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TEACHING ETHICS IN THE PRIMARY SCIENCE CLASSROOM: PLANNING SUPPORT FOR TEACHERS

A thesis

submitted in fulfilment

of the requirements for the degree of

Master of Education

by

BARBARA ELIZABETH RYAN



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

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ABSTRACT

The work presented in this thesis focuses on teaching ethics in primary science classrooms. Such teaching is important because it engages students not only in the human aspects of science, but also in science more generally, leading to enhanced scientific literacy and ultimately contributing to responsible citizenship. Teaching ethics in science also presents opportunities for developing students' argumentation, critical thinking and decision-making skills, and helps students become more ethically aware, knowledgeable and discerning in science. Ethics in science has a prominent role in the New Zealand Curriculum within the 'nature of science' strand in the science learning area. However, there is a paucity of research demonstrating how this might be implemented with primary-age students.

This work determines firstly whether primary students can engage in ethical discussions in science. Secondly, it focuses on the question of support needed for primary teachers and whether it is helpful for teachers to use a subject-specific planner for teaching ethics in science. The research adopted a sociocultural view of learning, in which learning is understood to be of a social and collaborative nature. The research involved two teacher development sessions, where three teachers were introduced to ethics concepts, examples on how they could be taught in a science context, and an ethics-in-science planner. Teachers subsequently developed and implemented an ethics in science programme using the ethics-in-science planner in their classrooms.

The data for this research were collected from three teachers within the same school. Document analysis, interviews and classroom observation provided data triangulation. The findings suggest that young students can engage in ethical discussions in science – and do so, enthusiastically. They also confirm that primary teachers need support to teach ethics in science. For example, all three teachers reported the development sessions were necessary to help them understand ethics concepts and to give them ideas and strategies for teaching ethics in science. This is supported by research

demonstrating that intervention in the form of teacher development and planning is vital for teachers to develop pedagogical content knowledge in a new area. In particular, teachers reported that the ethics-in-science planner helped them consider the classroom interactions on which they wanted to focus the outcomes, demonstrating that ethics in science can be meaningfully taught in the primary classroom. This raises the issue of teacher development and how this would be funded and implemented for the purpose of developing the pedagogical content knowledge of primary teachers for the teaching of ethics in science.

One way to support teachers' work with science curricula is through the development of educative curriculum materials, or those that are designed to promote teacher learning as well as student learning... especially in regard to the value-laden landscape of socioscientific issues.

(Forbes & Davis, 2008, p. 832)

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TABLE OF CONTENTS

Abstract.....	i
Acknowledgements.....	v
Table of contents.....	vi
List of appendices.....	xi
List of figures.....	xiv
List of tables.....	xv

CHAPTER 1

INTRODUCTION AND OVERVIEW.....	1
1.1 INTRODUCTION.....	1
1.2 MY PERSONAL JOURNEY.....	5
1.3 THE CURRENT RESEARCH.....	7
1.4 OVERVIEW OF THE THESIS.....	8

CHAPTER 2

A REVIEW OF THE LITERATURE.....	11
2.1 INTRODUCTON.....	11
2.2 WHAT IS ETHICS IN SCIENCE EDUCATION?.....	12
2.2.1 Morality.....	13
2.2.2 Values.....	15
2.2.3 Ethics.....	16
2.2.4 Bioethics and ethics in science.....	17
2.3 ARGUMENTS FOR TEACHING ETHICS IN SCIENCE.....	18
2.3.1 Moral development.....	19
2.3.2 Education for informed citizenship.....	21
2.3.3 Engaging students in science.....	22
2.3.4 Developing critical thinking and decision-making skills.....	23
2.3.5 Understanding scientific and technological advancements.....	24
2.3.6 Developing flexible thinking for changing ideas.....	25
2.3.7 Valuing multiple perspectives.....	25
2.3.8 Raising ethical awareness, knowledge and judgement in science.....	26
2.3.9 Arguments against and the way forward.....	27
2.4 ETHICS IN THE NEW ZEALAND SCIENCE CURRICULUM.....	28
2.4.1 The 1993 New Zealand science curriculum.....	28
2.4.2 The 2007 New Zealand science curriculum.....	29
2.4.3 The national curriculum and the enacted curriculum.....	31
2.5 ESTABLISHED ETHICAL APPROACHES.....	34
2.5.1 Consequentialism.....	35
2.5.2 Rights and responsibilities.....	36
2.5.3 Autonomy.....	37
2.5.4 Virtues ethics.....	37
2.5.5 Multiple perspectives.....	38
2.5.6 Additional ethics approaches.....	39
2.5.7 Summary.....	40
2.6 TEACHING ETHICS IN SCIENCE.....	41
2.6.1 Teaching frameworks.....	41
2.6.2 Common teaching topics.....	43

