning about controversial science issues. Another constraint was their personal lack of knowledge of some of the science concepts, especially in the new biotechnologies. One teacher (Harry) expressed surprise at the low percentage (12.5%) of respondents that did not find that a lack of effective learning and teaching strategies were a constraint. He commented that in light of the narrow range of strategies that were used by survey participants, along with the domination of teacher centred strategies, that “perhaps teachers don’t know what they don’t know.”

Session 2: Sharing prior experiences on teaching controversial science issues

In the second session the teacher-researchers were given opportunities to share experiences of teaching and learning about controversial science issues, including their use of contexts, strategies, approaches and resources.

Aimee commented:

I was asked to develop the junior science schemes. I had the freedom so I incorporated global warming and maintaining biodiversity. But once I had done them, he [Head of Department] said that it wasn't science ... it was social studies and we shouldn't teach things like that in science. So he changed the schemes. I was taken back as I thought we were moving forward as science teachers and allowed students the freedom to discuss controversial issues.

She then explained that she has more freedom with senior classes because NCEA provided flexibility in the number and topics of selected achievement standards for assessment. She particularly mentioned Biology AS 2.2 “Interaction between humans and an aspect of biology”, Biology AS 3.2 “Research a contemporary biological issue” and Science AS 3.2 “Researching a controversial issue”, saying:

The kids love that stuff – they respond to it and respond openly and enthusiastically – it's real! Discussing the issues empowers students in an adult world.

Harry stated that teaching Year 13 science with Science AS 3.2 “Researching a controversial issue” gave him a “leg in”, and that

Having those experiences with Year 13 students has meant that my teaching lower down has now started to include issues. We're looking at changing in year 9 to incorporate more of this and so give more of an emphasis to the nature of science.

He discussed a local issue that his senior science students had worked on and mentioned that

It was a magnificent piece of work. It's such a rich source of what I see as real science. It's there in the kids' faces and they need to be able to provide a balanced argument.

Ross described his approach:

I have dealt with some of this in classes but I only present my view – I present it as it is. But I am often disappointed that students do not see it my way. In senior classes a lot of these ideas, as much as they are interesting, I am realistic and sceptical about bringing in ideas that aren't examined. But

listening to the others, I'm thinking that for junior science and gifted and talented students these things could be "gold."

Trina mentioned that she did not directly teach controversial issues, but that she taught the students how to research:

They then go off and research for different points of view and come to a conclusion themselves and write an essay. Reading their essays has been a strong learning curve for me.

The teachers also discussed the strategies and approaches that they had used. Those mentioned were debates, acting as devil's advocate, essays, discussion, continuum and role play. They mentioned the use of resource packages, with Trina commenting that they go out of date very quickly, although the strategies may still be useful. They agreed that there was a "huge amount out there" and that it was a problem finding the time to search for it. Harry noted:

It's not so much about what packages there are, it's about alert teachers who are aware of current issues and are on to it. When teachers get more confidence, I don't think these packages will be quite as important as teaching a teacher how to teach a generic issue rather than the issue itself.

In conclusion, although teaching episodes involving teaching and learning about controversial science issues were infrequent, the teacher-researchers were positive about the enthusiastic response and high level of engagement by the students. Two of the teacher-researchers had experienced some teaching of controversial science issues and both had used a range of strategies that was more diverse than those used by the majority of teachers in the survey of Phase One of the project. Another teacher-researcher had not carried out any direct teaching of issues but instead had set the students an issue as a research task and from their individual research on the different viewpoints they were to write an essay. The fourth teacher-researcher was sceptical about the reality of teaching and learning about issues in science classrooms.

Session 3: The Literature

The third session introduced the group to some international literature on teaching and learning about controversial issues with the main aspects summarised in the Power Point presentation. One professional reading, *Bringing controversial issues into science teaching* (Van Rooy, 2004), was intended to be explored using a jigsaw strategy, but the previous sessions had left insufficient time for this to be

carried out effectively. The reading was quickly examined and following this Harry stated that it was good to have professional readings that were easy to read and which communicated the ideas in simple language. This reading and others were recommended for further follow-up and these readings are listed in Appendix K.

Links were then made to the teaching and learning about controversial science issues in *The New Zealand Curriculum* (2007). All four teachers acknowledged the need for more competence for themselves and science teachers generally in light of the Nature of Science strand in the science learning area of *The New Zealand Curriculum* (2007).

Session 4: Making ethical decisions

The ways in which people make ethical decisions were introduced in this session. Ethical frameworks and ethical thinking had been identified in the focused group interviews as areas where teachers had little knowledge and this was reinforced at the beginning of this session by comments such as:

Ethical thinking is thinking based on presented information but really I know nothing about ethics. (Ross)

Ethical thinking is making a decision about what is right or wrong. (Aimee)

Ethical frameworks enable us to think about events/strategies that have the potential to influence individuals or the community in a negative or positive way. I am unsure as to what different ethical frameworks might be. (Trina)

Ethical thinking is being reflective and creative in your thinking. Ethical frameworks are ways to make decisions with consideration and in a consultative process with viewpoints of all parties concerned. (Aimee)

Ethics is about principles or values that govern rules of human behaviour; the scientific community has to balance different viewpoints against each other. (Harry)

Harry was able to list some different types of ethical thinking, but was diffident in providing explanations that showed an understanding of some of the terms.

There was some confusion between *morals*, which concerns what is right or wrong, and *ethics*, which uses critical thinking to probe the reasoning behind the moral decisions. Use of the video clip *Ethics versus morals* (Reiss, 2006c) and subsequent discussion clarified the terminology. Then, in order to explore and develop an understanding of ethical frameworks for ethical thinking, discussion and activities were based around two short video clips, titled *Common ethical*

frameworks (Reiss, 2006b) and *Which ethical framework?* (Reiss, 2006d). The first activity (see Appendix L) which followed the showing of the video clip *Ethics versus morals*, asked teachers to sort a series of cards about genetic modification in a continuum from “I agree” to “I disagree”. The teacher-researchers were asked to sort the cards individually at first and then work in a group to see if they could come to a consensus, by justifying their card positions to the others.

Ross commented that although he had heard of a continuum he had not tried one with his classes and that the activity was a reminder of an effective way to engage and motivate the students, as well as a strategy to find out what their initial views were.

The second and third video clips, *Common ethical frameworks*, and *Which ethical framework?* introduced four frameworks of ethical thinking: rights and duties, consequences, autonomy and virtue or care ethics. Following the viewing of the two video clips, a fifth framework based on pluralism was then introduced to the teachers. All of the teachers agreed that consideration of pluralism, especially cultural perspectives, was essential in New Zealand society and enabled teachers to meet their Treaty of Waitangi obligations. Harry commented:

It's right that people in this country consider the cultural aspect thoughtfully and the Treaty of Waitangi asks us to do this. But in thinking about that, most countries also have increasing numbers of other cultures, either indigenous or migrant. Their voice should be heard and considered.

Aimee argued:

But there are also the religious views and in some cases gender can be an issue. I think it is important that these things, as well as the cultural aspects, are separated from the “rights and duties” framework.

And Trina commented generally on the frameworks:

I have heard about some of these ways of thinking [pause] these ethics [pause] but didn't really understand them. It has come together in my mind now and I can see them as a useful way to approach thinking, both for myself and for my students.

The second activity in this session was based around the issue of pre-natal genetic screening (see Appendix M). A definition and a statement about pre-natal genetic screening were provided as an introduction to the activity. Then a range of ethical arguments on individual cards was introduced for the teachers to consider in

pairs. They had to decide which of the five ethical frameworks best supported each argument. As the activity was being carried out, the discussion was lively as the teachers compared and justified their grouping of the arguments against the five frameworks.

The easiest arguments to group were those based on pluralism. Consequence-based decisions were also easy to identify. Rights and duties, virtue ethics and autonomy appeared to be the most controversial. Teachers were encouraged to write some additional statements for each ethical framework. Some examples of further statements were, “Nurses and doctors who do not want to participate in abortions should not have to”, and this was written to support an autonomous way of thinking. Another statement was, “It’s the will of God and it should be left to fate”, which was grouped under the pluralism framework. An additional statement, grouped into the virtue or care ethics framework and that evoked much discussion, was “A termination should be allowed when the disorder could mean lots of suffering and pain for the child.” The teachers found this grouping activity useful for clarifying their thinking about frameworks and reinforced their understanding of each way of ethical thinking. The teacher-researchers’ comments following this activity included:

This is an excellent activity to encourage us to think about other people’s perspectives. (Aimee)

This has really helped me to understand and use the ethical frameworks. Thinking up the extra statements was particularly good. (Ross)

Yes it [thinking up extra statements] made me think that I could make up a similar strategy in another context for my students. (Aimee)

There was agreement that although the strategy was a useful one, the context depended on the age of the students. Suggestions were made that less emotive contexts with younger students would be useful with examples “not directly related to people”, such as cell phones, power generation, marine reserves, endangered species, animal rights and local environmental issues being mentioned. There was discussion about the reduction of the number of ethical frameworks for younger students but a feeling that senior students could cope with the five frameworks. A further professional reading, *How we reach ethical conclusions* (Reiss 2003), was recommended for follow-up to reinforce the ethical frameworks that had been explored in this session.

After viewing the videos, participating in discussion based around the continuum and sorting activity, and the creation of extra statements to the sorting activity, all four teacher-researchers showed an increased understanding of the ethical frameworks. They were also identifying how these strategies could be incorporated in their teaching and were enthusiastic about applying them to other science contexts.

Session 5: Introducing and critiquing the model for ethical inquiry

Session 5 introduced Version 1 of the model for ethical inquiry that had been developed by the researcher (see Appendix D). Each stage in the model was discussed along with the associated colour-coded sidebars of strategies, approaches and question-prompts that could be considered at each stage.

The first stage in the model related to teacher preparation and it was suggested by Trina that the sidebar of questions-prompts include a prompt to check how the topic linked to *The New Zealand Curriculum* (2007).

Ross commented that “this [the model] is a logical sequence of steps with appropriate strategies” and Harry reinforced this by saying:

The key step is getting engagement with the issue and the rest of the model becomes a logical pathway. I like seeing those strategies there – they are useful. But engagement will also depend on the literacy level of the students, so you would use different strategies depending on their literacy level.

Trina also commented that backgrounding the issue needed to be clearly the “students backgrounding the issue”. Similarly she suggested that “students engaging with the issue” would be a useful addition, rather than just “engaging with the issue.”

Harry also noted that:

Perhaps in backgrounding the issue we need to add something about reliability and validity of the information. We need to talk about this with our students.

However, Aimee suggested:

Perhaps we need to do some work on the ethical frameworks even before backgrounding the issue as they won't have done anything on this before. I'd like to try this near the beginning so that they figure these out, get it in their heads so that it becomes a reference point. So I'd consider doing some teaching on that and then introduce the context.

There was discussion based around this idea and it was suggested that perhaps Aimee act on this in her trials and report back on the effectiveness of this change.

Further discussion on the stages of the model considered the writing of ethical questions. More detail was requested in the questions-prompt sidebar to remind them of the ‘ought’ and ‘should’ question starters to frame ethical questions. Harry also considered that instead of an ethical question, perhaps a provocative or controversial statement could be considered. Trina suggested:

I think designing the question or the statement is a key thing – it needs to be specific and requires careful teacher facilitation.

The strategies sidebar was also explored and further suggestions were made, such as “continuum” and “role plays” in the engagement stage, the use of “provocative statements” as an approach in two different stages of the model (engagement and deciding on the question or statement), “research report” was added to the stage of justification, and “submission to a local authority” was added as a strategy to the action stage. The suggestions made by the teachers were discussed and incorporated into the existing list of strategies and question-prompt statements on the sidebars of the model.

The teacher-researchers then explored the computer-based tool developed by a research team, including the researcher, at the University of Waikato, working on a project commissioned by the Bioethics Council of New Zealand (www.biotechlearn.co.nz). An initial teacher response to the interactive tool was:

This is great - students could be in groups with each group taking a different stone and therefore be ‘in other people’s shoes’. They could share their responses later with the other groups so they get a feel for other ways of thinking about the issue – rather like a jigsaw strategy. (Aimee)

The teacher-researchers all identified the computer-based interactive as a useful tool to assist students in deliberating and justifying their decisions.

In conclusion, strong and valuable feedback was given on the model. Changes and additions were made to the language used for identifying the stages of the pathway and additions were also made to the strategies and question-prompt statements in the sidebars. Comments on the activities indicated their usefulness as strategies to develop teacher understandings of ethical thinking as well as modelling how these strategies could be used in the classroom with students. The group

decided that the changes that had been incorporated into the model now made it more student-centred, rather than teacher-centred, in its approach.

Session 6: Applying the model to a context

The reality check in this session provided an opportunity for the group to apply the model of ethical inquiry to a chosen context of genetically modified food with a focus on milk. The teacher-researchers used a planning proforma to collaboratively develop this context. They followed the stages of the model, and chose strategies and question-prompts from the sidebars. They trialled some writing frames to scaffold their ethical thinking and finally developed and justified their decisions. Following this reality check, the group then returned to the model for interrogation and critique and some minor modifications were made, particularly in terms of strategies and question-prompt statements on the sidebars. From this co-construction, Version 2 of the model was developed and is shown in Appendix S.

Session 7: Preparation for trialling the model of ethical inquiry

The final session involved the preparation for trialling of the model in the classroom. Support materials were provided on a CD ROM to assist in the trials. These materials included video clips used in the workshop (Reiss, 2006b, 2006c, 2006d) for use with students, useful websites, the model of ethical inquiry (see Appendix I), the computer-based tool and planning proformas with a completed exemplar (see Appendix N). A range of templates to help scaffold students' ethical thinking was included on the CD ROM (see Appendix O). These were now familiar to the teachers from the trialling of these in the reality check made in Session 6. Reflection templates for students and the teacher-researchers were also supplied on the CD ROM (see Appendix P), as was a suggested template for reflective journals that could be used to map progress and thoughts during the trialling (Appendix Q). Five professional readings were also included (see Appendix K) as recommended articles to further extend their thinking on the teaching of controversial issues.

The researcher undertook to send the teachers Version 2 of the model for ethical inquiry for use in the classroom trials (see Appendix S). Ongoing support and guidance was offered during the trial time with the teacher-researchers able to consult the researcher by email or phone or request a visit. Some preliminary planning was finally carried out in preparation for the trials. Teachers examined

resources and by the conclusion of the workshop, each teacher had chosen a context within which they would base their trial.

In summary, guidance had been provided for planning and reflection, the teachers were positive about using the model and choosing and trialling strategies to implement the various stages of the model.

Teacher reflections on Workshop 1

At the end of the final session, teachers reflected on the Workshop through discussion. All of the teacher-researchers felt that Workshop 1 had developed their knowledge and understanding of ethical frameworks for decision making; increased their knowledge of, and confidence to use, some new teaching and learning strategies; increased their understanding of *The New Zealand Curriculum* (2007); and that the workshop had led to an increasing awareness of the important contribution that the teaching of controversial issues makes to the vision of science education and understanding of the Nature of Science strand. They identified that they had refocused their planning skills, especially in being clear about learning outcomes and articulating them to students, and felt confident and motivated to use the proposed model for ethical inquiry.

Harry commented:

It's been great having these discussions and having the time to work on this with other teachers. I can see how this could be motivating for our students – I'm looking forward to doing this with my classes.

Aimee mentioned that:

This day has been huge for me. I have gained in understanding Science in the New Zealand Curriculum and learned some philosophy in terms of ethical thinking.

Findings of Professional Development Workshop 2: Implementing and evaluating the model

The purpose of Workshop 2 was to report on the classroom trials carried out by each of the teacher-researchers in their use of the model for ethical inquiry. Following the reporting of the trials, the model for ethical inquiry was again critiqued and evaluated. The second workshop was held eleven weeks after Workshop 1 and the objectives were:

- to share and evaluate trialled classroom-based resources for teaching and learning about controversial science issues,
- to evaluate some tools for introducing ethical thinking to students, and
- to critique evaluate and reflect on the model for ethical inquiry.

The objectives were introduced through three sessions. The timetable is presented in Table 13 and the Power Point presentation that guided the workshop is shown in Appendix R.

Session 1: Presentation of the classroom trials

The introduction to Workshop 2 reinforced the pathway of the project and emphasised the contribution that the workshops made to Phase Three of the project. The objectives of the workshop were then presented.

The first session for the day involved a series of discussions led by each of the four teacher-researchers as they presented the work they had trialled with their classes. Each trialled unit was presented with a description of the task sequence and this was followed by an analysis of the individual lessons with an emphasis on any prominent issues that arose. Student work was encouraged to be presented. Each teacher-researcher was asked to sum up with how they perceived the learning impacted on a range of student outcomes – social, personal, academic and others they considered important. They were then asked to discuss their student evaluations of the unit as well as their own personal evaluations of the unit. The presentations were recorded on audiotape and later transcribed. Each of the teacher-researcher's trials is presented as a descriptive case study, written as a chronological narrative account which is interspersed with quotes, explanations and analyses. Each case study was sent, along with transcriptions, to the teacher-researchers for verification

and permission to use in the writing up of this project. The respondents' validations agreed with the interpretations made and they did not wish to add or qualify any points.

Harry's Case Study – Issues of choice

Harry's trial took place in two Year 13 classes at a decile 5 city school. The students were working towards an NCEA internally assessed achievement standard, "Researching a current scientific controversy" (AS 3.2). The learning intentions devised by Harry for the unit were:

- to introduce ethical thinking to students,
- to have students understand the differences between ethics and morals,
- to discuss and apply ethical principles to given bioethical arguments,
- to introduce researching and reporting on controversial issues to Year 13 students, and
- to have students select, process, interpret and provide a balanced report on a current scientific controversy of their choice and use the report to state, with ethical justification, their personal viewpoint.

Teaching and learning activities

Ethical engagement - introducing and engaging with the issue

The unit began with the teacher-researcher introducing some current controversial issues in New Zealand, using newspaper clippings. Other issues were elicited from the students using a brainstorm as the strategy. This was followed by a discussion on "What do we mean by an issue?" which provided opportunities for students to identify and become sensitive to a variety of ethical issues.

The students were introduced to the difference between ethics and morals and a continuum was used to illustrate the diversity of views that people hold on an issue. Harry modified this activity from the one used at Workshop 1 of the professional learning programme.

Ethical reasoning - thinking from a range of ethical frameworks

Harry introduced the range of common ethical frameworks through a video clip (Reiss, 2006b) and pluralism was added as a fifth framework for consideration. An understanding of these frameworks was reinforced by the pre-natal genetic screening activity from Workshop 1. The students carried out the activity individually to identify possible frameworks for each statement and then the responses were discussed in pairs.

Ethical justification – making and justifying a personal decision

Global warming was introduced as a context to model the research process and report writing for the internal assessment. The teacher discussed with students how they might research and write up a report, considering the science behind the issue, the viewpoint they held, the other viewpoints that people might hold and the reasons they might feel this way. The two classes were each randomly divided into two teams, allocated roles and asked to prepare for a debate on global warming to follow in the next lesson. The debate was carried out with students presenting and justifying the position of their allocated role, including identifying the framework from which they were arguing. Emphasis was made by the students that in many cases they were in “other people’s shoes”.

In the final part of the unit, students selected their individual issues for the assessed report and they began another cycle of ethical engagement, ethical reasoning and ethical justification on their individually selected issue. The students chose a range of issues which included genetically modified food, cloning, stem cells, transplantations, xenotransplantations, nuclear energy and animal testing. They used writing frameworks from Workshop 1 to draft their personal responses to the issue and were expected to identify the ethical framework from which they justified their position on the issue.

Outcomes

Data were collected from Harry’s presentation at Workshop 2, in which he presented in his portfolio various artefacts, such as his writings from his reflection journal, prepared resources, planning proformas for the unit, student work and evaluations carried out by himself and the students at the completion of the unit.