2.6.3	Classroom activities and strategies.....	44
2.6.4	Resources.....	45
2.6.5	A pilot study: Ethics in science primary classrooms.....	46
2.7	DESIGNING CLASSROOM PROGRAMMES.....	48
2.7.1	Views of learning.....	48
2.7.2	Argumentation.....	50
2.7.3	Narrative strategies.....	53
2.7.4	Scaffolding.....	57
2.7.5	Pedagogical content knowledge (PCK).....	59
2.7.6	Teacher development.....	61
2.7.7	Planning.....	62
2.8	SUMMARY AND RESEARCH QUESTIONS.....	65
CHAPTER 3		
RESEARCH METHODOLOGY.....		
3.1	INTRODUCTION.....	69
3.2	INTERPRETIVE RESEARCH.....	70
3.3	CASE STUDY.....	73
3.3.1	Notions of validity and reliability.....	75
3.4	METHODS.....	79
3.4.1	Observations.....	79
3.4.2	Interviews.....	80
3.4.3	Surveys.....	81
3.4.4	Primary documents.....	81
3.5	RESEARCH SETTING.....	82
3.5.1	The participants.....	83
3.5.2	The researcher.....	84
3.6	ETHICAL CONSIDERATIONS IN EDUCATION RESEARCH.....	85
3.6.1	Informed consent.....	85
3.6.2	Privacy and confidentiality.....	86
3.6.3	Protection of participants from potential harm.....	86
3.6.4	Other ethical concerns.....	88
3.7	CHAPTER SUMMARY.....	89
CHAPTER 4		
THE TEACHER DEVELOPMENT PROGRAMME.....		
4.1	INTRODUCTION.....	91
4.2	SESSION 1: INTRODUCING ETHICAL THINKING.....	92
4.2.1	Defining ethics and reasons for teaching ethics.....	92
4.2.2	The takahe example.....	93
4.2.3	Introducing the ethics approaches.....	94
4.2.4	Identifying ethical issues.....	95
4.2.5	Activities and strategies.....	97
4.2.6	Introducing the classroom planner for teaching ethics in science.....	98
4.3	MODIFYING THE ETHICS-IN-SCIENCE PLANNER.....	99
4.4	SESSION 2: INTRODUCING THE CLASSROOM PLANNER.....	103
4.4.1	Exploring the takahe issue in the science-in-ethics planner.....	103
4.4.2	Why teachers might use this planner.....	104
4.4.3	Exploring the planner.....	105
4.4.4	Planning a classroom programme.....	106
4.5	CHAPTER SUMMARY.....	109