Student outcomes

Harry commented that initially the students had viewpoints on issues but that they were not always informed ones. After the students had researched the science background, he thought that:

They were able to provide a balanced viewpoint on key aspects of all sides of the issue and then able to develop a personal viewpoint in their conclusion. There were some exceptional arguments although there were some who, having had a viewpoint at the beginning, then said “Now I can’t make up my mind”.

He noted that as the students discussed their personal views, they were all able to refer to the ethical framework from which they had worked and most were able to discuss alternative arguments in terms of ethical thinking. He considered that participating in the unit had improved the social outcomes for many students, such as interaction with their peers and himself as the teacher and increased sensitivity to others’ views, as well as increasing the students’ level of engagement, their content knowledge and comprehension and their understanding of ethical knowledge and ethical decision making. The teacher-researcher commented on gains in the students’ learning:

I think the students’ learning has been enhanced and challenged because this whole process has given them the opportunity to develop critical thinking. In the two classes I think there was about thirty plus kids who handed stuff in and more than two-thirds had commented specifically on ethical things on the way through. Usually I would only have 3 or 4 students [out of 2 classes] who considered this sort of thinking and now I have all understanding their individual thinking and two-thirds discussing alternative ways of ethical thinking that are based around their issue ... they are by far the best assignments I have ever had written on controversial issues.

He also commented that there had been an enormous improvement in the way that his students were processing information.

Using the model for ethical inquiry

Harry discussed his use of the model for ethical inquiry. He believed that the inclusion of a fifth framework of pluralism was essential in New Zealand culture as “cultural perspectives are hugely important in the way people view and see things”. He thought that the model provided a good focus for the teacher and stated that it was good to have a “consistent and concrete framework” that he could apply. He

said how he was able to use the model in a flexible way as he introduced the five ethical frameworks early in the discussions and then worked through with the whole class, in a selected context, the stages of ethical engagement, researching the science, individual values clarification and justification. The students then selected their own issues for exploration and followed through the same sequence to create individual reports for assessment.

Harry said he found the strategies sidebar useful for deciding which strategies would be appropriate. When asked about his use of teaching and learning strategies, Harry commented:

I really enjoyed the continuum activities which I hadn't really used too much before, and the kids loved them and I really enjoyed them as well. The sorting out of ethical arguments also from the workshop was useful. I would like to use this strategy and modify it for different contexts. [pause] The video clips with Michael Reiss were excellent. They provided appropriate reinforcement, were short with easily understandable language. The opportunity to debate and to discuss in class in a relatively formal way was really, really good. It was a good strategy to put the students in other people's shoes. The writing frames from the workshop were useful for students to draft their responses and I think these made the difference in helping them to address the types of ethical thinking.

Harry also indicated that the diversity of strategies suggested encouraged him to explore and be more adventurous in their use. "I've been around a fair while, but you're never too old to learn more strategies like we have been doing." He commented about the model:

It's a magnificent vehicle for teaching science [issues] and it's so important that we do it well because it gives relevance and meaning to a lot of stuff in today's world and it takes the theoretical science and brings it into a real discussion perspective and that's great.

Teacher outcomes

Harry acknowledged that his "own knowledge has been widened" with respect to understanding types of ethical frameworks and emphasized the importance for us all, including the students, of being able to "think from other people's shoes". He discussed how his awareness of teaching and learning strategies had been "awakened" and how such student-centred strategies provided a higher level of engagement than the teacher-centred ones. He also commented that his

understanding of the science backgrounding the issues had been greatly increased as he read and assessed the student assignments.

Aimee's Case Study 1 – Future Foods

This trial took place with a Year 9 class in a decile 10 rural, private school. The learning intentions of the unit were:

- to identify how food has impacted on and changed in people's lives on a personal, local, national and global level,
- to explore and justify their personal values with regards to genetically modified foods,
- to identify the science behind genetic modification of foods, and
- to report on a genetically modified food of their choice from a range of ethical viewpoints and state, with ethical justification, their personal viewpoint.

Teaching and Learning Activities

Ethical engagement - introducing and engaging with the issue

The unit started by asking students to brainstorm existing ideas about food of the present and the past, with a consideration of the environment in the past compared to that of the present. They were asked to think also about this from the perspective of families, and then communities, in New Zealand as well as globally. The students then worked in small groups with A3 paper and reorganised the ideas generated from the brainstorm into fishbone diagrams. They were asked to add some ideas they had about future foods into the "tail" of the fishbone.

Follow-up discussion on the fishbone diagrams addressed the following questions.

- What sort of things have changed in the way we eat foods now, compared to how we ate them in the past?
- What has caused the changes?

- How do you think someone else living elsewhere in the world would view New Zealanders as eaters?
- What about if we take a global view? What is the existing situation about foods and eating? Do all people get enough to eat? Do some overeat?
- What are some new foods that you know of?
- What words or ideas come to mind when you think of foods in the future?

Individual and group reflection on the issue was carried out as students explored, using a continuum, a range of statements about cell phones. The teacher chose cell phones because she wanted to model the use of the continuum in a context that she thought would be of interest to the students. After discussion on the cell phone statements, she then refocused the unit back to genetically modified (GM) foods, with the use of the continuum that had been used in Workshop 1. The teacher varied this to include some additional statements and also changed some of the language to make it simpler for Year 9 students. They had to justify their placement of the statement cards about genetically modified foods, on a continuum of preferable to not preferable. Students then compared their line-ups and discussed and justified the reasons for their sequence of statements.

The backgrounding of the science was carried out by the teacher-researcher describing, using computer animations, the process of creating a transgenic organism. This was reinforced by a sequencing activity on the process of genetic modification with this being carried out in pairs by the students.

Students were then put into groups and asked to choose a future food from a list to research in the library. They were asked to produce a Power Point presentation using the following questions as a writing framework to collate their research. Students were allocated different tasks within their groups – manager, slideshow developer, computer researcher, and scribe.

- How has the food been modified?
- Who would possibly use the food?
- Advantages and disadvantages of using the food.

All groups presented their research as a Power Point display and from these presentations the class decided on the ethical question to be addressed – “Is it right to genetically modify food?”

Ethical reasoning - thinking from a range of ethical frameworks

Aimee introduced the five ethical frameworks that can be used to make reasoned decisions on an issue, supported by viewing the video on common ethical frameworks on Biotechnology Hub (Reiss, 2006b). The students returned to their research groups to continue investigating their specific genetically modified food, this time basing it around the ethical question and thinking from a range of ethical frameworks. They were asked to present their views in a debate and this was videotaped. Following each presentation, the various viewpoints were identified and discussed.

Ethical justification - making and justifying a personal decision

Following the debates and associated discussions, the students were asked to write a statement about their own personal decision in the context of their group debate. This personal decision may have been different from that of their allocated role. The students used writing frameworks from Workshop 1 to help them draft their personal responses.

Outcomes

Data were collected from Aimee's presentation at Workshop 2 in which she discussed her reflection journal writings, her evaluations and the student evaluations that were completed at the end of the unit.

Student Outcomes

In the engagement phase and the exploration of values, the teacher decided to use the context of cell phones to enable the students to explore their values in a familiar context. She thought that this context

might be more pertinent to kids; they were uncomfortable at first that they had to do it individually, it was great starter to them starting to think the reasons they thought something was important and why they thought something wasn't important

She described how this was a good activity from which the students could then explore their values on genetically modified food. She then demonstrated to the other teacher-researchers the variety of genetically modified food presentations that her students had created. These included presentations about golden rice, papayas and tomatoes.

Following the presentations by the students in the classroom, Aimee facilitated a discussion with the students using the following question prompt “*What will shape the development of these biotechnologies in food?*” The ideas that emerged from the discussion were money, population changes (need for greater food production to feed the world; increasingly older people in the population), environmental issues and sustainability, unexpected events (pandemics, bioterrorism), public feelings about genetic modification, cultural and spiritual values, trade or market attitudes to genetic modification, and what the law will allow scientists to do. The teacher stated:

Then it was really easy for them to come up with the controversial key question for the next stage of the pathway. They came up with it straight away: “Is it right to genetically modify foods?”

In thinking about the question from a range of ethical frameworks, Aimee commented that the students appeared to be struggling with some of the terminology related to the frameworks, so she co-constructed words with the students.

Words such as consequentialism and autonomy were “huge” for the students. They were bright kids, but needed a simpler message. They thought they were too much and asked things like for consequentialism – what does consequences of action actually mean? Once we had modified the language of the frameworks they used them easily. We changed the language so that consequentialism became “for the greater good” and they found it easier to understand if they thought about the phrase “decision based on a result”. Autonomy became “a well informed individual”; Virtue became “a good kind person” and pluralism became “cultural, religious, spiritual”.

Rights and duties were easy to understand. They used these words easily and were able to apply the frameworks to the statements on the genetically modified food continuum.

The students were asked to decide which framework(s) they used to make their decisions on the genetically modified food continuum and then, after observation of the debates, to identify which ethical framework each person was arguing from. Aimee indicated that through the debates, many of the students went from being “poorly informed” to “well informed” and that some changed their minds. She mentioned that in the debates, students were able to adopt an alternative point of view and defend it, and that she was pleased with the empathy they were able to show.

Aimee commented on their use of the frameworks in making their personal decisions:

I was surprised how well they used the frameworks to justify their viewpoint – these were only Year 9 kids and yet they used them well. There seemed to be more use of consequentialism, although a good person/virtue ethical framework and autonomy were not far behind.

Students were asked about the main ethical framework that they argued from to make a decision for their issue and the numbers of students using the different frameworks is shown in Table 15.

Table 15. *Percentage of students using different ethical frameworks*

Ethical framework	Numbers of students using the framework	Percentage
Consequentialism	14	56
Autonomy	5	20
Rights and duties	1	4
Virtue ethics	4	16
Multiple perspectives	1	4

Some comments that students made about their decision on the main ethical frameworks they chose were:

I thought about the greater good and how many benefits there would be. I also thought about being a good kind person, sympathetic to those suffering from malnutrition.

I think I used the “good kind person” point of view. I think that GE [genetic engineering] is against nature but could be good for third world countries. Should be used to help poorer countries.

Some students mentioned their ability to defend their viewpoint:

I could defend my viewpoint alright but I would like to be a bit more informed about this issue before I finally decide on my perspective (although currently I’m for it).

Whichever stand I took, for or against, there were lots of arguments I could use. We were well informed.

Good because now I can see more perspectives and choose the best one.

Other students described what it was like participating in the debate and putting themselves “other people’s shoes”:

It was very fulfilling knowing how other people see the world.

It felt strange looking at it from someone else's view.

I could see the issues from the for and against views. And the positives and negatives.

It felt good to be able to know the reasons why people think differently.

It was weird because they might have a different opinion to me and they had just as many reasons to think that way as I did.

Some students described how their opinions on the issue changed throughout the unit:

Before I thought that GM [genetic modification] was bad, it wasn't natural and that it shouldn't be done, but now I agree that GM is the way to the future and we should promote its use. It can help so many people in the third world countries and it would be a wise decision to take for the greater good of the people.

No I didn't change my opinion – I don't believe that genetically modifying food is right because it's not natural and we don't know the side effects of the food.

Partly. At the start I thought genetic engineering was bad and shouldn't be done. Now I see some of the genetically modified food and how it can help people. I still think that genetic engineering is muddling things that may not necessarily need to be changed.

No, but I am now more informed in case I really have to decide if I am for or against it.

My opinion changed quite a bit because at the start I thought GE would be really bad, but through this I think that it is possible alternative.

I didn't have an opinion at the start but I kind of do now – I'm not just sure but I think I agree but we still need natural foods. I think it should be used for good only – no terminator genes!

I am more informed about G.M. and accept that it can be for good instead of hating it like I used to.

Most students identified that in the unit they had learned about making ethical decision :

I learned different ethical perspectives of looking at controversial issues.

The five different ethical principles/viewpoints that can be applied and combined to all situations including genetic modification.

The different ethics and perspectives on genetic engineering. And the benefits and advantages it has on our society. And the disadvantages.

I liked this topic quite a lot and I found it interesting to learn about moral ethics and different perspectives on issues.

And many were fascinated by the examples of genetic modification that they had found out about in their research:

You can make food taste better by adding genes from other food in to it and it makes it a lot healthier for you to eat.

Strawberries are being modified using arctic flounder.

That they only take one part of the gene out of a food and insert it in to the other food. I thought this would alter the whole food but it only adds the part that you take out from the other food.

For many students, further questions were raised:

- Should we keep modifying food?
- Why NZ doesn't want genetic modification and other countries allow it?
- I wonder what they will end up doing?
- How much food has been genetically modified?
- How will genetic modification change in the future?
- Does genetic engineering produce bad side effects?

In their feedback to Aimee about the unit, a number of students wanted it to “go for longer”, and that it was “fun and very informative”. Several mentioned they enjoyed the independent research work in the library and then using this information in the debate. Some final student comments were:

What are some other controversial issues that we can discuss?

It was very interesting learning about the types of argumentive thinking.

I really enjoyed it. It triggered a critical form of thinking inside my mind.

Using the model of ethical inquiry

Aimee discussed her use of the model for ethical inquiry. She found the pathway useful and workable for her junior science students. She commented that one of the strengths of the model was its “simplicity” and that the colour coding of the stages matching with the strategies and the prompts, made it particularly “user friendly”. She thought that a fifth aspect of pluralism was appropriate:

We've been subjected to different cultures here and Europeans generally haven't, but surely they've got lots of different cultures? Are their cultures as strong? And are they required to recognize them by legislation?

Aimee discussed her use of teaching and learning strategies:

The fishbone was a good critical thinking tool in the first engagement phase of the model. I also used the values continuum on genetically modified food from the workshop which I modified and added some other examples. The videos with Michael Reiss were useful again, even at this level, and reinforced what I did with the students. I also used writing frameworks for the kids to collate their research and these worked well to help students collate their information. These were great and I will now always scaffold students' research in this way. They have everything there from which they can move forward to process and interpret the information.

The debate is also a good strategy to put them in to other points of view and have to argue from those viewpoints. It was useful to have them feel about how others think and to be in other people's shoes"

Aimee also indicated that the strategies sidebar is "really broad – there's heaps of them and you think "I haven't done that for ages" and "that could really work here". She listed the range of strategies she had used throughout the unit: brainstorm, fishbone diagrams, continuums, small and whole class discussion, guided research, Power Point presentations (or oral reports), video clips, debates, personal report writing and mentioned that this range was far more diverse than she would normally use.

When asked to identify any unexpected learning with her junior science students, Aimee commented:

I didn't expect them to be able to think in other people's shoes so easily.

She also commented that for her there was an unexpected outcome in that

I really enjoyed learning about and applying the ethical frame works myself! I thought I knew a little about ethics but I have come a long way in learning about and applying ways of ethical reasoning. I would now like to know more!

Aimee's Case study 2 - Euthanasia

Although only asked to carry out a trial with one class, Aimee was keen to trial the model with a senior class. This trial took place with a Year 12 class in the same decile 10, rural, private school. The learning intentions of the unit were:

- to discuss the difference between morals and ethics,
- to introduce students to a range of ethical frameworks that can be used to explore controversial issues,
- to negotiate with students an issue to examine and decide on an ethical question to address, and
- to explore the negotiated issue from a range of ethical frameworks using a computer-based bioethics tool.

Teaching and Learning Activities

Ethical engagement - introducing and engaging with the issue

Students discussed a range of statements about genetically modified foods and justified their placement of their cards on a continuum of preferable to not preferable. Discussion followed as to what are controversial issues as well as a discussion of the difference between morals and ethics.

The students then viewed the video clip of Michael Reiss talking about the difference between morals and ethics (Reiss, 2006c). Further discussion and examples of the differences followed. Students then negotiated a controversial issue that they, as a class, wanted to explore. Their choice was euthanasia.

To provide an opportunity for individual reflection on the issue and to background the science related to the issue, the students were asked to research the issue individually in the library using the Internet. To carry out this task, they were required to use a worksheet to record their responses to some statements on death and euthanasia and students returned to class with completed responses. There was a group discussion of the issue in relation to the responses and a decision was then made by the class to address the specific question, “*Should euthanasia be legal?*”

Ethical reasoning - thinking from a range of ethical frameworks

The teacher introduced the five ethical frameworks of the model and the students viewed the video clip about ethical frameworks (Reiss 2006b). The class reflected on the viewpoints collected from their background research, put each viewpoint on a card and then placed each viewpoint into an ethical framework that they felt was appropriate.

The computer-based tool was introduced to the students on the shared drive at the library. The students were put randomly into groups to investigate and discuss the issue from an allocated ethical framework using the bioethics tool. Students identified and evaluated a range of responses using their allocated ethical framework and then presented these as a Power Point presentation to the class.

Ethical justification - making and justifying a personal decision

After listening to all of the presentations, the students were asked to produce a position paper on their personal viewpoint with justification of their decision and an acknowledgement of the ethical framework that they had used to make it.

Outcomes

Data were collected from Aimee's presentation at Workshop 2 in which she presented her portfolio with a range of artefacts which included writings from her reflection journal, prepared resources, planning sheets, student work, a video of the student debate and evaluations carried out by herself and the students at the completion of the unit.

Student Outcomes

After working with the computer-based tool, a number of students described what it was like thinking from a range of ethical frameworks:

Seeing how other people thought and what influenced the decision helped me to understand reasoning and ideas of other people.

I could put myself in other people's shoes and feel how other people view the issue.

I was able to see different sides of the argument which made my views not as strong.

It was difficult to put on other people's shoes because I feel strongly about my opinion.

I could see how other people view the issue, but it was still hard when I had my own opinion of it.

Some students described how their opinions on the issue changed through out the unit:

After the presentations I still believe euthanasia should be legal, but with strong protection from it being overused and abused.

My thinking changed a little – it made my opinion on euthanasia not so strong because really it is “killing somebody” – and how some people can be killed against their own right.

My opinion didn't change much – I could just express my opinion better.

I didn't change my way of thinking about euthanasia because I still believe autonomy is the best way to look at it.

Although my thinking did not change, I learned about other people's opinions, especially the people in my group.

Students identified the kind of ethical framework that they used to make their personal decision. For many students, for this issue, autonomy was a prevalent framework:

I am thinking from a framework of autonomy in that everyone has their own right to do what they want.

Autonomy – everyone has the right to choose whether they want to live or die.

Some also were influenced by their religious views:

Pluralism as my religion highly influences my decision on euthanasia.

The students mentioned their ability to defend their viewpoint and justify their decision:

I think I could defend it [my viewpoint] quite well, while learning about it; I learned new stuff about it so developed more arguments.

I found it hard to defend my viewpoint. I did not have very strong reasoning.

I defended my viewpoint very well. Everyone listened and while they may not agree with me, they listened and understood my viewpoint.

Most students identified that in the unit they had learned about making ethical decision making

I enjoyed learning the different perspectives and how many there were.

Actually thinking that everyone has different perspectives and seeing what different groups believe.

The topic – it is very controversial and there are many ways of thinking about it.

Some students commented on how different countries, cultures and religions have different perspectives:

It was interesting hearing different views and opinions in different countries and religions – I didn't know that before.

Some students made comments about how thinking about issues had interested them in careers in bioethics. One student commented, “This is such cool stuff; I’m going to be an ethical lawyer”!

In their feedback to the teacher about the unit in general, students mentioned that they enjoyed “getting to argue” and “the argument”, that it was “fun to learn about the issue” and that they found it interesting to hear other people’s opinions and extend their knowledge about the topic. One student commented that “my understanding has been really deepened.”

Aimee discussed how her students’ learning had been enhanced:

I feel that their decision-making ... they're far better equipped to make decisions. I feel that many of them saw career opportunities popping up that they didn't know existed within ethics ... intermixed with biology.