CHAPTER 5

CLASSROOM FINDINGS.....	111
5.1 INTRODUCTION.....	111
5.2 LYNDA'S CLASSROOM PROGRAMME.....	112
5.2.1 Links with the science learning.....	113
5.2.2 Exploring ethical perspectives.....	114
5.2.2.1 <i>Using a 'space jump' activity to understand consequences.....</i>	115
5.2.2.2 <i>Using a noisy round robin activity to identify consequences for stakeholders.....</i>	115
5.2.2.3 <i>Using a PMI (Plus-minus-interesting) analysis to identify consequences for stakeholders.....</i>	117
5.2.3 Formulating an argument through role-play.....	118
5.2.3.1 <i>Mantle of the expert (role-play).....</i>	118
5.2.3.2 <i>'What do you think?' worksheet.....</i>	123
5.2.3.3 <i>Transactional writing.....</i>	124
5.2.4 Student learning.....	126
5.2.4.1 <i>Transactional writing.....</i>	126
5.2.4.2 <i>Student views of their learning.....</i>	134
Conceptual learning.....	134
Considering multiple viewpoints.....	135
Confidence in decision-making.....	136
Thinking about ethics.....	136
5.2.4.3 <i>Activities for learning.....</i>	138
5.2.4.4 <i>Home support.....</i>	140
5.2.5 The teacher development programme.....	141
5.2.5.1 <i>Teacher development.....</i>	141
5.2.5.2 <i>Use of the classroom ethics-in-science planner..</i>	142
Science context.....	142
Science curriculum links.....	142
Ethics question.....	142
Relevant science knowledge.....	143
Ethical approaches and questions.....	143
Ethics focus questions.....	143
Activities and strategies for intended learning.....	143
5.2.6 Summary.....	144
5.3 AMY'S CLASSROOM PROGRAMME.....	145
5.3.1 Links with the science learning.....	147
5.3.2 Exploring ethical perspectives.....	148
5.3.2.1 <i>Understanding consequentialism through class discussion.....</i>	149
5.3.2.2 <i>Using familiar scenarios to identify consequences.....</i>	150
5.3.2.3 <i>Defining stakeholders through class discussion.....</i>	152
5.3.2.4 <i>Listing the stakeholders.....</i>	154

	5.3.2.5	<i>Prioritising stakeholders and introducing rights and responsibilities.....</i>	154
	5.3.2.6	<i>Identifying benefits and harms in various viewpoints.....</i>	156
	5.3.2.7	<i>Using a PMI framework to identify stakeholder benefits and harms.....</i>	157
5.3.3		Formulating an argument through role-play.....	159
5.3.4		Student learning.....	161
	5.3.4.1	<i>Presenting arguments through role-play.....</i>	161
	5.3.4.2	<i>Student views of their learning.....</i>	162
		Conceptual learning.....	162
		Considering multiple viewpoints.....	163
		Confidence in decision-making.....	164
	5.3.4.3	<i>Activities for learning.....</i>	165
5.3.5		The teacher development programme.....	166
	5.3.5.1	<i>Teacher development.....</i>	166
	5.3.5.2	<i>Use of the classroom ethics-in-science planner..</i>	168
		Science context.....	169
		Science curriculum links.....	169
		Ethics question.....	170
		Relevant science knowledge.....	170
		Ethical approaches and questions.....	170
		Ethics focus questions.....	170
		Activities and strategies for intended learning.....	171
5.3.6		Summary.....	171
5.4		ANTON'S CLASSROOM PROGRAMME.....	172
	5.4.1	Links with the science learning.....	174
	5.4.2	Exploring ethical perspectives.....	176
	5.4.2.1	<i>Using a values continuum.....</i>	176
	5.4.2.2	<i>Using class discussion to identify consequences.....</i>	177
	5.4.2.3	<i>Using class discussion to identify and list stakeholders.....</i>	177
	5.4.2.4	<i>Using a noisy round robin activity to identify benefits and harms to stakeholders.....</i>	178
5.4.3		Formulating an argument through role-play.....	179
5.4.4		Student learning.....	180
	5.4.4.1	<i>Student views of their learning.....</i>	181
		Conceptual learning.....	181
		Considering multiple viewpoints.....	184
		Confidence in decision-making.....	184
	5.4.4.2	<i>Activities for learning.....</i>	185
5.4.5		The teacher development programme.....	186
	5.4.5.1	<i>Teacher development.....</i>	186
	5.4.5.2	<i>Use of the classroom ethics-in-science planner..</i>	188
		Science context.....	189
		Science curriculum links.....	189
		Ethics question.....	189
		Relevant science knowledge.....	189