Using the model for ethical inquiry

In discussing her use of the model, Aimee explained how she found the pathway useful and workable for her and her senior students. She reinforced her earlier comments that the strengths of the model were its “simplicity” and the colour coding of the strategies sidebar with the stages of the model. She discussed her use of some of the teaching and learning strategies:

I used writing frameworks for the kids to collate their research and these worked well to help students collate their information. These were great and I will now always scaffold students' research in this way. They have everything there from which they can move forward to process and interpret the information.

Aimee mentioned the usefulness of the continuum and videos as strategies that engaged and motivated the students. She discussed her use of the computer-

based tool. She found the *kete* (flax kit) and the stones “clever and quirky” in the way each stone represented an ethical framework, which when dropped into the pond created the ethical questions for consideration for that framework. She discussed how this appealed to the students and also mentioned that the students found it useful to be able to go back and forward with the tool, checking their understanding of the definitions and refining their statements. She affirmed by saying “It worked well for groups – they were able to discuss, reflect and argue with each other. Just making them put themselves in others’ shoes was hugely important”.

Teacher Outcomes

Aimee commented that:

I really enjoyed learning about and applying the ethical frameworks myself! My own knowledge has increased. I've become quite passionate about it. I now critically listen to people's reasons for things and am better equipped to argue their reasoning. If not, I would go away and reflect on what they said and think [pause] you know address the different ethical perspectives. I'm far more critically aware for myself.

She also described some of her students’ responses:

My seniors went, ‘Oh my goodness! Is this biology? This is fantastic!’ and here we were doing biology all year and I hadn’t tickled the fancy of those particular kids. They were social biologists and they just thought, “Oh! This is cool! I want to do this”.

Aimee finished her presentation by saying:

If you ask any student why they believe in something, they all have a moral reason, but seldom have they thought about reasons as to why they think this. This unit gave them the opportunity to realise some of their arguments are quite unfounded and some of their arguments were coming directly from what their friends or parents thought. It became a growth and maturity thing. I'd love to do it again – make it longer. The kids really enjoyed it – they were engaged, motivated and their enthusiasm was contagious.

But she also added a revealing note:

When I was discussing this issues stuff with X [teaching colleague] and telling him what I actually got about these ethical issues, he argued that he and some others would not accept that sort of thing because it's not science. And I said, “Well this is interesting X, but this is something that's going to be something that's going to be brought into the science curriculum”. But he was very adamant that it was not science.

Trina's Case Study – In vitro fertilisation

This trial took place in a Year 10 class at a decile 5 city school. The learning intentions of the unit were:

- to identify the science behind in vitro fertilisation as a human reproductive technology, and
- to explore and justify a range of viewpoints on the use of in vitro fertilisation as a procedure to overcome human infertility.

The trial of this topic was intended to be for four to five lessons, but due to unexpected school timetable changes, the teacher had to reduce the trial to two lessons⁷.

Teaching and learning activities

Ethical engagement - introducing and engaging with the issue

The students had been working on a unit of reproduction in mammals, including people. The idea of reproductive technologies for people was introduced and a continuum activity was used for the students to work with individually and then in pairs. In the activity, they placed statement cards on reproductive technologies in people on a continuum of preferable to not preferable. In vitro fertilisation (IVF) as a procedure was then explained by the teacher, using the whiteboard to record the main points of the discussion.

Trina then used a scenario in which the students worked in pairs as a “committee” who had to make decisions on funding for couples for IVF treatment. In the scenario, there were six couples wanting funding for IVF treatment, but there was only funding for three couples. So the question was, “*Which three couples should get the IVF funding?*”

⁷ Since this workshop, the teacher has developed a full teaching unit for the rest of her department on reproductive technologies which is planned around the model for ethical inquiry and focuses strongly on ethical decision making. It is currently being taught to eight, Year 10 classes in the school.

Ethical reasoning and justification

Each “committee” was asked to consider each application and then choose the three couples to receive treatment and to give reasons for their choices. There was brief class discussion on the various committee choices.

The teacher-researcher then outlined the five kinds of ethical thinking and used the video clip (Reiss, 2006b) to reinforce the ways of ethical thinking. The students were then asked to go back to their choices, and explain which types of ethical thinking they had used in making each of their decisions.

Outcomes

Data were collected from Trina’s presentation, in which she outlined the teaching lessons, the outcomes and the evaluations made by her and the students of the unit.

Student outcomes

Trina discussed how the students were all engaged.

This is just a normal mid-band, Year 10 with that range of ability and the range of work-ethic that you get in a normal mid-band, Year 10 – but they all seemed to be engaged – especially with some of the boys and they were able to give well thought-out reasons for their viewpoints. Engagement was high. Those students, who often do not participate in more formal lessons, took an active part in discussion.

Tina also discussed how the continuum showed they already had personal viewpoints but that these:

Changed over the two periods – and they changed significantly in some cases as they talked about why they believed that with other students.

It was particularly obvious during the second lesson when they’d had a chance to assimilate the issue, think about the issue, and formulate ideas gut feelings and second-hand opinions changed what they used to rank these in the first place.

She commented:

I was impressed with how well they discussed their viewpoint and listened to the viewpoints of others, but they found it difficult to identify which ethical viewpoint they had used. However this was their first exposure to this type of thinking and it was over a very short period of time and once again they impressed me with their willingness to think about the frameworks and to apply them.

In terms of student learning she commented:

I think my Year 10's learnt more than they would have normally in those two periods, and they were learning from each other. Not from me, so the ability for the kids to teach each other is enormous. And I think there's really enormous potential in doing this with a whole variety of classes.

She identified that the teaching time was “too short” and that she would ideally have required four to five lessons. In the two lessons she mentioned that she had not expected

just how well the kids discussed, just how thoughtful they were of each other, how they didn't pick at each other, how they sat and listened to each other, how they contributed and just the feeling in the class [pause] the whole class being involved and talking. The kids really like discussing things.

Using the model for ethical inquiry

Trina discussed how she followed through the model “step by step – bringing in – in that order, the stages”, but she identified that she could alter the phases depending on what the situation could be and the background that the students had in making such decisions. She discussed how the strategies sidebar was a useful prompt to try different strategies, especially collaborative learning ones:

My perspective has changed quite a bit and there are lots of other ideas up the side here that I'll be able to make use of too.

One of her final comments identified that for her an outcome was:

There's really enormous potential in doing this with a whole variety of classes. I hadn't come across the four ethical ... the five [frameworks] ... before, so I've learnt an enormous amount as well. And Harry's presentation with his Year 13 ... I'm definitely going to go that way when I do it with my Year 13's as well.

Ross's case study – Issues of choice

This trial took place with a Year 12 class in a decile 10, rural, private school.

The learning intentions of the unit were:

- to introduce students to a range of ethical frameworks that can be used to explore controversial issues,
- to identify a range of current controversial science issues and individually choose an issue to explore, and
- to introduce students to a template for reporting on a current scientific controversy of their choice and write a position paper in which their personal viewpoint is justified.

Teaching and learning activities

Ethical engagement - introducing and engaging with the issue

Students explored, using a continuum, a range of statements about genetically modified foods that had been trialled in Workshop 1 (Appendix L). They had to justify the placement of their cards on a continuum of preferable to not preferable. Students compared their individual line-ups and then in pairs discussed and justified the reasons for their sequence of statements.

The teacher-researcher introduced the five ethical frameworks that can be used to make reasoned decisions on an issue. This was supported by viewing the video of Michael Reiss talking about ethical frameworks (Reiss, 2006b). An understanding of these frameworks was reinforced by the pre-natal genetic screening activity from Workshop 1 (Appendix M). The students carried out the activity individually to identify possible frameworks for each statement and then the responses were discussed in pairs.

Discussion followed as to what was a controversial issue and the class identified a number of science issues. The students then chose one from this list to research individually. The research was guided using a template that was based on the model for ethical inquiry and which scaffolded the students' research through the phases of backgrounding the science, reflecting on individual values, and deciding

on an ethical question. Question-prompts from the sidebar of the model were used to develop the first part of the research template.

Ethical reasoning and justification

The students individually continued through the phases of ethical reasoning and justification using templates from Appendix O as a scaffold. The students then used all their collated material to write a position paper. The teacher-researcher allowed four periods for students to do the individual research task. He made it clear that his approach emphasised individual research with little collaborative work being carried out for ethical reasoning and justification because of his absence from school over that period of time.

Outcomes

Data were collected from Ross's presentation at the workshop, in which he outlined the teaching lessons and discussed his and the students' evaluations completed at the end of the unit.

Student Outcomes

The teacher-researcher reported that the engagement level for the continuum on future foods was high. He commented:

So much for twenty minutes here, there went my entire period. They were just so passionate talking about some of the statements, [the] reasons why this is a good thing and a bad thing [pause] just really brilliant discussion.

For the following activity, Ross was initially concerned about the appropriateness of the genetic screening context in which statements on genetic screening of human embryos were assigned to a particular framework. However he stated that:

The kids were really comfortable, they wanted to talk more after we had been through the frameworks, they wanted to discuss some of the individual concepts [about genetic screening] themselves. But we were just using this activity to look at frameworks, as opposed to actually looking at these individually as concepts.

He then explained how the students

followed through the flow chart [model] so that when I was away they would follow this process and develop their position paper as a final outcome.

He explained how he took the model and modified it to give to the students as an “individual sort of scaffold” for students to work their way through their individual research:

I think it worked well. It definitely wasn't the way I was planning on doing it originally, but obviously the fact that I wasn't there for a heck of a lot of it, I had to try and empower them to do a lot more themselves which ... is probably a good thing.

He noted that the kinds of issues chosen included euthanasia, xenotransplantations, global warming, animal testing, use of nuclear energy and assisted human reproduction technologies. One student had found out that there was a bill before Parliament on assisted reproductive technologies and chose to write a submission to the parliamentary committee rather than write a position paper.

Ross commented:

One of the real good outcomes was, they had a viewpoint, then they actually started thinking about why they had this viewpoint and they could either come up with some justifications, some reasoning behind why they thought they would, or they'd think, 'God! Actually why the hell do I think like this?' and 'Actually, now I know what the heck we're talking about, actually I might believe something else'. So it's really good coming with ideas for supporting a viewpoint.

He explained that they were able to discuss and defend their viewpoints strongly from the framework they believed in.

They were able to discuss and defend their viewpoints strongly from the framework they believed in the most. and they were often selecting the framework that they thought, 'Oh, this is the one that I want to go from and they were very good at defending that'. They were less comfortable applying other frameworks but they could do that.

He considered that the students were working from a range of frameworks, with well informed and the right to choose (autonomy) and the greater good (consequentialism) the most commonly used frameworks.

I think students' learning has been enhanced, challenged and reshaped. I guess it was a huge opportunity for them to talk to each other and to try and find their feet and their [place?] almost in society definitely in the classroom, to share their ideas, to have that confidence to put those ideas out there and have them critiqued and even attacked without feeling like they were being attacked. I think that was a really important tool, lesson that was learned by them.

Ross described how he was

staggered at the depth of some of the analysis like ... honestly ... I knew these kids were smart but ... almost ... I don't know, intimidate is not the word, but you know, it's just like ... staggered at how deep that they were thinking and how confident they were at presenting their case and how honest they were at maybe looking at other views.

He commented on the position papers:

Some of these kids...I've really underestimated some of their abilities...most [position papers] are outstanding...one piece of work is just the most astounding piece of work I've ever read; and it's really opened my eyes into the thinking of some of these kids.

Using the model for ethical inquiry

Ross commented that he found the model “really useful”, especially in that he was able to use it for creating individual guided research tasks for the students. The question-prompts in the sidebar were particularly useful for this approach. He commented that the model was a guideline and could be used flexibly, as he had done, by bringing in the ethical frameworks at an earlier stage for these students to whom the frameworks were unfamiliar. He mentioned that when he used the model again with these students he would leave it in the designated part of the model as they would be familiar with the frameworks and would only need reminding about them. He clarified this by saying:

This is a fantastic tool – but I don't think you want to say “This is how it is” – its structure is flexible enough to be moved around yet you can see what you need to do.

Ross explained his use of teaching and learning strategies:

I used a continuum strategy for the first time ... I used approaches that I haven't used an awful lot of, but that I have used from time to time, so that was kind of exciting and just listening to these guys today thinking, ‘Yeah, well actually I could try a few of these things’. You get caught in a bit of a rut of ... got to get through this work. Sit down, shut up, write this. ... So you always get empowered to think, ‘No I should be doing a bit more and be trying to prepare this and organise that’. So hopefully this time I can do a bit more of that.

Ross mentioned that he had not expected the students to be able to

attack the issue as opposed to the person... they were just so enthusiastic about it and getting into it and making sure that they weren't having a go at the person, but at the issue.

He also mentioned the growth for him and the students together:

I came into the last session with essentially zero knowledge on ethics, other than 'I believe this' and 'Here's a few pieces of evidence that I might present to defend myself if anyone actually cared to ask'. Now I've got a far superior understanding of the frameworks and I'm comfortable to put myself in other shoes, in fact. As I'm saying 'me' here, I'm kind of including my whole class as well, 'cos I feel like I was learning as much as them. So myself and my kids were comfortable putting ourselves in other people's shoes and having a bit of a think. We didn't necessarily [pause] well obviously you don't always agree, but you can put yourself there and come up with some of the arguments some of the evidence that they would use to defend themselves in those frameworks and from those viewpoints. Critical thinking [pause] ah, obviously myself and the students are comfortable in doing that now, whereas we had no concept of that really, to begin with.

And Ross's final comment:

Pretty stoked that I got asked to be here – it's been a huge learning curve for me, so, big ups!

Session 2: Evaluating the model for ethical inquiry

Following the presentation and discussion of the trialled trials, Session 2 involved a final critique of the model for ethical inquiry.

The teacher-researchers reflected on the structure of the model. There was agreement that the sidebars with the question-prompts and the strategies were a useful part of the model. There was discussion on additions that would be useful to the question-prompts sidebar. One that was discussed in detail concerned the reliability or trustworthiness of information. Further suggestions for question-prompts were added to the boxes adjoining the stages of ethical justification and backgrounding the science behind the issue. The question-prompts sidebar was considered very useful by one of the teacher-researchers as a scaffold for students working independently through the latter phases of engagement and phases of ethical reasoning and justification. For other teacher-researchers, the sidebar was useful for developing oral focusing questions as they worked with students in group or class discussion.

The variety of strategies in the strategies sidebar was considered useful to extend the range of strategies that they normally used. They reflected, once again, on

the strategies they had used successfully during the professional learning programme and mentioned the value of the sidebar in making them consider the value of using a diversity of teaching and learning strategies with all of their classes.

The teacher-researchers considered that the model provided a strong scaffold for a sequence of the teaching and learning activities to address ethical inquiry, but that it was flexible enough to allow modification as teachers gained in confidence. Discussion on this flexibility focused around the stage at which the frameworks of ethical reasoning were introduced to students, and teachers reiterated the different ways that they had successfully introduced these. In the first way, a specific issue was introduced to the students and then they all worked through the same issue following the stages of ethical engagement, ethical reasoning and ethical justification as indicated in the model of ethical inquiry. This may or may not have included students considering alternate viewpoints and discussing the types of ethical reasoning used in these alternate views. The students finally came to a personal viewpoint on the issue and justified their decision. In the second way, principles about ethical reasoning were introduced generically early in the model, and then the students chose an individual issue and worked individually through the phases of ethical sensitivity, ethical deliberation and ethical justification to make their justified decision.

Whichever sequence was followed, scaffolding research on the science backgrounding the issue, and scaffolding the types of ethical thinking with the use of the computer-based tool or writing frameworks, was regarded by teachers to be important. The teacher-researchers noted that as well as students being able to make reasoned and justified decisions using ethical frameworks, they could also adopt alternative viewpoints and defend them. They also reinforced the high level of enthusiasm, motivation and engagement shown by the students.

The frameworks of ethical reasoning were also discussed and there was discussion on the incorporation of the fifth ethical framework of pluralism, in addition to the four frameworks as discussed by Reiss (2006b). They considered it a valuable addition in terms of New Zealand identity as “cultural perspectives are hugely important in the way New Zealanders view and see things.”

The critique addressed the model's usefulness, its strengths and weaknesses, and provided suggestions for further improvement. From this critique, refinements were made to produce a final version of the model (Version 3 – see Appendix T).

Session 3: Reflection on the project

The final session asked teacher-researchers to reflect on the project in terms of how their learning, and the students' learning, had been enhanced, challenged or reshaped as a result of using the model for ethical inquiry.

For the students, the academic outcomes were positive in terms of engagement in tasks, increase in science knowledge, increase of ethical knowledge, development of critical thinking skills and ability to carry on a reasoned argument, and an increased understanding of the nature of science. There were positive social outcomes for students in that in their interactions with peers and teacher, they showed sensitivity to others and tolerance of other people's viewpoints. The personal outcomes perceived by the teacher-researchers were that the students' decision making was now reasoned rather than a 'gut' decision and that students seemed to show a stronger sense of identity and self esteem.

In their final reflection, the teachers identified a significant increase in their own learning about ethical frameworks and decision making, and mentioned that the professional learning programme had developed their awareness of useful resources, tools, websites and templates for scaffolding student activities. There was evidence of social development through the teacher-researchers' conversations during the reflective session. All indicated that they valued working in collaborative ways with their colleagues and that the professional conversations during the trial time in their schools were helpful, encouraging and supportive.

Sustainability

The teacher-researchers reflected on sustainability of the project and how they might continue to work with the model of inquiry in the future. They saw an opportunity to hold training within their departments for other science staff where they could meet and discuss new practices in relation to the implementation of the nature of science strand of new science curriculum. One pair of teachers was planning a half day with their science faculty, using resources from Workshop 1.

Aimee added a cautionary note here:

I think I need the support of the HOF of science, but I'll definitely keep it in my classes especially bio, but I think I need the support of, well, Dave is really supportive I think, he's pretty cool with us coming along and really wants to know about it, so I think he would take it as a learning tool and a progression [pause] perhaps something bigger and greater for our science department. But I would only feel comfortable if it was actually included formally with our junior sciences. He was fine about us using them as guinea pigs but...

They had also examined the possibility of applying for a grant from the Parents' Association and had already approached the Principal for funds that could be used to develop further resources and prepare for the implementation of this training with the faculty. The Principal's response had been "that's eminently possible".

The other pair of teachers mentioned that an issue could easily be incorporated within most of the junior science units. Harry stated:

We've got a day organised next term, we always have one where we kind of review our science delivery and that. So, I can see that this is going to be on the agenda for us, [isn't it?] on that day, Trina? And we already had a go at reassembling things in preparation for the draft curriculum, so just get ourselves a little bit ahead. So we've already started. About kind of eighty percent there, maybe, but this bit wasn't really there, was it? So it's quite neat to fit that in. So we'll actually probably do it by putting it into our, formally into our units and stuff like that and then doing some PD with our staff.

The teacher-researchers indicated that they wanted continued engagement with the researcher as well as an opportunity to present either with the researcher or as a group, their findings at science education conferences or local science teachers meetings:

It's just that – as far as I know – this is not happening anywhere else in New Zealand. I think this is kind of important enough that, what we are doing, and what you are doing, should be going to every school to be part of their new science curriculum planning. (Harry)

They also commented that their professional learning might be of use in assisting the Ministry of Education by facilitating in any future professional development for science teachers in terms of curriculum initiatives. They felt that they now had a strong theoretical base to teaching and learning about ethical decision making and were now more equipped with the skills aligned to ethical

reasoning. They were confident that the model gave them a theoretical framework on which to base their thinking, their teaching and learning strategies to implement the model and that they would continue to build and extend upon this as they monitored their students' engagement and progress.

Findings of the professional learning programme

A cross-case analysis of the five case studies was made to explore the relationships and patterns from the individual cases, and this analysis was then used to test the validity of the model for ethical inquiry. Four key themes emerged from the cross-case analysis: usefulness of the model for ethical inquiry; student knowledge and outcomes, teacher knowledge and outcomes, and unexpected outcomes. Each is discussed below.

Usefulness of the model for ethical inquiry

The teacher-researchers found the model for ethical inquiry was “useful”, “workable”, “user friendly” and an “effective tool” for them to use in their planning and teaching of controversial science issues. They found that the model provided a clear focus and pathway and that its simplicity and colour coding of the stages of the model with the sidebars of strategies and question-prompts made it easy to follow. One teacher-researcher commented that it was a “magnificent vehicle” and how important it was in terms of meeting the requirements of *The New Zealand Curriculum* (2007) as well as its relevance for students. All considered that pluralism as an additional framework was worthy, “culturally appropriate” and “essential” for New Zealand teachers in their attempt to meet the requirements of the Treaty of Waitangi.

Two of the teacher-researchers identified that they could use the model flexibly with the ethical frameworks being introduced earlier in the model and then reinforced again later in the model as suggested. Another mentioned that the model could be used as a guideline for individual student guided research as well as a class room discussion-based approach.

Particular reference was made by all teacher-researchers to the usefulness of the strategies sidebar. They reflected on the fact that the diversity of strategies encouraged and reminded them of the value of student centred and co-operative learning strategies in providing a higher level of engagement than the teacher centred

ones that they tended to use. The teachers made special mention of the value of the writing frames and the computer-based tool as effective scaffolds to assist students in collating their research and making and justifying their ethical decisions. They acknowledged their confidence in the final version of the model (Version 3 –see Appendix T).

Student knowledge and outcomes

In terms of academic outcomes, all of the teacher-researchers agreed that for successful ethical discussion and ethical decision making, the students needed to be grounded in knowledge of the science behind the issue. They commented that the students moved from being poorly informed to well informed, and that as a result of the teaching and learning activities most students had increased their science knowledge and understanding.

The engagement of the students for all trials was at a high level with students “motivated and enthusiastic,” “highly engaged and passionate,” and a high level of engagement demonstrated by students who were not normally engaged.

All of the teacher-researchers found that there was an increase in the students’ ethical knowledge. In terms of the students’ ethical reasoning, most students were able to identify the five ethical frameworks of the model, and could comment on the framework that they, or others, were arguing from. Some of the younger secondary students struggled with the terminology of the framework and one teacher made some changes to the language and found that this made the use of the frameworks more workable for many students.

The end of unit written reports, activities, debates, and role plays indicated that the students had incorporated ideas gained from their research, classroom discussion, group discussion and the classroom activities. Some teacher-researchers commented that the students’ reports were the best they had seen.

The students were able to identify that they had learned about ethical decision making, and how to defend their viewpoint. They admitted that they sometimes changed their opinions as they listened to other viewpoints or as they became better informed. The teacher-researchers also commented that the students’ ability in ethical justification had been enhanced, that they were able to justify their viewpoints and provide “exceptional” arguments. They indicated that the students

were able to use a range of frameworks, with the most commonly used ones for ethical justification being those of consequentialism, autonomy and virtue ethics. The frameworks were applied to their arguments and they had the confidence to critique ideas and not the person.

In terms of social outcomes, students frequently commented that they were able to appreciate other viewpoints and the students also made several references to their interest in other people's perspectives. They stated how it was useful to be in "other people's shoes" as experienced in some of the classroom activities. The teacher-researchers also commented on the students' sensitivity towards others and the tolerance that the students had towards other people's viewpoints.

The students mentioned their enjoyment of the teaching and learning topics and commented that they found them fun, interesting, informative and that they would like to spend more time working with, and learning about, issues in science.

Teacher knowledge and outcomes

All of the teacher-researchers expressed that they found the professional learning workshops valuable and identified a significant change in their learning about ethical frameworks and ethical decision making. Most reported to knowing very little, if anything, about ethical thinking before the professional learning workshops. They commented on their enjoyment in learning about and using the ethical frameworks, and all ended up wanting to know more in order to develop this area of their teaching. They identified and discussed the potential of the range of suggested strategies and approaches not only for addressing science issues, but in the wider contexts of their science teaching.

The importance of understanding the science concepts was strongly identified as knowledge of the background science concepts enabled them to extend discussions with students. Some mentioned that reading of student reports also extended their knowledge of science concepts. Similarly to the students, they found that thinking in "other people's shoes" was interesting and valuable.

The teacher-researchers commented that the professional learning programme had developed their awareness of available resources and tools such as videos, computer-based tools, useful websites, templates for some students activities, planning proformas and templates for scaffolding students' ethical thinking. They

indicated that they valued the strong planning focus and the learning and reminding about student centred teaching and learning strategies in their classroom practice. There was a strong awareness amongst the teacher-researchers of an enhanced pedagogical base for their science teaching.

The teachers in this project were prepared to take risks and were open to new ideas and willing to share and discuss ideas with colleagues. None of the teachers showed negativity or cynicism towards change, nor did they lack commitment or believe they were “experts”. There was enthusiasm for the project and awareness that teacher learning was something that they valued and that it was a continuing process in the professional life of a teacher.

Unexpected learning

All of the teacher-researchers commented in their presentations on the unexpected learning that arose out of their trials in the classroom. They had not expected the high level of engagement of the students. Nor had they expected the students to be able to identify and then work so easily with the five ethical frameworks, including their ability to “think in other people’s shoes.”

They were unprepared for the depth of discussion and analysis which they considered “outstanding” and “thoughtful” and the confidence with which the students presented their views. Finally, they were surprised at the level of enjoyment of the students and how some students thought that working with issues could be an interesting career.

Summary of findings of the professional learning programme

This chapter reported on Phase Three of the project and presented the findings of the professional learning programme in which a model for ethical inquiry was introduced, trialled, critiqued and evaluated. Workshop 1 of the professional learning programme backgrounded and prepared the teachers to implement the model for ethical inquiry and Workshop 2 reported on the implementation and evaluation of the model.

Each of the five classroom trials presented by a teacher-researcher was written up as an individual case study and then the findings were discussed in terms of a cross-case analysis that explored the relationships and patterns from the

individual cases. The four themes that emerged from the cross-case analysis were usefulness of the model for ethical inquiry, student knowledge and outcomes, teacher knowledge and outcomes, and unexpected outcomes.

The positive outcomes emerging within these themes validated Version 3 of the model for ethical inquiry in terms of being a vehicle that supported and assisted teachers to address controversial science issues in their classrooms.

The following and final chapter discusses the design and the findings of the three phases of the research project in relation to the research questions. This is followed by a critical reflection of the project, including a discussion of the limitations. Finally, the implications of the project, in terms of its contribution to the theoretical base on the teaching and learning of controversial issues, and the implications for teachers and further research are discussed.

CHAPTER 7: CONCLUSIONS, REFLECTIONS AND IMPLICATIONS

Introduction

The purpose of the final chapter is to present the conclusions, reflections and limitations, and implications of this research project. The project attempted to answer three research questions:

1. *How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*
2. *What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*
3. *In what ways will a professional learning programme support teachers to address controversial science issues in secondary science classrooms?*

Firstly, the research design of the project and its findings are summarised and conclusions are made in relation to the research questions. The conclusions are followed by a critical reflection on the nature of the project, including a discussion of its limitations. Finally, the implications of the project in terms of its contribution to the theoretical base on the teaching and learning about controversial science issues, and the implications for teachers, professional development providers, school administrators and national curriculum facilitators, are discussed, followed by a consideration of further research directions.

Research design of the project

Chapter 3 outlined the research design of this project. Following the setting out of the theoretical paradigms or frameworks of the research project, Phase One involved the development and administration of a postal survey to secondary science teachers and focused group interviews with some survey respondents. Chapter 3 also described the data collection techniques and how the quantitative and qualitative data were managed and analysed to answer Research Questions 1 and 2. The generation and analysis of data in Phase One of the project informed subsequent data generation phases.

Next, Phase Two involved the design and development of a professional learning programme involving two workshops. A key focus of this planning phase was the development of a pedagogical model for ethical inquiry (Version 1) which was to be introduced, critiqued, trialled and evaluated as a part of the professional learning programme. Literature that played a key role in the design of the model for ethical inquiry was described, as was literature describing key principles for professional learning.

The design of Phase Three of the project utilised an interpretative case study approach and, as is common practice in interpretative design, a mixed-method approach was used for data gathering. This phase was designed to allow the delivery of two professional learning workshops. Workshop 1 was designed to background, introduce, and allow interrogation and critique of the model for ethical inquiry to develop Version 2, and then prepare the teacher-researchers for trialing the model, including the exploration of a range of resources to support the trials. Provision was made for the workshop to be audio-taped and the conversations later to be transcribed. The planning of Workshop 2 allowed for the teacher-researchers to report on the trialing of the model in a self-selected context. This was followed by a final critique and evaluation of the model to co-construct Version 3. As in Workshop 1, proceedings in the second workshop were audio-taped and the tapes subsequently transcribed to enable a series of case studies of the trials to be developed. The data from each of five trials were analysed as with-in case analyses and following this, a cross-case analysis was made to explore the patterns and relationships between the cases. These data, together with the teacher-researchers' final critique and evaluation of the model, were used to address Research Question 3.

In summary, the research design of this project focused on the gathering of a large amount of qualitative data on the teaching of issues in five classrooms and this was set against the background of the more general quantitative and qualitative data from the survey results of a larger group. The project demonstrated the value of using both qualitative and quantitative data from the survey and focused group interviews, which were then used to inform a professional learning programme to meet and support the identified needs of teachers to address controversial science issues.

Summary and Conclusions

This section summarises and draws conclusions from the research in relation to the three research questions.

Research Question 1: *How are controversial science issues currently addressed in secondary science classrooms in New Zealand?*

It was clear from the literature review that there was a lack of research on teaching and learning about controversial science issues in New Zealand classrooms, so a postal survey and focused group interviews were carried out and then the findings discussed (see Chapter 4) in order to establish the current status of teaching and learning of controversial science issues in New Zealand, and enable the first research question to be addressed.

Analysis of the findings showed that all of the science teachers in the survey and focused group interviews believed that controversial science issues should be discussed in science classrooms and all of the teachers indicated that they did so, but in varying degrees. This contrasted with research carried out with teachers internationally which indicated that many science teachers perceived science as an objective and value-free, realistic discipline (Allchin, 1999; Claxton, 1997; Hall, 1998; Levinson & Turner, 2001; Lloyd & Wallace, 2004), and recognised that a common perception of many science teachers was that the teaching of science was about the delivery of content and therefore it was not realistic for them to address moral and ethical aspects. They believed that science works with descriptions and explanations, and therefore addressing issues for which there are no clear solution, is inappropriate in science (Hall, 1998; Hodson, 2003; Levinson & Turner, 2001; Lock, 2002; Simonneaux & Albe, 2003; Van Rooy, 1994, 2004).

Although the New Zealand teachers indicated that they addressed controversial science issues in their classrooms, they used a narrow range of teaching and learning strategies and approaches. The most commonly used strategies and resources were teacher-led classroom discussion and use of newspaper articles and videotapes. Student centred and co-operative learning strategies were seldom utilised and teachers had little or no understanding of frameworks of ethical thinking. These results reinforced the findings of a study by Newton et al. (1999) that also indicated that secondary science classrooms in the United Kingdom were strongly teacher-

centred with little opportunity provided for small group or whole class discussion. Teachers emphasised in the Newton et al. study that, although they saw the value of discussion, they had few strategies for structuring discussion in both small groups and with a whole class.

The main reasons why New Zealand science teachers considered that controversial science issues should be addressed in science programmes were that students gained an awareness of the nature of science and an awareness of different perspectives on an issue. It helped them to develop their critical thinking skills and to make informed decisions, and the students gained some understanding of science concepts as they addressed the issue. These reasons linked strongly to the aims identified by other international studies (Barab et al., 2007; Davies, 2004; Jenkins, 1999; Kolstø, 2001a; Levinson & Reiss, 2003; Longbottom & Butler, 1999; Reiss, 1999, 2007; Sadler & Fowler, 2006; Van Rooy, 2004; Zeidler et al., 2005).

The majority of teachers (93%) reported that they felt confident or very confident, with only 7% tentative, about addressing controversial science issues. Once again this contrasted with the results from Levinson and Turner (2001) which reported that many teachers felt the skills and knowledge needed to teach science differed from those required to address ethics, and that they did not have the confidence or skills to do this. It appears that New Zealand teachers currently have more confidence in their ability to address controversial science issues than did their counterparts in the United Kingdom, at the time of Levinson and Turner's study.

The New Zealand teachers in this project identified constraints to teaching controversial science issues and perceived these to be: lack of time to address issues in current programmes, lack of time to plan topics, lack of relevant understanding of science concepts associated with the issues, lack of knowledge of effective teaching and learning strategies and lack of teaching resources. These constraints were similar to those commonly identified in the international literature (Dawson, 2001; Forbes & Davis, 2007; Levinson & Turner, 2001; Osborne et al., 2004; Reiss, 1999; Sadler et al., 2006; Van Rooy, 1994, 2000).

In summary, Research Question 1 of the project was answered by the findings from the survey and the focused group interviews. These findings enabled the current status of the teaching and learning about controversial science issues in

New Zealand to be determined and compared with science education practices in other parts of the world.

Research Question 2: *What support do New Zealand teachers need to address the teaching of controversial science issues in secondary science classrooms?*

The survey results and focused group interviews data (see Chapter 4) also revealed the support that teachers needed in order to address the teaching of controversial science issues in secondary science classrooms. The areas the teachers identified for support were the need for more resources, the need for more time to plan, prepare, and background the science behind an issue, as well as more time to search for resources related to an issue. They also indicated that opportunities were needed for professional development in both pre-service and in-service programmes to assist in the development of pedagogical approaches, including use of appropriate strategies.

There was a large amount of information in the international literature about students making decisions on controversial science issues, but there was little information on teacher support, and about changes in teacher practice as a result of support or professional learning programmes. However, some research has been carried out to support teachers in the United Kingdom in the area of facilitating argumentation (Bell, 2004; Erduran, et al., 2004; Evagorou & Osborne, 2007; Osborne et al., 2001; Simon & Maloney, 2006; Simon, et al., 2006). Although resources, including web-based resources, are available, it appears that teachers are unwilling or reluctant to search out support materials (Pedretti & Hodson, 1995; Wishart et al., 2007).

The survey and the interview data showed that there was a need to move teachers away from a focus on content, towards a pedagogy that focused on processes such as ethical thinking, argumentation and appropriate use of strategies and approaches to support these. Ways were considered in which teachers might best be supported and a professional learning programme was developed for a small group of four science teachers. The design of the professional learning programme was informed by the large amount of literature in this area (for example, Bell & Gilbert, 1994, 1996; Fishman et al., 2003; Guskey & Huberman, 1995; Hewson, 2007; Hiebert et al., 2002; Hoban, 2002; Loucks-Horsley et al., 2003; Showers et al.,

1987; Timperley et al., 2007). Firstly, the models and frameworks for professional development put forward by Bell and Gilbert (1994, 1996), Loucks-Horsley et al. (2003) and Fishman et al. (2003) were considered in the design of the professional learning programme and secondly, key principles were identified from the literature for successful professional development and integrated into the programme design. Finally, the professional learning programme was designed to deliver two workshops separated by an eleven-week trial period.

The main focus of the professional learning programme was the development of a pedagogical model for ethical inquiry as a pedagogical approach to support teachers to address controversial science issues. The model for ethical inquiry was informed by the data from the survey and focused group interviews, examination of *The New Zealand Curriculum* (2007) and international curricula, and my work as part of a research team for the Bioethics Council of New Zealand. It was also informed by the literature of Reiss (1999, 2006a), Levinson (2003, 2006), Dawson (2001, 2003), Osborne (2006) and Beauchamp and Childress (2008) and others, a model was proposed that incorporated the four ethical frameworks of consequentialism, right and duties, autonomy and virtue ethics. A justification was provided for the inclusion of a fifth framework of pluralism on the basis of the importance of acknowledging society's diversity. The argument is strong for New Zealand society because of the acknowledgment required by the partnership articles of the Treaty of Waitangi between Māori and the Crown in New Zealand.

Version 1 of the model (Appendix I) was developed as a coloured representation which showed the steps in the process of inquiry, together with some useful strategies and question-prompts as sidebars which were colour-coded to link with the relevant steps in the model. This version was then critiqued by teachers at the first workshop, with the comments incorporated to develop Version 2 of the model (Appendix S) that the teachers used for trialling. A final version (Version 3) was developed as a result of feedback from the trialling in Workshop 2 (Appendix T).

In summary, Research Question 2 was addressed by using the data from Phase One of the project to establish the areas of support required by teachers, and a professional learning programme was designed within which a model for ethical inquiry was introduced, to provide support in the identified areas of need.

Research Question 3: *In what ways will a professional learning programme support teachers to address controversial science issues in secondary science classrooms?*

The professional learning programme, or Phase Three of the project, involved two, full-day professional development workshops, eleven weeks apart, with classroom trialling of the model for ethical inquiry between each workshop.

Chapter 6 outlined the findings for Phase Three of the project and presented data related to the third research question which asked in what ways would a professional learning programme support teachers to address controversial science issues in secondary science classrooms. The chapter provided a narrative account of the teacher discussion and responses during Workshop 1 of the programme, in which a model for ethical inquiry was backgrounded, introduced and interrogated. This was followed by the reporting of Workshop 2 of the four teacher-researchers' classroom trials in their use of the model, with each trial being presented as an individual case study. A cross-case analysis of the trials was then made to explore the relationships and patterns from the individual cases and this analysis used to test the validity of the model. A final critique and evaluation by the teacher-researchers provided a final version (Version 3) of the model (Appendix T). The analysis of the discussions from Workshop 1 along with the cross-case analysis of the case studies from Workshop 2 provided information to answer the third research question.

The professional learning programme supported the teachers to address controversial science issues in a number of ways. Firstly, the final version of the model for ethical inquiry (Version 3) was developed, which the teacher-researchers validated as being useful support. They indicated that the model provided a clear pathway of progressive stages that provided a framework that supported them to address controversial science issues. The colour-coded sidebars of the model that linked to each stage, assisted in the development of a stronger pedagogical knowledge base in terms of student-centred and co-operative learning strategies and approaches that engage and motivate students.

Secondly, the professional learning programme provided support in that it introduced frameworks of ethical reasoning to the teachers. Five frameworks for ethical thinking were introduced; consequences, right and duties, autonomy and

virtue ethics (Beauchamps & Childress, 2008; Reiss, 1999, 2006b, 2000c, 2000d) and pluralism. The inclusion of a fifth framework of pluralism ensured acknowledgement of the uniqueness and diversity of New Zealand society, including that of Māori views and perspectives consistent with the New Zealand Government's commitment to the Treaty of Waitangi responsibilities. Use of the frameworks was modelled and reinforced in the workshops using a number of activities which teachers could subsequently use with students in their classrooms.

Thirdly, the programme provided support in the form of resources to implement the model, such as videos (Reiss, 2006b, 2000c, 2000d), useful websites, templates for some student activities, planning proformas, a range of writing frames for scaffolding students' ethical thinking. The programme also provided access to professional readings on teaching and learning about controversial science issues for teachers to further extend their pedagogical knowledge base.

In this professional learning programme, and similarly to the findings of Barak and Pearlman-Avni (1999) and Ramsay et al. (1990), none of the teachers refused to change their practice, nor did they indicate a view that things should stay as they are; none believed that they were "experts" and had little to learn; and none lacked commitment to their teaching. Experienced teachers have a wealth of knowledge and have developed positions on many matters related to teaching. They also have a wide repertoire of ideas on which they can draw, and all bring with them a set of beliefs and understanding about teaching and learning. As a result, teachers in professional learning programmes can respond in a number of ways. Timperley et al. (2007) identified a number of responses of participants in professional learning programmes and lists these as: rejecting or ignoring the new ideas; continuing with prior practice; selecting parts of the new theory and practice and adapting to current practice; implementing as required by actively engaging with, owning and applying the new theory or practice and therefore changing substantively their practice, and finally, ensuring desired outcomes for students. These teacher-researchers responded to the professional learning programme by implementing and actively engaging with the programme, especially the model for ethical inquiry and its associated strategies, tools and resources. They changed their practice and in doing so enabled positive outcomes for themselves and their students.