	Ethical approaches and questions.....	190
	Ethics focus questions.....	190
	Activities and strategies for intended learning.....	190
5.4.6	Summary.....	191
5.5	CROSS-CASE ANALYSIS.....	192
5.5.1	Exploring ethical perspectives in science.....	193
5.5.1.1	<i>Incorporating ethics into an existing programme.....</i>	193
5.5.1.2	<i>Linking with the science context.....</i>	194
5.5.1.3	<i>Collaboration.....</i>	196
5.5.1.4	<i>Ethical approaches.....</i>	198
5.5.1.5	<i>Activities and strategies.....</i>	201
	Engagement.....	202
	Benefiting all students.....	203
	Authenticity.....	205
	Argumentation.....	207
	Scaffolding.....	208
	Teacher direction.....	209
5.5.1.6	<i>Critical thinking and multiple perspectives.....</i>	209
5.5.1.7	<i>Summary.....</i>	211
5.5.2	Student learning.....	212
5.5.2.1	<i>Progression in ethical thinking.....</i>	213
5.5.2.2	<i>Science learning.....</i>	215
5.5.2.3	<i>Nature of science.....</i>	216
5.5.2.4	<i>Teaching time.....</i>	217
5.5.2.5	<i>Summary.....</i>	220
5.5.3	Teacher development including the ethics-in-science planner.....	221
5.5.3.1	<i>Teacher development sessions.....</i>	221
5.5.3.2	<i>Teacher knowledge.....</i>	223
5.5.3.3	<i>The ethics-in-science planner.....</i>	224
5.5.3.4	<i>Summary.....</i>	226
5.6	CHAPTER SUMMARY.....	227
CHAPTER 6		
DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS.....		
6.1	INTRODUCTION.....	229
6.2	DISCUSSION OF THE FINDINGS.....	230
6.2.1	Sociocultural perspectives of teaching and learning ethics in science.....	230
6.2.2	Exploring ethical perspectives in science.....	232
6.2.3	Enhancing student learning.....	235
6.2.4	Teacher knowledge and development.....	238
6.2.5	The ethics-in-science planner.....	242
6.3	RESEARCH CONCLUSIONS.....	244
6.4	IMPLICATIONS FOR TEACHING AND LEARNING.....	246
6.5	RECOMMENDATIONS FOR FUTURE RESEARCH.....	249
6.6	FINAL COMMENTS.....	250
REFERENCES.....		
252		

LIST OF APPENDICES

APPENDIX 1	Science lesson planner: Takahe: An endangered species (Ethics lesson: Micro task 9).....	269
APPENDIX 2	Survey and interview questions for the students Interview questions for the teachers.....	279
APPENDIX 3	Power point presentation 1: Teacher development session 1	280
APPENDIX 4	Power point presentation 2: Teacher development session 2	284
APPENDIX 5	Informed consent letters and forms.....	289
APPENDIX 6	Plus, minus and interesting (PMI) format for use with ethics lesson in science unit: Takahe: An endangered species.....	296
APPENDIX 7	Noisy round robin strategy for ethics lesson in unit: Takahe: An endangered species.....	297
APPENDIX 8	Example chart of student responses: Consequences for saving the takahe – ethics lesson in science unit: Takahe: An endangered species.....	298
APPENDIX 9	‘What do you think?’ worksheet used in ethics lesson from science unit: Takahe: An endangered species.....	299
APPENDIX 10	Ethical approaches and questions that could be used as a framework for teaching ethics in science (Jones et al., 2007).....	300
APPENDIX 11	Activities and strategies teachers could use for intended learning.....	301
APPENDIX 12	Plus, minus and interesting (PMI) format for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?.....	302