There was evidence of social development through the teacher-researchers' conversations during the workshops. All the teachers indicated that they valued working in collaborative ways with their colleagues and that the professional conversations during the trial time in their schools were helpful, encouraging and supportive. They also emphasised the value of sharing their personal experiences of their classroom trials.

The cross-case analysis of the five case studies indicated that the support provided by the programme and, in particular, use of the model for ethical inquiry, was successful in that not only did it show positive outcomes for teachers but also significant positive outcomes for students. These were increased student learning and understanding of the science concepts associated with the issue, a high level of student engagement and motivation when exploring issues and an increased awareness of how ethical decisions were made. Students were able to justify their decisions using ethical frameworks and demonstrated a high level of sensitivity to the wide range of views that people hold on various issues and showed respect and tolerance of other peoples' viewpoints.

In summary, the findings confirmed that the professional learning programme supported teachers to address controversial science issues effectively in their teaching programmes in a number of ways. The success of the professional learning programme was indicated by both positive teacher and student outcomes, and the project has validated a pedagogical model for ethical inquiry that can contribute to the body of knowledge of teaching and learning about controversial science issues in secondary science classrooms. The assumption that developing such a model within a professional learning programme would support and assist the teachers to successfully address controversial science issues, was justified within the small scale implementation in this project, and enabled Research Question 3 to be answered.

Critical reflection and limitations

This research provided my first opportunity to design a survey and, despite it being field tested, I found that some questions could have been better phrased to enable the collection of more detailed data. For example, Question 12 of the survey asked whether respondents addressed controversial science issues in their classrooms, but it did not gather data as to the depth these issues were covered. Probing in the focused group interviews showed that one participant felt that he addressed them by a “mention in passing.” Clearly this is addressing controversial science issues in a different way to other teachers who interpreted it as teaching a full unit. Also, in analysing the open-ended questions in a postal survey, one can only work with what the respondents write, which is possibly less than what they know. This emphasised the importance of the focused group interviews which gave the opportunity to probe for greater depth in teachers’ views.

Another limitation of the survey was its range and small sample number of forty teachers. For pragmatic reasons, the survey was limited to all teachers in a geographical region within which I had worked as a science adviser for several years. A wider geographical distribution of the survey across New Zealand and also increasing the sample number may have provided a different set of data. There was no indication that this may have been the case, but nonetheless, the limited size and range of the sample must be considered a constraint on generalising the findings of the project.

The project could have also considered a larger sample size for the focused group interviews, from which only some participants could have been selected to participate in the professional learning programme. In planning the project, I justified the use of small focused group interviews because of the possible sensitive nature of the issues being discussed, but in the end, sensitivity did not turn out to be an issue and it would have been possible to have all four participants together for these interviews. On further reflection, possibly one larger focus group could have also achieved the gathering of worthwhile data to inform the subsequent phase of the project.

It is important to note that in the professional learning programme I knew three of the four participants. We had worked together over the years as I visited

their schools as an adviser and later as a visiting lecturer with pre-service students. It is possible that these teachers may have wished not to offend me by refusing my request to participate. Only one teacher came in as a person unknown to me. Prior knowledge of at least some of the participants was unavoidable, given my background and the surveying of teachers in the local area. However this may have influenced the outcome and must be considered as a limitation to generalising the results beyond the region.

Presenting my research findings has meant critical reflection on the within-case study analyses and the cross-case analysis. I needed to consider whether these provided sufficient evidence that would validate the model of ethical inquiry as a useful tool to support teachers in the addressing of controversial science issues. The ways in which the teacher-researchers reported the information about their teaching experiences is dependent on the teacher accounts and their perceptions of the experience. One critic of case study research suggested that there are opportunities for subjectivity in implementation, presentation, reporting and evaluation of the case study, because such an approach relies on the personal interpretation of data (Tellis, 1997). Tellis argued that consideration needed to be taken of the integrity, sensitivity and possible prejudices of the investigators. There is also a possibility that during the reporting of the trials, participants could distort, deliberately falsify or be selective of information provided to the researcher (Cohen et al., 2007). However, overall, the analyses and evaluations of the case study trials were supported by the teacher-researchers' final reflections where they confirmed the value of the professional learning programme and the usefulness of the model as an approach to teaching and learning about controversial science issues.

A final critique of the project lies in examining its sustainability. Is the participants' enthusiasm short-lived, or will they continue to use the model for ethical inquiry and student centred strategies consistently in the future? Such significant changes required for teachers who have traditionally used a transmissive pedagogy, requires a change in teacher beliefs on the purpose of science education and an understanding of the concepts of the nature of science. (Baggot la Velle, et al., 2004; Goodrum et al., 2001; Hipkins, 2006; Levinson & Turner, 2001; Ratcliffe & Grace, 2003; Tytler, 2007). This issue of sustainability is discussed further in the implications of the project.

Implications

In this section, I consider the implications of the research project for teachers, providers of professional development, school administrators, national curriculum facilitators and researchers. Firstly, the conclusions of the project have implications for classroom teachers. The model for ethical inquiry provided a supportive pathway for teachers to follow that was flexible in its use and which enabled students to background the science behind the issue, identify their individual values and then make and justify their decisions on an issue using common ethical frameworks. The project identified that New Zealand teachers use a narrow range of teacher-centred strategies, and a response to the lack of variety in teaching and learning strategies has been the development of the colour-coded sidebars to the model. These increased awareness and subsequently the development of a stronger pedagogical knowledge base of teachers on a range of strategies and open-ended questioning and prompts that can support student-centred learning in the different stages of the ethical inquiry process. This pedagogical model, now trialled, is simple, effective and supportive and may encourage more teachers to take a step in the direction of teaching and learning about controversial science issues and in doing so, further develop their own, and their students', scientific literacy.

Secondly, there are implications for assessment practices. There are no right or wrong answers when exploring issues, although some decisions may be better than others. It is about arriving at and justifying a decision and the process of deliberation (Levinson & Reiss, 2003). Assessment which measures students' ability to weigh up alternatives, rather than provide fixed answers that have traditionally driven assessments, may be problematic (Conner, 2004; Ratcliffe, 2007). What is assessed tends to drive teaching and learning programmes, so it is important to develop assessment practices that support a more flexible, challenging curriculum. Teachers may need assistance in developing criteria that support them in the assessment of such a process, and a realignment of achievement standards for assessment in NCEA qualifications in New Zealand is just beginning. Some performance levels and criteria have been developed internationally using rubrics which recognise a student's ability to examine an issue from multiple perspectives, demonstrate scepticism and recognise bias. Other assessment schedules have been developed which evaluate a students' ability to communicate arguments using a

progression of supporting evidence (Erduran et al., 2004; Sadler et al., 2007; Slingsby, 2008).

Thirdly, the conclusions of the project have implications for providers of in-service education. The project provided evidence that changing curriculum requirements places considerable demands on teachers and for change to occur, effective training, support, adequate time and resources need to be provided. These findings are consistent with those of Fullan (2001). Professional development on teaching and learning about controversial science issues is necessary for practicing secondary classroom teachers so that they can adequately meet the changing requirements of *The New Zealand Curriculum* (2007), increase their pedagogical knowledge base and work towards developing their own, and their students', scientific literacy. The changes to pedagogy required by the curriculum changes requires a significant shift beyond the reach of single day, professional development events, which has been demonstrated to be ineffective in promoting significant changes in practice (Hoban, 1992). There is a need for longer term programmes where teachers are able to ground new ideas relative to teaching and learning about issues in personal experiences and have opportunities to share their experiences. With the impetus for curriculum change, this project may contribute to the development of approaches for implementing these changes.

Fourthly, there are implications for resource provision. Support could be provided by Ministry of Education national curriculum facilitators in science, and professional development providers, to establish resource writing groups as well as networks for teachers to share resources and experiences on controversial science issues. Case studies of successful or “good practice” models of teaching and learning about issues could be made available for science teachers to access through established networks such as TKI (Te Kete Iirangi at www.tki.org.nz)⁸ or the Biotechnology Learning Hub developed by the University of Waikato (www.biotechlearn.co.nz).

⁸ TKI is a bilingual portal and web community which provides quality-assured educational material for teachers, school managers, and the wider education community. It is an initiative of the New Zealand Ministry of Education, which aims to enhance teaching and learning, raise student achievement and advance professional development for materials school management and teaching staff.

Fifthly, there are implications for pre-service educators in that pre-service programmes need to be designed and implemented that support a contemporary view of science and scientific literacy, and which focus explicitly on the teaching and learning of controversial science issues, including the development of capabilities such as critical thinking and ethical decision-making.

Sixthly, the project has implications for school administrators as it identified that teachers need support in terms of further resources, time to attend professional development sessions, time to research the rapidly changing science background to many science issues, and time to plan for and to teach programmes that allow for the implementation of teaching and learning about issues. Teachers also need support in terms of time being provided to enable them to explore and develop further resources in a variety of contexts related to controversial issues.

This project also has implications for researchers. It provided information on teaching and learning about controversial science issues in New Zealand science classrooms and partly filled a gap in the science education literature in New Zealand. The project contributed to understanding how controversial science issues are currently addressed in New Zealand secondary science classrooms and it identified that there are organisational, conceptual, and pedagogical constraints that hinder the addressing of issues although there appeared to be few attitudinal constraints for New Zealand science teachers. There are implications for researchers in that replication of the survey using a larger sample of teachers might identify that if these constraints are more broadly typical, then an assumption could be made that the model for ethical inquiry will be more readily applicable. And now that the project has validated the usefulness of the model in supporting teachers to address controversial science issues, it is ready for testing to a wider group of secondary science teachers and secondary pre-service teachers which was beyond the scope of this project. Further reflection on practitioner use of the model made me consider that although this programme was carried out with secondary science teachers, would the model in a modified form be useful to classroom teachers and pre-service students in the teaching of primary science? This is another possible area for further research.

And finally, the project has implications for the Ministry of Education in New Zealand terms of sustainability, in particular, how the project might be “scaled-

up” and so reach more teachers. Teacher change that is sustainable will take time, support, professional development and resource development. Sustainability of the professional learning programme was discussed with the teacher-researchers participating in the project, including how they might continue to work with the model for ethical inquiry in the future. They saw opportunities to hold training within their departments for other science staff to discuss new practices in relation to the implementation of the nature of science strand of *The New Zealand Curriculum* (2007). One pair of teachers was planning a half-day workshop with their science faculty, using resources from Workshop 1. The teacher-researchers also commented that their professional learning experiences might be of use for presentations at science education conferences or local science teachers’ meetings. They also commented on the possibility of assisting the Ministry of Education in the future by facilitating in any future professional development for science teachers in terms of curriculum initiatives. They felt that they now had a strong theoretical base to teaching and learning about ethical decision making and were more equipped with the skills aligned to ethical reasoning.

As a result of this research I have become more informed about bioethics education literature, and have a greater awareness of the constraints to teaching and learning about controversial science issues. Together with the teacher-researchers, I have developed a stronger pedagogical knowledge base which will continue to evolve, and within which I can base further research on the teaching and learning of controversial science issues with teachers and pre-service teachers in science classrooms. Above all, it has increased my enthusiasm and reaffirmed my strong belief in the value of teaching and learning about controversial science issues in science classrooms.

If we decide that we do not have the time to stop and think about right and wrong, then we do not have time to figure right from wrong, which means we do not have time to live according to our model of right and wrong, which means, simply put, we don't have time for lives of integrity. (Carter, 2005, p. 10)

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APPENDIX A: WEB-BASED RESOURCES TO SUPPORT THE TEACHING OF CONTROVERSIAL ISSUES

- The European Initiative for Biotechnology Education (<http://www.eibe.info/>) is a multi-disciplinary network involving specialists in biotechnology education from 17 European countries and published 20 teaching units with teaching materials to stimulate debate on biotechnology issues among 16-19-year-olds, such as DNA profiling and transgenic plants, human genetic dilemmas and diseases. These materials provide in depth information to background ethical issues, although provide little support to develop ethical reasoning in students.
- The BioEthics Education Project (BEEP), (<http://www.beep.ac.uk/content/index.php>), is a joint project of the University of Bristol and the Wellcome Trust and provides information and opportunities for students to practice argument skills through online discussion, as well as the provision of teaching resources, and on-line peer support for teachers on a wide range of ethical issues in science. It provides an ethics toolkit which assists students and teachers to analyse issues from deontological and consequentialist frameworks. This project was evaluated by Wishart, Baggot la Velle, Green and McFarlane (2007) and feedback from teachers and students was supportive, indicating they liked the design and ease of use of the site. However, most were unwilling or unable to find out how to make the most of opportunities provided on the site for on-line discussion.
- The Citizen Science at Bristol website (<http://www.at-bristol.org.uk/cz/default.htm>) is funded by the Wellcome Trust and set up by the At-Bristol Education team and the University of Bristol, along with teachers and scientists. Citizen science is designed to be instrumental in engaging young people and teachers in discussion about biomedical science issues that affect society today. The site provides a range of guidelines and resources for teachers to explore and debate controversial science issues.
- Meet the gene machine (<http://www.scu.uwe.ac.uk/projects/events/meetthe/genemachine.htm>) is a project from the Science Communication Unit at the University of West of England and funded by the Wellcome Trust. The project is an extensive one with training materials provided for facilitators for a

professional development programme for teachers to use the resource. Resources and activities are provided that can be used in the classroom to promote student interest, debate and ethical thinking on issues about the application of genetic knowledge. The resource has been piloted and trialled within a number of countries.

- The Update8 site (<http://www.update8.org>) is a website supported by the Association of Science Educators (UK) that creates resources and activities for teachers that are relevant and based on current science news, issues and popular culture. This site is well supported with colourful activities for the classroom and extensive accompanying teacher's notes, curriculum links and links to other relevant websites.
- The Centre for Biosciences website (<http://www.bioscience.heacademy.ac.uk/resources/ethicsbrief.aspx>) provides briefings to help teachers with science background to various ethical topics. It contains a balance of scientific and ethical input along with case studies and up-to-date examples of bioethics news and items.
- The University of Iowa Bioethics Outreach programme (<http://www.bioethics.iastate.edu/classroom.html>), includes on-site workshops and a range of case studies related to bioethics and available online. This resource however needs experience and confidence in dealing with ethical issues in order to use it effectively.
- The Eubios Ethics Institute site (<http://www.ubios.info/index.htm>) contains an online book titled *A Cross Cultural Approach to Bioethics* (2006), edited by Darryl Macer, which contains extensive teaching and learning materials for teaching bioethics. It also has a useful section on ethical approaches.
- An Australian biotechnology site that provides resources and support for teachers and students as well as an explanation of several ethical frameworks is the Australian Government Biotechnology site (<http://www.biotechnologyonline.gov.au/>). In this site, the frameworks are grouped in to three areas of action-based, situation-based, and agent-based with these explained using an interactive tool. The site provides extensive links to interactive activities, animations and video clips.

- The New Zealand Biotechnology Hub (<http://biotechlearn.org.nz>) is a website that provides a range of student and teacher learning materials and constantly updates examples of biotechnological developments in New Zealand through video clips, interactive activities, animations. It has a major theme of bioethics and includes a bioethics tool to support ethical decision-making that can be customised by teachers to meet their instructional needs. Other teaching resources include teaching units that have ethics and values integrated and which develop both science and technology outcomes.
- The New Zealand Bioethics Council site (<http://www.bioethics.org.nz>) provides up-to-date information about current bioethical issues in New Zealand. Although there is little pedagogical focus, it does provide material that may be readily used to extend teachers' knowledge and provides examples of localised issues for New Zealand. A recent report (2006) *Choosing genes for future children: regulating preimplantation genetic diagnosis* introduces a range of approaches to ethical thinking. Another report recently released, *Who gets born?* (2008), presents New Zealanders' cultural, ethical and spiritual views on a range of pre-birth testing. These views were obtained by a public deliberation process and the report
- Ideas, evidence and argument in science education (IDEAS) <http://www.kcl.ac.uk/schools/sspp/education/research/steg/ideas.html>
Work on argumentation in the United Kingdom which has produced curriculum materials that involve students in activities which challenge and encourage them to hypothesise and resolve claims, counterclaims on the basis of evidence.

APPENDIX B: THE SURVEY

Survey of the teaching of controversial issues in secondary science classrooms in New Zealand



Section 1:

Please tick the appropriate box for your answer and/or comment in the space provided

1. Gender:

Male

Female

2. Age Group:

Under 25 years

25-35 years

36-45 years

46-55 years

55 + years

3. Ethnic Origin

European /Pakeha

Maori

Other: *(please specify)* _____

4. Number of years teaching:

1-2 years

3-5 years

6-10 years

11-20years

20+ years

5. What are your current academic qualifications?

Trained Teachers Certificate

Undergraduate degree (eg B.Sc)

Diploma of Teaching

Other: *(please specify)*

6. What is your school roll number?

Under 200

201-500

501-1000

1001-1500

1500+

7. What best describes your school?

- | | |
|---|---|
| <input type="checkbox"/> State high school - urban | <input type="checkbox"/> State high school - rural |
| <input type="checkbox"/> Integrated high school - urban | <input type="checkbox"/> Integrated high school - rural |
| <input type="checkbox"/> Private school - urban | <input type="checkbox"/> Private school - rural |
| <input type="checkbox"/> Kura kaupapa | <input type="checkbox"/> Area School |

8. What is your position in your school?

- | | |
|--|---|
| <input type="checkbox"/> subject teacher | <input type="checkbox"/> teacher in charge of a subject |
| <input type="checkbox"/> head of faculty or department | <input type="checkbox"/> other: <i>(please specify)</i> |
-

9. Which subjects do you currently teach in your school?

- | | |
|---|--|
| <input type="checkbox"/> Junior Science | <input type="checkbox"/> Senior Science |
| <input type="checkbox"/> Biology | <input type="checkbox"/> Chemistry |
| <input type="checkbox"/> Physics | <input type="checkbox"/> Agriculture |
| <input type="checkbox"/> Horticulture | <input type="checkbox"/> Environmental Education |
| <input type="checkbox"/> Other: <i>(please specify)</i> | |
-

10. Which of the above subject(s) do you regard as your specialty area?

Section 2:

Please tick the appropriate box for your answer and/or comment in the space provided

Some controversial scientific issues often debated or discussed in society today are genetic modification, cloning, reproductive technologies, global warming, stem cell research and whaling.

11a) Do you think that controversial scientific issues should be addressed in schools?

- Yes
 Unsure
 No

11b) Why do you think this?

12. Do you actually address controversial scientific issues with your students

Yes

No

13a) If your answer was "no" please comment. Then please go to Q. 19

13b) If your answer was "yes", in which subject area and level do you address controversial scientific issues?

√	Subject Area	√	Subject Area
	Junior Science (Yr 9-10)		Agriculture (Yr 11-13)
	Senior Science (Yr 11-13)		Horticulture (Yr 9-13)
	Biology (Yr 11-13)		Environmental Education (Yr 9-13)
	Chemistry (Yr 11-13)		Other (specify)
	Physics (Yr 11-13)		

14. What controversial scientific topics have been parts of your teaching and learning programme?

- whaling
- reproductive technologies
- animal to human transplantation
- animal testing
- surrogacy
- human gene therapy
- euthanasia
- global warming
- ecotourism
- pest control
- ozone depletion
- introduced species
- waste disposal

- genetic screening
- human genome project
- organ transplantations
- genetically modified foods
- genetic engineering in plants
- genetic engineering in animals
- genetic engineering in humans
- genetic engineering in microbes
- stem cell research
- pesticides
- cloning
- energy production
- nuclear power

other(s): *(please specify)*

15. What would you consider the three most important issues to address in science classrooms? (Use responses from the list above and list in order of priority)

1. _____ 2. _____ 3. _____

16. How confident do you feel about addressing controversial scientific issues in science classrooms?

very confident

confident

tentative

not confident

Can you explain your level of confidence ?

17. What resources and /or teaching and learning strategies have you used when addressing controversial scientific issues? Please specify any titles if possible.

not applicable

videos

newspaper/magazine articles

textbooks

prepared teaching packages/kits

case studies

debates

role plays

continuum of opinions

guest speakers/ visitors

classroom discussion

dilemma stories

other: *(please specify)*

18. What problems/constraints have you found in addressing controversial scientific issues?

not applicable

my personal interest and motivation

my background knowledge on some issues

lack of interest by students

lack of teaching resources at school

how to assess such units of work

insufficient funding to purchase resources

finding effective teaching and learning strategies

lack of time in current programmes

lack of time to plan such units of work

confidence to try different strategies

remaining unbiased and nonjudgmental

handling a discussion of different values and attitudes amongst students

other: *(please specify)*

19. What previous support have you had in addressing controversial scientific issues?

none pre-service in-service

other: *(please specify)*

20. What support would be a help to you in addressing of controversial scientific issues?

- pre-prepared teaching packages/kits
 professional development on effective teaching and learning strategies for teaching issues
 networking/ sharing resources with other teachers teaching controversial issues
 visit by a subject adviser
 professional development updating background knowledge about specific controversial scientific issues
 other: *(please specify)* -
-

Section 3:

21. Please comment on any additional aspect(s) of teaching and learning about controversial scientific issues that is of concern to you, or that you think is important.

22. Would you be prepared to participate in an interview, at your convenience, to discuss your responses further? Confidentiality will be assured.

- Yes (please supply contact details below)
 No
 Maybe

Contact details:

Name: _____ School: _____
Phone: _____ Email: _____

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY. THE RESULTS ARE IMPORTANT TO ME AS WELL AS OF VALUE TO A NUMBER OF SCIENCE EDUCATORS IN NEW ZEALAND. PLEASE SEND THE SURVEY BACK IN THE PREPAID ENVELOPE BY.....

Kathy Saunders, Senior Lecturer, Dept Maths, Science and Technology Education, University of Waikato, Hamilton. Ph 8384466, Ext 7733; Email kathy@waikato.ac.nz

APPENDIX C: EXPLANATORY LETTER ACCOMPANYING THE SURVEY

Survey on Teaching of Controversial Issues in Secondary Science Classrooms in New Zealand



Dear

The teaching of controversial issues or socio-scientific issues in science is an area traditionally not covered by many teachers in their science classrooms, although it may be addressed by some teachers in senior biology and in Year 13 science programmes.

Although research on the teaching of controversial issues in secondary schools has been carried out in other countries, very little has recently been conducted on the teaching of these in New Zealand science classrooms.

What is this survey about?

This survey is part of a research project for a Doctorate in Science Education that I am working towards. The survey aims to collect data to enable me to answer the following research questions:

1. How are controversial issues currently addressed in secondary science classrooms in New Zealand?
2. What support do New Zealand teachers need to address the teaching of socio-scientific issues in secondary science classrooms?

The survey, along with a pre-paid return envelope, has been sent to Head of Science departments in secondary schools and Area schools in the Waikato and Bay of Plenty regions. Please feel free to distribute copies of the survey to members of your department.

Significance of this research

Data collected from the survey will provide current information on the state of teaching controversial issues in New Zealand secondary science classrooms and identify the constraints that hinder, and the support that could assist (without revealing the names of teachers or schools) the teaching of such issues. The findings will be openly published and will be of interest to teachers, pre-service educators and the Ministry of Education. A copy of the findings will be sent to the HOD Science in all participating schools.

All information given in this survey will remain confidential. The surveys are numbered only for my reference to judge the response rate from the different areas. This study has been approved by the Curtin University Human Research Ethics Committee. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth, 6845 or telephone +61 8 9266 2784.

Thank you for your time and co-operation. The comments and responses from you and members of your science department are valuable and will be read with interest.

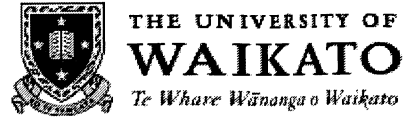
Many Thanks

Kathy Saunders
Senior Lecturer,
Dept Maths, Science and Technology Education,
University of Waikato, Hamilton.
Ph 8384466, Ext 7733; Email Kathy@waikato.ac.nz

APPENDIX D: INFORMATION LETTER AND CONSENT FORMS TO PRINCIPALS FOR TEACHERS TO TAKE PART IN RESEARCH PROJECT

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone 07 838 4466 ext 7733
Facsimile 07 838 4555
e-mail kathy@waikato.ac.nz



July 2007

Dear [Principal],

I am writing to ask for your permission to include your school in a research and development study evaluating the effectiveness of resources to help support teachers to introduce and manage discussions about ethics as part of their science classroom programmes. The aim is to help students develop their reasoning abilities in order to justify their decisions about acceptable responses to science-related scenarios such as DNA related technologies and environmental issues. Strong links will be made between the teaching and learning and the new draft science curriculum, in particular the Nature of Science strand.

The work is also being supported by Toi te Taiao, the Bioethics Council, and will ultimately be published on the New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz). The findings will also contribute to Stage 2 of my study towards a Doctorate in Science Education through Curtin University of Technology (Perth).

I have already met informally with _____ and she/he/they is/are willing to be involved, subject to your permission.

The project will include one focused group meeting and two professional development workshops, for which teacher release funding of \$220 per day is available. I am then keen to see how the teacher incorporates the ideas explored at the workshops into his/her classroom teaching. With your permission, and that of the teacher and students, I may ask to: take photocopies of planning materials and teacher worksheets or other resources, observe classroom lessons, interview the teacher(s) whose classes are observed, take photocopies of some of their students' work, and interview/survey some of the students.

Permission will be sought from the individuals concerned before any of these activities take place, including the teacher and the students and their caregivers. Participants also have the right to withdraw their participation at any stage, and to withdraw any or all of the data associated with them. You can also choose to withdraw your school from the project at any time.

Data collected from your school will be used to inform the ongoing development of resources to support bioethics education, and may be used in writing academic publications or in presentations at education conferences. Some of the findings may also be published on the New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz) to help support other teachers using materials published on this site. Pseudonyms will be used in any reporting of the work to protect the anonymity of your school, and all participants. As a consequence, the contribution of individual teachers will not be able to be acknowledged in a public forum.

I am excited about this project, and would greatly appreciate your permission for your school to be involved. If you need any more details please contact me at the above address. In the event of any issues arising from the research, you can also contact the project director, Professor Alister Jones (e-mail a.jones@waikato.ac.nz; Tel. 07 838 4245) or my doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

If you are willing for your school to be involved, please sign the attached consent form and return via the self addressed envelope included.

Yours sincerely

Kathy Saunders
Senior Lecturer
Dept Maths, Science and Technology Education
University of Waikato
Hamilton
Ph 07 8384466, Ext 7733

Research Consent Form

I have read the attached letter of information.
I understand that:

1. My school's participation in the project is voluntary.
2. I have the right to withdraw my school from the research at any time.
3. Informed consent will be gained from any teacher taking part in the research, and from students and their caregivers before collecting any data from them for this project.
4. Data may be collected from my school in the ways specified in the accompanying letter. These data will be kept confidential and securely stored. Any reporting of the data will be done using pseudonyms.
5. Data obtained during the research project will be used for the purpose of informing resource development, and may be used in presentations or education articles. Some of the work may also be published on the NZ Biotechnology Learning Hub (www.biotechlearn.org.nz) to support other teachers using materials on this site.
6. I can direct any questions to Kathy Saunders University of Waikato (e mail: kathy@waikato.ac.nz, Tel. 07 838 4466 ext 7733).
7. For any unresolved issues I can contact the project director, Professor Alister Jones (e-mail a.jones@waikato.ac.nz, Tel. 07 838 4245) or the doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

I give consent for my school to be involved in the project under the conditions set out above.

Name: _____

Signed: _____

School: _____

Date: _____

APPENDIX E: INFORMATION LETTER AND CONSENT FORMS FOR TEACHERS TO TAKE PART IN RESEARCH PROJECT

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone 07 838 4466 ext 7733
Facsimile 07 838 4555
e-mail kathy@waikato.ac.nz



July 2007

Dear [Teacher] ,

As a result of your response to an earlier survey on teaching of controversial science issues in science classrooms, I am writing to invite you to participate in a research and development study evaluating the support that teachers need to introduce and manage teaching of issues as part of their science classroom programmes. The aim is also to help students develop their reasoning abilities in order to justify their decisions about acceptable responses to science-related scenarios such as DNA related technologies and environmental issues. Strong links will be made between the teaching and learning and the new draft science curriculum, in particular the Nature of Science strand.

The work is also being supported by Toi te Taiao, the Bioethics Council, and will ultimately be published on the New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz). The findings will also contribute to my study towards a Doctorate in Science Education through Curtin University of Technology (Perth).

I have already written to your principal, who has given permission for me to invite you to participate in this project.

The project will include one focused group meeting and two professional development workshops, for which teacher release funding is available. The focused group meeting will be an informal 'get-together' of teachers in the project to find out your background in the teaching of issues and introduce you to the project

The first workshop will be held in late July and will introduce you to teaching of controversial science issues, and help you to prepare a unit to trial with one of your science classes

A second half day workshop will be held in early October where we will share and critique 'what works' in discussions about teaching issues in science classroom programmes

I am particularly interested in seeing 'what works' within your particular classroom. With your permission (and that of your students and their caregivers), this may involve: taking copies of your planning materials, worksheets or other resources (where permission is given), observing some classroom lessons, interviewing you, taking copies of some of your students' work, and interviewing / surveying some of the students.

You and your students will have the right to withdraw from the project at any stage. Also, any data that are collected will be coded to protect your anonymity, as well as that of your students and your school. However, this does mean that your individual contributions will not be able to be acknowledged within a public forum.

The findings will be used to inform the ongoing development of bioethics teaching resources, and may be used in writing academic publications or in presentations at education conferences. Some of the findings may also be published on the New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz) to help support other teachers as they use materials published on this site. Some of the findings will also contribute to my study towards a Doctorate in Science Education through Curtin University of Technology (Perth).

I am excited about this project, and hope that you will be keen to be involved. If you need any more details, please contact me at the above address. In the event of any issues arising from the research you can also contact the project director, Professor Alister Jones (e-mail a.jones@waikato.ac.nz; Tel. 07 838 4245) or my doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

If you are willing to participate and involve your class in this project, please sign the attached consent form and return via the self addressed envelope included.

Yours sincerely,

Kathy Saunders
Senior Lecturer
Dept Maths, Science and Technology Education
University of Waikato
Hamilton

Research Consent Form

I have read the attached letter of information.

I understand that:

1. My participation in the project is voluntary.
2. I have the right to withdraw from the project at any time.
3. Informed consent will be gained from students and their caregivers before collecting any data from them for this project.
4. Data may be collected from me and my class in the ways specified in the accompanying letter. These data will be kept confidential and securely stored.
5. Any data will be reported using pseudonyms in order to protect the anonymity of me, my school, and the students in my class.
6. Data obtained during the research project will be used for the purpose of informing resource development, and may be used presentations or education articles. Some of the work may also be published on the NZ Biotechnology Learning Hub (www.biotechlearn.org.nz) to support other teachers using materials on this site.
7. I can direct any questions to Kathy Saunders University of Waikato (e mail: kathy@waikato.ac.nz, Tel. 07 838 4466 ext 7733).
8. For any unresolved issues I can contact the project director, Professor Alister Jones (e-mail a.jones@waikato.ac.nz, Tel. 07 838 4245) or the doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

I am willing to be involved in this project under the conditions set out above.

Name: _____

Signed: _____

Date: _____

**APPENDIX F: INFORMATION LETTER AND CONSENT FORMS TO
CAREGIVERS FOR STUDENTS TO TAKE PART IN RESEARCH
PROJECT**

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone 07 838 4466 ext 7733
Facsimile 07 838 4555
e-mail kathy@waikato.ac.nz



July 2007

Dear Caregiver,

[Name of teacher] is teaching a unit on [provide details on the unit]. As part of this unit, students will explore some of the ethical issues associated with [the context of the unit]. The aim is to help the students learn how to make reasoned decisions about what they believe are more / less acceptable responses to a science-related scenario.

[Name of teacher] has developed this unit in conjunction with a University research and development project supported by Toi te Taiao, The Bioethics Council. Some of the findings will also contribute to my study towards a Doctorate in Science Education through Curtin University of Technology (Perth). As part of the project, [name of teacher] has also agreed that we can come into her/his classroom to observe her/his teaching, and the students' learning.

As I will be in your child's classroom, I am now writing to ask for your permission to: take notes of things your child says and does during class, take photocopies of some of your child's work, and ask your child some questions about his/her learning experiences.

In all cases, we will take care to get your child's permission. For example, we will ask your child whether he/she would mind talking to us for a while. Some of the discussions may be tape recorded. Pseudonyms will be used in any reporting of the work to protect the anonymity of your child, and [teacher's name].

The purpose of the research is to better understand the learning and learning experiences of your child and others in the class, especially as they think about ethical issues.

I have found that students really enjoy discussing ethical issues, and that they are motivated to talk about these discussions with researchers in the classroom. I really hope that you will be happy for me to record your child's views for research purposes. I also invite you to discuss the research aspect with your child.

If you are not willing for research information to be collected about your child, he/she will still be expected to participate as usual in the classroom programme.

In order to allow us to include the views of your child, please sign the attached consent form and return to school. If you need any more details, please contact me at the above address. In the event of any issues arising from the research you can also contact the project director,

Professor Alister Jones (e-mail a.jones@waikato.ac.nz; Tel. 07 838 4245) or my doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

Yours sincerely,

Kathy Saunders
Senior Lecturer
Dept Maths, Science and Technology Education
University of Waikato
Hamilton

Research Consent Form

I have read the attached letter of information.

I understand that:

1. My child's participation in the project is voluntary.
2. I have the right to withdraw my child's participation at anytime.
3. Data may be collected from my child in the ways specified in the accompanying letter. These data will be kept confidential and securely stored.
5. The data will be used to inform resource development. It may also be presented at conferences or in education articles, and in some cases may be published on the Biotechnology Learning Hub (www.biotechlearn.org.nz).
5. Any reports of the data will use pseudonyms, so that the identity of my child will be protected.
5. I can direct any questions to Kathy Saunders, University of Waikato (e mail: kathy@waikato.ac.nz, Tel: 07 838 4466 ext 7733).
6. For any unresolved issues I can contact Professor Alister Jones, project director (e-mail a.jones@waikato.ac.nz, Tel. 07 838 4245) or the doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

I am willing for my child to be involved in the project under the conditions set out above.

Name: _____

Child's name: _____

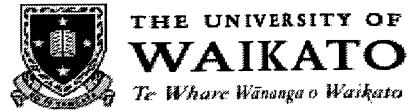
Signed: _____

Date: _____

APPENDIX G: INFORMATION LETTER AND CONSENT FORMS FOR STUDENTS TO TAKE PART IN RESEARCH PROJECT

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone 07 838 4466 ext 7733
Facsimile 07 838 4555
e-mail kathy@waikato.ac.nz



July 2007

Dear Student,

[Name of teacher] is teaching a unit on [provide details on the unit]. As part of this unit, you will explore some of the ethical issues associated with [the context of the unit]. The aim is to help you learn how to make reasoned decisions about what you believe are more / less acceptable responses to a science-related scenario.

[Name of teacher] has developed this unit in conjunction with a University research and development project supported by Toi te Taiao, The Bioethics Council. As part of the project, she/he has also agreed that we can observe some of your classroom lessons. Some of the findings will also contribute to my study towards a Doctorate in Science Education through Curtin University of Technology (Perth).

I am now writing to ask for your permission to: take notes of some of the things you say and do during class, take photocopies of some of your work, and ask you some questions about your learning experiences. Some of the discussions may be tape recorded.

Pseudonyms will be used in any reporting of the work so that your individual responses can't be identified from others in the class.

The purpose of the research is to better understand the learning and learning experiences of your class, and especially what you and your classmates about ethical issues.

In order to allow us to include your views, please sign the attached consent form and return to school. If you need any more details, please contact me at the above address. In the event of any issues arising from the research you can also contact the project director, Professor Alister Jones (e-mail a.jones@waikato.ac.nz; Tel. 07 838 4245) or my doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

If you are not are not willing for research information to be collected about you, you will still be expected to participate as usual in the classroom programme.

Yours sincerely,

Kathy Saunders
Senior Lecturer
Dept Maths, Science and Technology Education
University of Waikato
Hamilton

Research Consent Form

I have read the attached letter of information.

I understand that:

1. My participation in the project is voluntary.
2. Data may be collected from me in the ways specified in the accompanying letter. These data will be kept confidential and securely stored.
3. I have the right to withdraw my participation at anytime. If I do withdraw, I will still be expected to participate in classroom activities as usual, but no information about my responses will be recorded by the researcher.
4. The data will be used to inform the development of teaching resources. It may also be presented at conferences or in education articles, and in some cases may be published on the Biotechnology Learning Hub (www.biotechlearn.org.nz).
5. Any reports of the data will use pseudonyms, so that my identity will be protected.
5. I can direct any questions to Kathy Saunders, University of Waikato (e mail: kathy@waikato.ac.nz, Tel: 07 838 4466 ext 7733).
6. For any unresolved issues I can contact Professor Alister Jones, project director (e-mail a.jones@waikato.ac.nz, Tel. 07 838 4245) or the doctoral supervisor, Professor Leonie Rennie (email L.Rennie@curtin.edu.au)

I am willing to be involved in the project under the conditions set out above.

Name: _____

Signed: _____

Date: _____

APPENDIX H: QUESTIONS TO CONSIDER IN FOCUSED GROUP INTERVIEWS

What controversial scientific issues have you recently addressed in your teaching?
At what level? How long did you spend i.e. was it a unit of work, part of a unit, one lesson or a mention in passing etc?

Please comment specifically on a good experience (or otherwise) in the teaching of issues.

What factors contributed to the success (or otherwise) of this experience?

What teaching strategies or approaches have you used in the teaching of issues?
Which ones worked well? Why?

Can you give an example of how you enabled students to make a judgment about a scientific issue?