APPENDIX 13	
	The noisy round robin strategy adapted for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?.....303
APPENDIX 14	
	‘What you think?’ worksheet for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?.....304
APPENDIX 15	
	Ethics-in-science example planner: Should money and effort be spent understanding and saving the takahe?.....305
APPENDIX 16	
	‘Fire retardants: An advantageous solution to fire protection’. An article all teachers had access to.....309
APPENDIX 17	
	Notes on chemical fire retardants that were given to the teachers...311
APPENDIX 18	
	‘Slowing the burning’. An article all teachers had access to.....313
APPENDIX 19	
	Science unit plan: The science of fire.....315
APPENDIX 20	
	Consequences for specific stakeholders as identified by students in the noisy round robin activity.....317
APPENDIX 21	
	Consequences for specific stakeholders as identified by students in a PMI analysis.....319
APPENDIX 22	
	An example assessment checksheet for transactional writing from Lynda’s classroom.....321
APPENDIX 23	
	Lynda’s classroom ethics-in-science planner.....322
APPENDIX 24	
	‘The flammability of fabrics’. An article used by Amy’s class (questions by Amy).....326

APPENDIX 25	
	Viewpoints on the use of chemical fire retardants selected from the Internet by Amy.....327
APPENDIX 26	
	Class-generated lists of stakeholders affected by whether chemical fire retardants in furniture should be made a regulation in New Zealand (for both Amy and Anton’s classes).....329
APPENDIX 27	
	A list of stakeholders and consequences generated by student groups.....330
APPENDIX 28	
	Class results from PMIs asking whether chemical fire retardants should be used in furniture.....332
APPENDIX 29	
	Responses made to the prime minister about whether chemical fire retardants in furniture should be a regulation.....333
APPENDIX 30	
	Amy’s classroom ethics-in-science planner.....334
APPENDIX 31	
	Controversy over fire-retardant chemicals. An article selected and used by Anton in his class.....336
APPENDIX 32	
	Articles on chemical fire retardants selected and used by Anton in his class.....338
APPENDIX 33	
	Benefits and harms to stakeholder groups, collated from the PMI worksheets.....343
APPENDIX 34	
	Anton’s classroom ethics-in-science planner.....345

LIST OF FIGURES

Figure 2.1	The first layer of a science education planner (InSiTE Project, 2006).....	63
Figure 2.2	The second layer of a science education planner (InSiTE Project, 2006).....	64
Figure 5.1	Tim’s argument.....	127
Figure 5.2	Peter’s argument.....	129
Figure 5.3	Julie’s argument.....	130
Figure 5.4	James’ argument.....	132

LIST OF TABLES

Table 4.1	Summary of what the teachers identified as ethical issues.....	96
Table 4.2	Prototype of the ethics-in-science planner.....	99
Table 4.3	Prototype lesson sequence plan for teaching ethics in science.....	99
Table 4.4	The ethics-in-science planner.....	100
Table 5.1	Results of vote for fire retardant seating in a movie theatre..	122
Table 5.2	‘What do you think?’ worksheet responses.....	123
Table 5.3	Some examples of consequences identified by student groups in response to a given scenario.....	151
Table 5.4	Student responses to the survey question: “Tell me about some of the things you learned”	163

Chapter 1

Introduction and overview

1.1 INTRODUCTION

The inclusion of ethical issues into the teaching of science is becoming crucially important in science education (Jones, McKim & Reiss, 2010; Zeidler & Sadler, 2008). This is because the notions of what it means to learn science are expanding to include not only the practical utility of science but also the importance of preparing students to participate as effective citizens who are scientifically literate.

The inclusion of ethics in science education is associated with the international trend towards including values in science education (Atkin & Black, 2003; Corrigan, Dillon & Gunstone, 2007; Hildebrand, 2006; Jenkins, 2006; Reiss, 1993; Tobin & Roth, 2007). The literature contends, though, that values to a greater or lesser degree have been associated with science education since its earliest years. For example, Aikenhead (2006), Atkin and

Black (2003), Bull, Gilbert, Barwick, Hipkins and Baker (2010) Jenkins (2006) and Tobin and Roth (2007) describe ongoing, at times conflicting, redefining of science curricula over the last century and a half. However, there was strong resistance from many science educators and Reiss (1999) suggests that the apparent separation of values from science over this time was a phenomenon probably fuelled by conflict with religion. As a result science in school curricula was seen to be objectively neutral (Gunstone, Corrigan & Dillon, 2007), with secondary schools in particular emphasising scientific knowledge as objective facts (Bull et al., 2010). Science educators also resisted bringing science closer to everyday life, with Gunstone et al. pointing out that science was taught in the 1950s and 1960s as if in a historical and social vacuum. For example, references made to carbon did not indicate any use or application of carbon. Topics related to electricity did not include how electricity was used. The more academic emphasis given to science was to try to help students think the way a scientist thinks, to encourage students into careers as scientists.

Whilst a more academic approach to science education was being discussed throughout the western world in the 1960s, Jenkins (2006) points out that scientists were becoming concerned with particular issues, such as inappropriate use of pesticides, and recognition of diminishing fossil fuel and food at a global level. The educational response to this was the formation of the science-technology-society (STS) movement, advocating the inclusion of scientific issues with a humanistic content in the science curriculum (Aikenhead, 1994, 2003, 2006). Some science educators then extended STS by including environmental issues (science-technology-society-environment (STSE)). However, although Zeidler, Sadler, Simmons and Howes (2005) suggest STSE education was an improvement over STS, they comment that it (along with STS) was lacking in "...discourse, reasoned arguments, explicit nature of science, emotive, developmental, cultural or epistemological connections within the issues themselves" (p. 359). Zeidler et al. comment that the later development of socioscientific issues (SSI) targeted these aspects that were lacking in STS(E). Zeidler and Sadler (2008) suggest SSI as a powerful anchor for situating social and ethical issues in science education.

SSI subsumes STS(E) and in addition “empowers students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them” (Zeidler et al., 2005, p. 360). These issues provide complex science contexts for students to learn in and make reflective decisions – particularly concerning, as Hodson (2003) puts it, what is good, right and just.

Thus, the exponential growth in science and technology and subsequent controversies that resulted, forced science educators to recognise that science needs to be taught in schools in conjunction with values inherent in society and culture. It became increasingly accepted that goals of science education needed to include informed citizenship (Jenkins, 2006) and science for all (Reiss, 1993; Tobin & Roth, 2007). ‘Science for all’, as used here, relates to a goal where science (including knowledge, skills and attitudes) is made available to all students so that they become scientifically literate (American Association for the Advancement of Science, 1989); that is, they are aware of the interdependence of science (and related mathematics and technology) with human society and that it has strengths and limitations; and they understand key concepts and principles of science and can use scientific knowledge and scientific ways of thinking for individual and social purposes.

Humanistic perspectives and values are thus embedded within many school science curricula and students tend to be viewed as consumers of everyday science rather than only as future scientists (Aikenhead, 2003, 2006). Values in science education were and are still being developed through frameworks such as ‘essential learning’, ‘rich tasks’, and ‘productive pedagogies’ (Gunstone et al., 2007). Values are being critically and reflexively redefined. The New Zealand Curriculum (Ministry of Education [MoE], 2007) not only embraces values to produce life-long learners, but also mandates the teaching of ethics in science. This is emphasised through the ‘nature of science’ strand in the science learning area, and has opened the way for

ethical approaches (ways of exploring values) to be incorporated into school science.