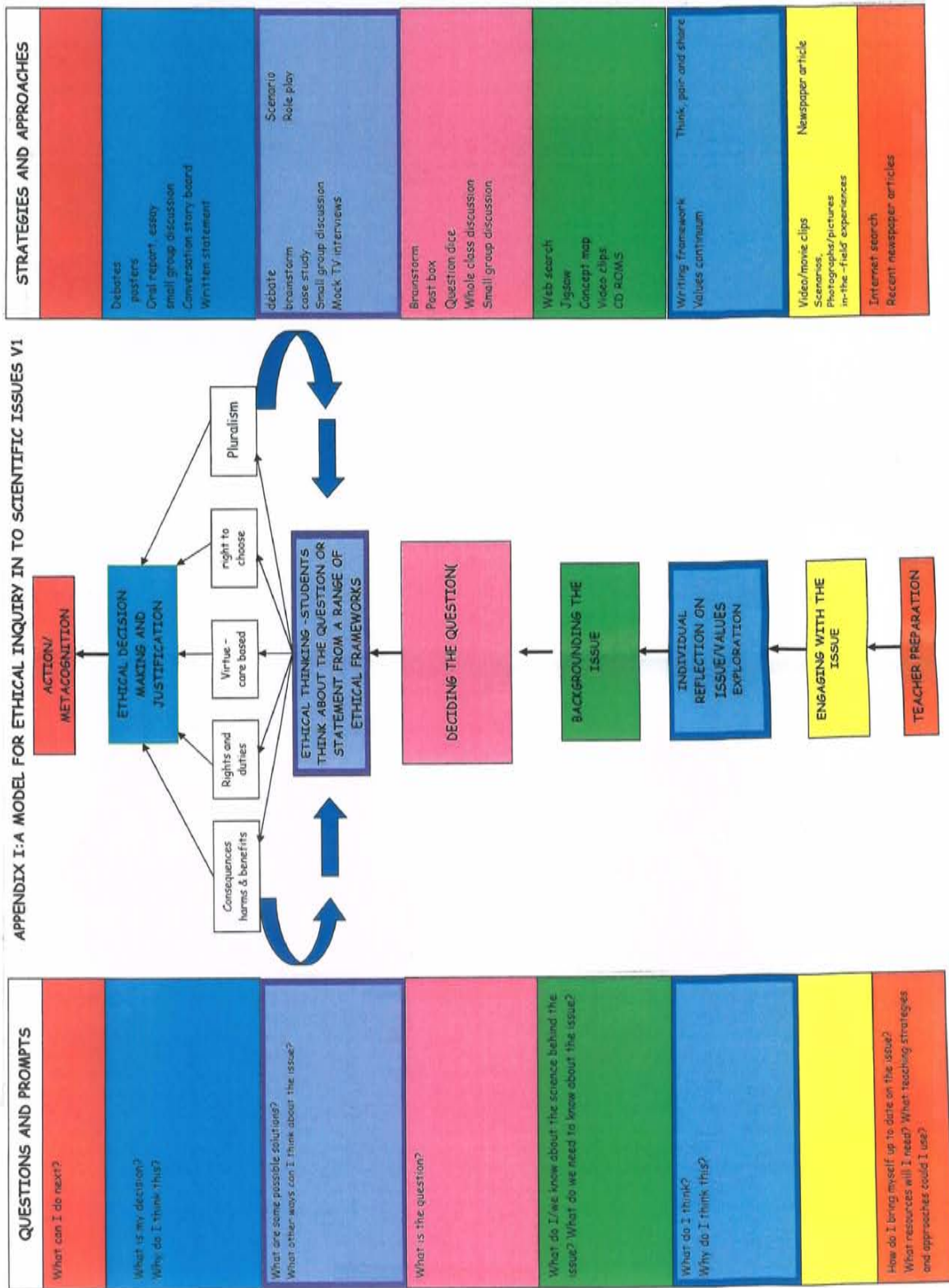
What are some benefits in issues based learning associated with science for students?

What types of resources do you think would be useful to support issues based learning associated with science

What do you understand by the terms “ethical thinking” and “ethical decision making?”

Are there any questions you would like to ask or feel should have been included?

APPENDIX I: MODEL FOR ETHICAL INQUIRY VERSION 1



APPENDIX J: WORKSHOP 1 POWER POINT

Introducing bioethics in to science classrooms

Day 1
August 2007

Objectives for Day 1

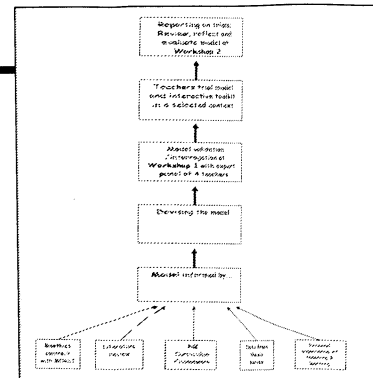
- Review the current situation in the teaching of controversial issues
- To explore and interrogate a model of ethical inquiry for introducing bioethics/controversial issues into science classroom programmes
- To explore five frame works to assist ethical thinking for students
- To identify strategies and resources to support the teaching of bioethics/ controversial issues in science classroom programmes
- To develop ideas and begin planning for a bioethics unit to trial in a science classroom

This project is supported by the Bioethics Council of NZ, University of Waikato and Curtin University of Technology, Perth

Objectives for Day 2

- To share and evaluate trialled classroom based resources for bioethics education
- To critique the model for introducing bioethics/controversial issues into science classroom programmes
- To evaluate some tools for introducing ethical thinking to students

How will we do this?



Session 1 Survey results on teaching controversial issues in NZ schools – what did they show?

- Survey sent to 50 schools, 40 respondents (21 males, 19 females)
- 62.5% over age 45 years; 53% had more than 20 years teaching experience
- All felt teaching of controversial issues should be addressed in science classrooms although not all were doing so
- 27% felt very confident to do so; 65% felt confident; 7.5% tentative

Survey results – constraints to teaching controversial issues

- Lack of time in current programmes (69%)
- Lack of personal background knowledge (50%)
- Lack of teaching resources (35%)
- Ability to handle discussion (17.5)
- Finding effective teaching and learning strategies (12.5)
- Confidence to try different strategies (7.5%)

Survey results – which types of support would be useful

Ranked order:

- Prepared teaching packages/kits
- Professional development to update science background
- Professional development on effective strategies

Session 2

Your experiences in teaching of controversial issues

Session 3 Why introduce bioethics/controversial issues?

International literature shows:

- Makes science more interesting and relevant
- Prepares students to make informed decisions about scientific issues
- Heightens ethical sensitivity – being able to identify the issues and different viewpoints
- Increases ethical knowledge – making choices; learning to argue and reason persuasively

- Improves ethical judgment – justifying choice; weighing up different viewpoints
- Science knowledge and understanding
- Promotes higher order thinking skills and scientific literacy including an understanding of the nature of science – an important aspect of the draft curriculum

Controversial issues and the curriculum

- SiNZC
- Draft curriculum (July 2006)

“By studying science, students

- **Use scientific knowledge and skills to make informed decisions about the application of science and its implications with regard to their own lives and the environment”**

- **“The nature of science is the overarching, unifying strand...students learn what science is and develop skills attitudes and values... Learn to make links between scientific knowledge and everyday decisions and actions”**

Other strands

- "The Living World Strand.....are able to make informed decisions about significant biological issues"
- The physical world By understanding physics, people are able to design technological solutions in response to a wide range of contemporary issues and challenges
- The Material Worldby using their knowledge of chemistry, people can predict and control changes in matter, leading to technological advances and the possibility of a sustainable future

Session 4: Introducing ethical frameworks

Bioethics involves using an ethical approach to make decisions about biological issues such as those associated with use of living organisms and the environment

Ethics is the study of why certain decisions are understood to be morally right or wrong and the reasoned view behind making these judgments.

Often the words 'ethics' and 'morals' are used interchangeably but they can be usefully distinguished.

- **Moral** decisions are made daily on matters great or small about what a person thinks is the right thing to do.
(much thought or little thought)
- **Ethics:** probes the reasoning behind a moral decision by critically analysing the thinking. Ethical decisions are based on reason and take in to account well established ethical principles

<http://www.biotechlearn.org.nz/>

Video clip

Ethics vs morals – Michael Reiss

Establishing priorities – Continuum activity

- Why can people have different views about what is important?
- Will all problems concern all people?
- How do you decide which problem is more important than others?
- Why are some people's view considered more significant or important than other people's views?

Different people make different decisions in different ways

However.....

There are four frameworks commonly used to make ethical judgments

- Weighing the benefits and harms/risks of the consequences to increase good done for the greatest number (utilitarian)
- Rights and duties
- Autonomy and the right to choose – making decisions for yourself
- Virtue ethics e.g. compassion, honesty, courage, thoughtfulness, tolerance, fairness, wisdom

Multiple perspectives

- Bicultural and multicultural perspectives
- Religious and spiritual views
- Traditions
- Other forms of knowledge
- Other world views

Video clip

<http://www.biotechlearn.org.nz/>

Common ethical frameworks
Which ethical framework?

Activity – thinking about our thinking on a scientific issue

Prenatal genetic screening

Right or wrong?

Ethics does not come up with a right or wrong answer

Ethical conclusions are valid if based on

- reason
- well established ethical frameworks
- A reasonable amount of consensus arises from genuine debate

So a planned **sequence of learning** in conjunction with the

ethical frameworks

of bioethical thinking, can help move our students from being

'**intuitive**' decision makers (lacking a clear rationale for their views)

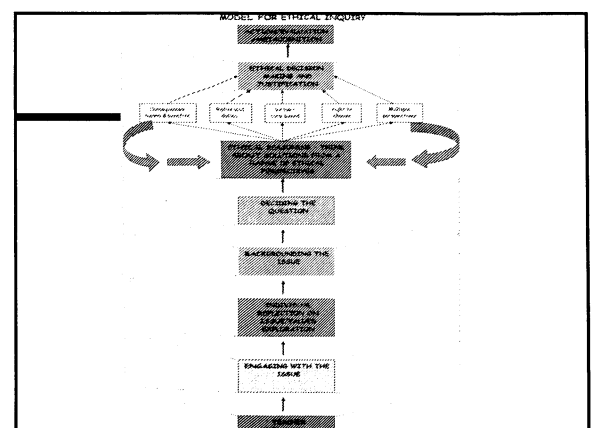
to

logical decision makers who can **justify** their decisions and show **tolerance** for other people's viewpoints

Session 5 A model of ethical inquiry

Informed by

- Literature review
- Draft science curriculum
- Data from teacher survey
- Bioethics contract
- Personal experiences



A range of strategies?

Some strategies for exploring controversial issues in the classroom

- Pair and Share
- Small group discussion
- Continuum or values line up eg transgenic revolution
- Role plays eg transplantations, rainforest

Use of the rain forest

- UN Conference on Environment and development
- Roles as representatives of
 - Government in the country
 - A logging company
 - Subsistence farmers in the area
 - Cattle ranchers
 - A multinational chemical company
 - UN commission on sustainable development

- Dilemma stories eg Genetic dilemmas
- Group presentation where group thinking is presented publicly (OHT's posters etc)
- Media analysis (newspaper, magazine articles, television interviews stories etc)

How could you link the following news stories to your teaching of bioethics?

Case study – Paul and Sophie

Paul is a twenty –three year old engineer. He is engaged to Sophie and she has recently discovered that she is expecting their first child. In 2003, Paul's maternal grandfather died from Huntington's disease (HD), a late onset degenerative disease of the nervous system. HD is inherited in a dominant fashion: if you do have HD, you have a 50% chance of passing it onto your children. Paul's mother has decided not to take the test to find out if she got the faulty gene from her father. But Paul, now that he is expecting to be a father himself is keen to find out if there is any risk that he has passed on the condition.

- What are some of the issues at stake for Paul and Julie?
- What are the consequences of deciding to take the test, or not deciding to?
- If you were Paul, what would you do?

- **Debate**
- **Concept cartoons**

- Strategies for exploring controversial issues in the classroom continued.....**
- Support which scaffolds and builds our sense of an effective argument e.g. writing frames or templates

My Argument

My idea is that.....

My reasons are that.....

Arguments against my idea might be that...

I would convince somebody that does not believe me by....

The evidence I would use to convince them is that.....

- Writing frame**
- "There is a lot of discussion about..."
 - "Some people think that it is a good idea because....."
 - "Others think it is a good idea because..."
 - "Further arguments in favour are...."
 - "But some think it is not a good idea because..."
 - "Others say....."
 - "Further arguments against are"
 - "Having looked at arguments for and against, I think...."

A range of templates to support ethical thinking

Use a template/scaffold with the earlier *Genetic Screening* activity to develop the argument that you support

Interactive toolkit for frameworks of ethical thinking

www.biotechlearn.co.nz

Questioning

- **Teacher initiated prompts/questions**
Why do you think that?
What is your reason for that?
Can you think of another argument for your view?
Can you think of an argument against your view?
How do you know?
What is your evidence?
Is there another argument for what you believe?
What kind of ethical thinking are you using?

Full model for ethical inquiry

Session 6

Applying the model and the interactive tool to a context

- Which ethical issues/controversial issues can you think of?
- Apply this context to the model of inquiry
- Explore how the framework for ethical thinking works with this topic

Video clip

<http://www.biotechlearn.org.nz/>

Introducing ethics in teaching
The ethics of whaling

Session 7

Classroom trials

- **To trial the model of inquiry**
- **To see how ethical thinking can be introduced and managed in classrooms using the interactive toolkit/and or other frameworks**
- **What activities/strategies work well?**
- **What are students capable of?**

Helpful websites

- www.bbc.co.uk
(articles as well as video clips)
- www.bioethicsbytes.wordpress.com
(multimedia resources for teaching bioethics)
- www.beep.ac.uk
(large site to support teaching and learning of bioethics)
- www.at-bristol.org.uk/cz/default.htm

- www.bioscience.heacademy.ac.uk/resources/ethicsbrief.htm
(background science underlying some issues)
- www.eibe.info
- www.biotechlearn.org.nz (Michael Reiss video clips)
- www.biotechnologyonline.gov.au
- www.upd8.org.uk

What do you need to help you plan, trial and evaluate your resource?

- Full model of inquiry
- Interactive tool to analyse ethical thinking
- Some templates to help ethical decision making
- Videos / handouts about ethical thinking
- Planning format
- Evaluation templates for students and you as teacher
- List of useful websites/resources
- Reflection journal??
- Guide to teaching and learning strategies??
- Email contacts for group??
- ????????????

For Day 2

- share and evaluate the trialed classroom based bioethics resources
- critique the model for introducing bioethics/controversial issues into science classroom programmes
- evaluate the interactive toolkit/and or other frame works to introduce ethical thinking to students

Bring to Day 2

- Plan of trialed unit to share
- Student work
- Student evaluations
- Your evaluation
- Reflection journal

We all need opportunities to:

- develop
- articulate
- critically evaluate our own bioethical values
- Reflect on and modify our values
- become aware of the many different values that exist in our society
- Become aware that views do and can change
- be able to put forward our views in an atmosphere of tolerance and sensitivity and acknowledgement

Some possible bioethics topics:

- genetically modified food
- ~~DNA profiling~~ to determine involvement in crime
- forcibly taking blood samples to determine blood alcohol levels
- sex selection in people
- cloning people (reproductive cloning)
- therapeutic cloning
- in vitro fertilisation
- surrogate motherhood
- abortion
- experiments with human foetal tissue
- transplantation of organs
- ~~xenotransplants~~

- Maori cultural harvest of kereru
- rabbit calcivirus
- ~~human responsibility to other species~~
- conserving our native species
- genetic engineering to
 - provide plant resistance to herbicides
 - allow cows to produce 'human' milk
 - correct human genetic defects
 - remove proteins from food that some are allergic to
 - reduce speed of ripening in fruit and vegetables
 - Some historical issues such as dinosaur extinctions, Minamata disaster,

APPENDIX K: PROFESSIONAL READINGS

Dawson, V. (2002). Teaching ethics in science classrooms. In J. Wallace & W. Loudon (Eds.), *Dilemmas of science teaching* (pp. 171-190). London: Routledge.

Van Rooy, W. (2004). Bringing controversial issues into science teaching. In G. Venville & V. Dawson (Eds.), *The art of teaching science* (pp. 194-208). Sydney: Allen & Unwin.

Reiss, M. (2003). How we reach ethical conclusions. In R. Levinson and M. Reiss (Eds.), *Key Issues in bioethics* (pp. 14-23). London & New York: Routledge Falmer.

Newton, P., Driver, R., & Osborne, J. (1999). The place of argument in the pedagogy of school science. *International Journal of Science Education*, 21(5), 553-576.

Levinson, R. (2003). Teaching bioethics to young people. In R. Levinson & M. Reiss, (Eds.), *Key issues in bioethics* (pp. 3-13). London & New York: Routledge Falmer.

APPENDIX L: CONTINUUM ACTIVITY “SORTING PRIORITIES”

<p>Potatoes have a gene put in them to protect them from insect attack. Farmers don't need to use chemical sprays (pesticides)</p>	<p>Cows milk has been genetically modified so that contains a drug to fight cystic fibrosis (people with CF make thick mucous that clogs lungs and other organs - they rarely live beyond the age of 30)</p>	<p>Onions have a gene inserted that makes them milder, sweeter and don't make eyes water when they are peeled</p>
<p>Strawberries have a gene inserted that makes them resistant to weedkillers (herbicides). This means that farmers can spray for weeds but not kill the strawberries. Weed management is greatly simplified</p>	<p>Rice ("Golden Rice") has genes inserted so that it is enriched with Vitamin A and iron for people in Third World countries. Lack of Vitamin A can cause blindness blindness and anaemia can cause physical and mental retardation</p>	<p>Bread is produced with folic acid added to it to prevent spina bifida developing in babies during the first month of pregnancy. SB occurs when there is incomplete development of the brain and spinal cord and the baby has physical and often learning disabilities</p>
<p>Goats' milk has been genetically modified to produce proteins that dissolve clots in arteries</p>	<p>Salmon in fish farms have been genetically modified for increased growth rate - Super salmon</p>	<p>Spreads such as margarine are produced with plant sterols added that reduce cholesterol levels in the blood</p>
<p>Sheep's' milk has been genetically modified to provide clotting proteins for haemophiliacs (bleeders)</p>	<p>Eggs are produced that have had omega 3 added that can reduce the risk of heart disease and arthritis</p>	<p>Genes have been inserted in to peanuts so that people don't have allergic reactions to them</p>
<p>Bananas have been genetically modified to contain a vaccine that can block the transmission of the HIV virus that causes AIDS</p>	<p>A plant is modified with a 'terminator' gene so that any seeds it produces are sterile. This means that farmers can't keep a portion of seeds to plant again the next year. It can also reduce the spreading of the genetically modified variety</p>	<p>New varieties of crops are produced that contain a drought resistant gene. This means that large areas of some countries where there is no irrigation may be able to grow crops</p>

APPENDIX M: ETHICAL FRAMEWORK ACTIVITY “PRE-NATAL GENETIC TESTING”

Using ethical frameworks

Context: Genetic screening

The science of genetics has given rise to many new technologies, many of which have developed very rapidly, and many of which give rise to ethical issues that people have not previously needed to consider

Genetic testing or screening involves using DNA of a human (or other organism) to draw conclusions about its past or make predictions about its future. It can be undertaken at any stage of the life cycle. For example in humans

- Before implantation
- During pregnancy
- Shortly after birth
- During childhood or adulthood

What are the issues related to genetic screening?

Choose *one* of the four areas of practice for genetic engineering described below, and identify *one* or *two* related ethical issues.

Share your ideas with other groups who have chosen another area of practice

1. Preconception screening of parents

Couples considering becoming parents can be screened to identify a potential reproductive genetic risk eg screening can identify carriers of genetic diseases such as cystic fibrosis

2. Pre-implantation screening

In an IVF-like procedure, around 6-10 embryos are created and tested. Embryos containing a gene for the disorder being screened for are discarded.

3. Pre-natal screening

Cells of the foetus are screened for a particular genetic disorder. Chorionic villus sampling can be carried out between 8-12 weeks of pregnancy; amniocentesis can be carried out at 15-17 weeks.

4. Screening of adults

Adult screening can detect existing or late onset diseases such as Huntington's or Alzheimer's. Screening can test for susceptibility to certain cancers with a genetic basis and polygenic diseases. It can detect carriers of recessive disorders.

Task:

Read the following statement about the ethics of prenatal genetic screening.

Pre-natal genetic screening not only carries risk of miscarriage, it also leads to the possibility of abortion where the test result is positive. Most people would not consider getting rid of a child with a genetic disorder such as Down's syndrome or cystic fibrosis – a newborn baby with either of these conditions is offered

medical care and support to lead the fullest life possible. How can it be right to abort the same individual a few months previously, as a result of genetic screening?

Activity:

You will be provided with a range of ethical arguments challenging or supporting the statement above. Sort these arguments in to five groups depending on which of the five ethical frame works below best fits each one.

Rights and duties

Consequences

Autonomy and making the decision yourself

Virtue ethics

Multiple perspectives

When you have finished sorting, try to produce at least one *additional* argument relating to the passage within each framework

Adapted from Salters Nuffield Advanced Biology programme, Nuffield Foundation, UK.

<p>Every individual, born or unborn has the right to life</p>	<p>In a society where the number of children born to most parents is limited by the use of contraception, allowing a child with a genetic disease to be born in effect replaces a healthy child with an unhealthy one. Selecting healthy children will strengthen, rather than weaken the gene pool, reducing the numbers of faulty genes in the population</p>
<p>Parents may have to make a special commitment of care to a child with a disability. It is up to the parents to decide if they are willing and able to do this</p>	<p>A 'good' society is prepared to love and care for individuals irrespective of their physical or mental capacities</p>
<p>It is unethical to bring a child with a genetic disease in to the world if it will result in suffering of the individual, reduce the happiness of the parents and family, or drain the financial resources of society</p>	<p>Rights of the foetus may conflict with the rights of the pregnant mother if a pregnancy presents risks to the mother's health or mental health</p>
<p>Allowing pre-natal genetic screening to take place is only acceptable in a limited range of cases. These include cases where early detection of a disorder will improve the effectiveness of post natal treatment and care</p>	<p>Medical professionals need to take time and care to explain the full implications of a positive result in pre-natal genetic screening. Unless parents understand the range of potential scenarios, positive and negative, they are not in a position to take the necessary decisions</p>
<p>The foetus has a wairua and mauri that must be respected; genetic screening may put this at risk or damage it</p>	<p>The termination of a pregnancy will breach the tapu of the mother and embryo and has implications for the whakapapa of the wider family. Such decisions are the collective responsibility of the whanau</p>

APPENDIX N: PLANNING PROFORMAS

Planning Proforma		Date(s):
		Class: No in Class:
TOPIC/TITLE	Estimated time:	
RATIONAL/ETHICAL THINKING FOCUS This unit of work gives students the opportunity		
CURRICULUM FOCUS:		
Level:		
SCIENCE Contextual strand(s): Making sense of the nature of science:	Learning Intentions/Outcomes:	
Assessment strategies/opportunities		
Materials/equipment		
Resource links and References		

Learning intentions /outcomes	Teaching and Learning Activities
	Introduction/focus/ setting the scene
	Main Activities/Tasks

Learning intentions /outcomes	Teaching and Learning Activities
	Main Activity/Task continued.....
	Reflection/Closure

APPENDIX O: TEMPLATES FOR SCAFFOLDING ETHICAL THINKING

WHAT DO I THINK? HOW AM I THINKING?

Bioethical question		
Consider possible solutions	Which ethical framework?	Making your decision Rank from 1-5
1.		1.
2.		2.
3.		3.
4.		4.
5.		5.
<p>Justifying your decision</p> <p>My decision is</p> <p>The reason I think this is</p> <p>The ethical framework I have given priority to is</p>		
<p>Others viewpoints</p> <p>Three reasons why others might not agree with my decision is</p> <p>1.</p> <p>2.</p> <p>3.</p>		

What do I need to decide about?

Consequences

My way of thinking is to weigh up the harms and benefits of my actions and choose the option that makes the most people happy or produces the most good



Who or what is affected?			
What are the benefits of doing this?			
What are the harmful things about doing this?			
Which option will produce the most good and do the least harm			
My conclusion			

Modified from Upd8 resource: www.upd8.org.uk

What do I need to decide about?

Virtue or care-based thinking

My way of thinking is to be a "good person" such as caring about people, being honest, kind, patient



Who or what is affected?			
What virtues or values are important in this situation?			
Will doing this make their life better?			
Will doing this make their life worse?			
What actions related to the issue would make you a more caring person?			

My conclusion

Modified from Upd8 resource: www.upd8.org.uk

What do I need to decide about?

Rights-based thinking

My way of thinking is to make sure I do not take away other people's rights and I do my best to ensure other people's rights. This means I may have duties to carry out.



Who or what is affected?			
What rights need to be protected?			
Who or what other groups have rights associated with this issue			
Do these groups also have responsibilities or duties? What are these?			
My conclusion			
<p><i>Modified from Upd8 resource: www.upd8.org.uk</i></p>			

What do I need to decide about?

Multiple perspectives

My way of thinking is to consider the groups of people that have opinions on this issue and think about why they might think like this. I also need to think whether the opinions of the groups have equal



Who or what groups are affected?			
What opinions do the groups of people have?			
Why do they think like this?			
Do the opinions of the groups have equal weighting			

My conclusion

Modified from Upd8 resource: www.upd8.org.uk

What do I need to decide about?

Right to choose - making decisions for yourself - Autonomy

My way of thinking is to be able to make my own choice



Who is affected?		
Is this a good or bad thing for me? Why?		
What effect might my choice have on others		
Does everyone think the same way?		
How important is this to me?		

My conclusion

Modified from Upd8 resource: www.upd8.org.uk

Supporting and refuting arguments

Bioethical question	
Science behind the issue Look for relevant and valid evidence	
Supporting arguments	Which ethical framework?
1.	
2.	
3.	

**APPENDIX P: REFLECTION TEMPLATES FOR TEACHERS AND
STUDENTS**

Teacher Evaluation sheet of Unit

1. Comment on how well the students were able to develop a personal viewpoint on the issue.
2. Comment on how well they analysed and gave reasons for their viewpoint.
3. Describe the students' ability to discuss the kind of ethical thinking they used to develop their personal viewpoint.
4. Comment on the students' ability to adopt an alternative viewpoint and defend it.
5. Comment on the usefulness of the model of inquiry. What were some of the strengths and weaknesses of the model?
6. What changes would you like to make? You could mark these on your copy of the model

7. What tools/strategies did you use to develop the students' ethical thinking? How useful did you find these tools/strategies?

8. Please comment on how useful you found the bioethics interactive tool. What were some of the strengths and weaknesses?

9. What changes would you like to make? You could mark these on your copy of the model

10. Was there any unexpected learning that occurred?

11. Any further comments you would like to make?

Student evaluation sheet for Unit

What were some interesting things that you learned about in this unit?

Did your opinion about the issue change in any way during the unit? If so, what caused the change?

Discuss the kind of ethical thinking did you use to develop your opinion?

Comment on how well you felt you were able to defend your viewpoint.

APPENDIX Q: TEMPLATES FOR TEACHER REFLECTIVE JOURNALS

REFLECTIVE JOURNAL

TOPIC:

Date:

LEARNING INTENTIONS:

Were learning intentions achieved?

What evidence shows this? eg students comments, student work, formative assessment

What were the strengths of this lesson?

What were the weaknesses?

What improvements could be made?

Were the students engaged and motivated?

APPENDIX R: WORKSHOP 2 POWER POINT

Reporting and evaluating on classroom trials for bioethics education

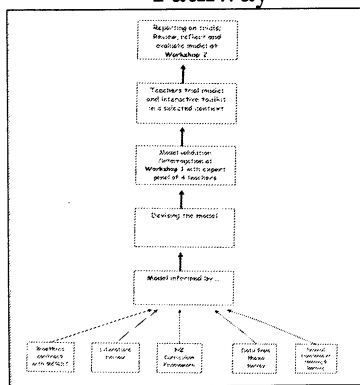
Day 2
October 2007

Objectives for Day 2

- To share and evaluate trialed classroom based resources for bioethics education
- To critique the model for introducing bioethics/controversial issues into science classroom programmes
- To evaluate some tools for introducing ethical thinking to students

This project is supported by the Bioethics Council of NZ, University of Waikato and Curtin University of Technology, Perth

Pathway

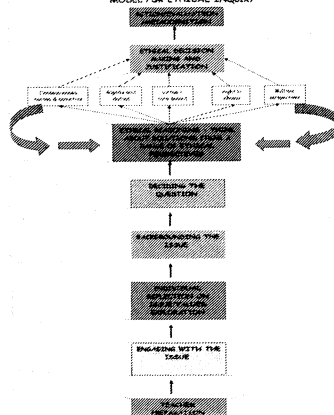


A model of ethical inquiry

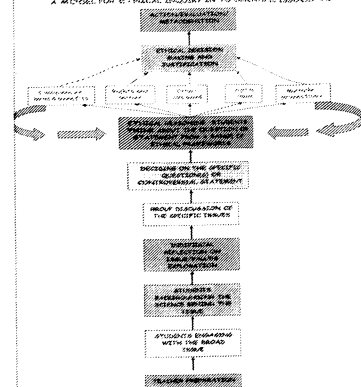
Informed by

- Literature review
- Draft science curriculum
- Data from teacher survey
- Bioethics contract
- Personal experiences
- TEACHER CRITIQUE

MODEL FOR ETHICAL INQUIRY



A MODEL FOR ETHICAL INQUIRY IN TO SCIENTIFIC ISSUES VS



Classroom trials

Individually share with us.....

- The unit you trialed – context, class level, sequence of teaching and learning activities
- Student work if possible
- Student evaluations
- Your evaluation and reflection of the unit

Impact of unit on student outcomes				
Student Outcomes	Declined	No improvement	Limited improvement	Substantial improvement
SOCIAL e.g. Behaviour, interactions with peers, teacher, sensitivity to others, sensitivity to other viewpoints				
PERSONAL e.g. Identity, informed decision making, self concept, self esteem				
ACADEMIC Engagement in tasks, thinking skills, development of argument, increase in science knowledge, increase in ethical knowledge, understanding of nature of science				
OTHER				

As a group....critiquing the model of inquiry

- 6. Usefulness of the model ?
- 6. Strengths
- 6. Weaknesses
- 7. How could it be improved?

Traditionally four main ethical frameworks are proposed in addressing bioethical issues. In this model a fifth one – multiples perspectives has been added

- What comments do you have on incorporating this dimension in to the model?

Model - strategies/ tools

- 8.What tools/strategies/approaches did you use?
- 8.How useful were these?
- Are there some you would like to add/or delete?

Model - question starters/prompts

- Was the list of question starters/prompts useful?
- In what ways ?
- Are there some you would like to add/or delete?

Bioethics interactive tool for frameworks of ethical thinking

- 9. How did you use it?
- 9. Strengths
- 9. Weaknesses
- 10. How could it be improved?

Overall....

- How has your students' learning been enhanced/challenged/reshaped?
- How has your knowledge developed/changed over the time of this project in terms of ethical thinking and decision making.
- How has your awareness of teaching and learning strategies changed?
- 11. Unexpected learning for you/students?
- 12. Further comments?

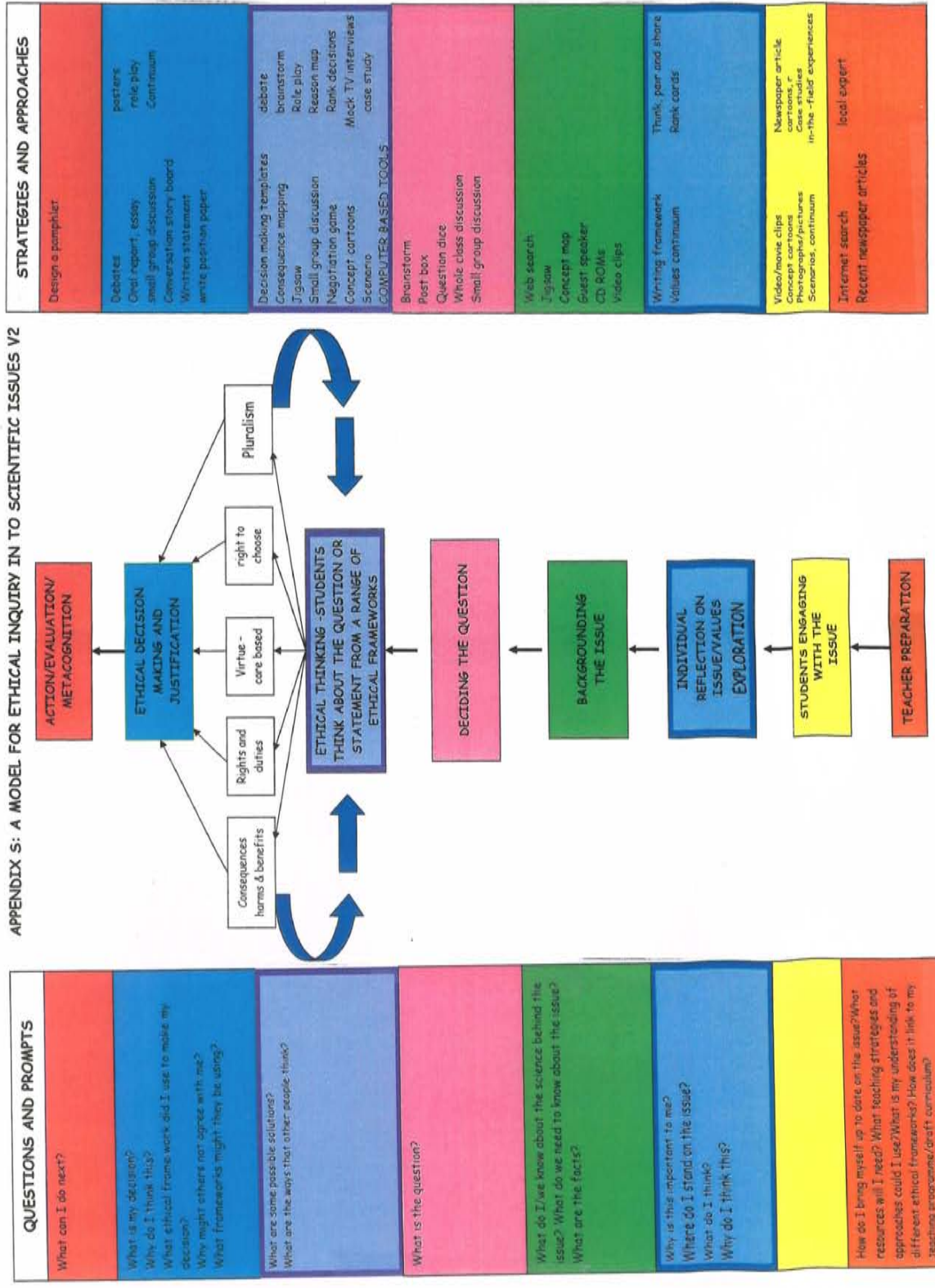
WHERE TO NEXT?

SUSTAINABILITY?

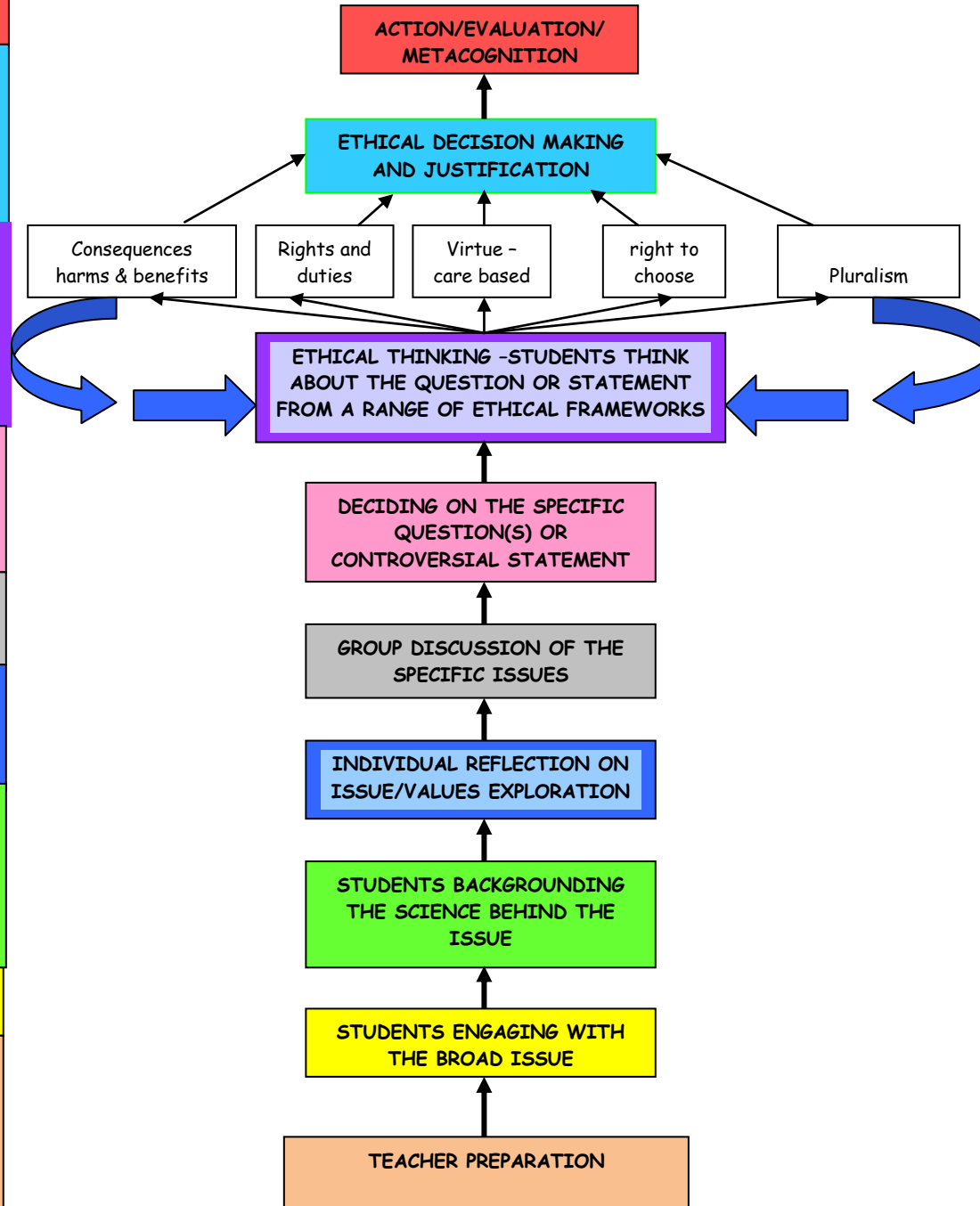
**THANK YOU VERY MUCH FOR
YOUR PARTICIPATION AND
CONTRIBUTIONS TO THIS
PROJECT**

APPENDIX S: MODEL FOR ETHICAL INQUIRY VERSION 2

APPENDIX S: A MODEL FOR ETHICAL INQUIRY IN TO SCIENTIFIC ISSUES V2



**Appendix T
MODEL FOR ETHICAL INQUIRY INTO SCIENTIFIC ISSUES V3**



QUESTIONS AND PROMPTS
What can I do next? How has my thinking changed?
What is my decision? Why do I think this? What ethical frame work did I use to make my decision? Why might others not agree with me? What frameworks might they be using?
What are some possible solutions? Who/what will be affected by the decision? How will they/it be affected by the decision? What other ways can I think about the issue? What are the ways that other people think? What does it feel like in other people's shoes?
What is the question? How do we write an ethical question? What might be a controversial or provocative statement?
What are the main arguments in this issue?
Why is this important to me? Where do I stand on the issue? What do I think? Why do I think this?
What do I/we know about the science behind the issue? What do we need to know about the issue? What words can't I understand? What are the facts? How reliable is our information source?
How do I bring myself up tp date on the issue? What resources will I need? What teaching and learning strategies could I use? What is my understanding of ethical frameworks? How does this link to my teaching programme/ curriculum document?

STRATEGIES AND APPROACHES	
Design a pamphlet Posters	Submission
Debates Design a pamphlet Oral report, essay small group discussion Conversation story board Written statement write position paper	newsletter posters role play speech bubbles think,,pair,share Continuum video
Decision making templates Consequence mapping Jigsaw Small group discussion Negotiation game Concept cartoons Mock TV interviews COMPUTER BASED TOOLS	debate brainstorm Role play Reason map Rank decisions Scenario case study
Brainstorm Post box Whole class discussion Small group discussion	Starburst Question dice
Negotiation game Brainstorm Three/four of a kind Consequences wheel	fishbone
Writing framework Values continuum PMI	Think, pair and share Rank cards Negotiation game
Web search Jigsaw Guest speaker Video clips KWL	Web quest Concept map Case studies CD ROMS
Video/movie clips Concept cartoons Role plays Photographs/pictures Scenarios,	Newspaper article cartoons, continuum Case studies in-the -field' experiences
Internet search Recent newspaper articles	local expert