Internationally, science educators have been calling for more explicit teaching of the nature of science as part of scientific literacy (e.g., Driver, Leach, Millar & Scott, 1996; Irwin, 2000; McComas, 1998). Curriculum writers also recognise that learning about ethics in science is an important component of science literacy (Jones et al., 2007; Lehr, 2007; Zeidler et al., 2005). In addition, teaching ethics in science can engage students in science as well as present opportunities for developing student argumentation (discourse), critical thinking and decision-making skills, making students ethically aware, knowledgeable and discerning in science (Jones et al., 2010).

In spite of curriculum calls to teach ethics in science, studies suggest that few teachers do and even fewer teach it well (Hipkins et al., 2002; Jones, 2005; Lundmark, 2002; Saunders, 2009; Slingsby, 2008). While there is at least some ethics teaching undertaken in New Zealand secondary schools, it appears that little ethics in science teaching is occurring in New Zealand primary schools, in part because science generally does not tend to be taught to any significant extent in primary schools (Bolstad & Hipkins, 2008; Bull et al., 2010; Cox, 2009; Crooks, 2008; Gerritsen, 2009; Milne, 2008; National Educational Monitoring Project (NEMP), 2008). One reason for this could be that primary teachers generally do not have science backgrounds and therefore do not have adequate science knowledge and consequently are not confident teaching science (Forbes & Davis, 2008; Wine, Moreland, Jones, & Cowie, 2005). Another reason could be that teaching ethics in science is a new area of the curriculum. Although values in science were alluded to in the 1993 New Zealand science curriculum (MoE, 1993), the teaching of ethics in science has only become explicit in the 2007 curriculum (MoE, 2007). Teachers, therefore, need teacher development to learn about ethics, ethical approaches and strategies to be able to teach ethics in science in the primary classroom (Jones et al., 2007).

Bell and Gilbert (1994) and Moreland, Cowie and Jones (2008) demonstrate that intervention in the form of teacher development and planning are vital for teachers to develop pedagogical content knowledge (PCK) – a unique domain of teacher knowledge that is a blend of content, subject matter and pedagogy in such a way that students can learn the idea being taught. This thesis argues that teachers need such support to be able to teach ethics in science in primary schools. The focus for the project was developed out of my personal experiences of science teaching and a scholarly introduction to ethics and ethics teaching and learning.

1.2 MY PERSONAL JOURNEY

I have taught in primary schools for over thirty years. During this time I endeavoured to enhance my pedagogy to improve students' learning. Ideas and suggestions were used from educational research and from professional development courses.

In 2006 I was awarded a Science, Mathematics and Technology Teaching Fellowship funded by the New Zealand Government. This allowed me to take a year out of the classroom to join two teams at the University of Waikato, one developing teaching resources for the New Zealand Biotechnology Learning Hub (BLH) (www.biotechlearn.org.nz), and the other carrying out research in science and technology primary classrooms. The latter work, 'Interactions in Science and Technology Education' (InSiTE), was a three-year study exploring the nature of effective student-teacher interactions in science and technology primary classrooms. An important element of teacher development included a teaching planner that required participant readers to plan some of the interactions they would have with the students. Moreland, Cowie and Jones (2008) later reflected that, although quite detailed and time consuming to complete, the teachers discovered the value of being well prepared and having a well thought through unit. Using the planner seemed to enhance PCK for the teachers involved, and Cowie, Moreland, Jones and Otrell-Cass (2008) concluded, "One of the most effective means for developing... teachers' PCK was the use of a planning tool specific

to each subject” (p. 22). Personally, I could see the value of using such a planner for teaching.

In 2007 I returned to school as a specialist, teaching science and technology to middle and senior classes (Year levels 3-6). I used the InSiTE planners and encouraged the other teachers in the school to use them as well. I noticed my own teaching improving, particularly my questioning and facilitation of student discussion. The students were enthusiastic and seemed to develop a love for science and technology learning.

Part of my earlier work with the Biotechnology Learning Hub involved working with a research team to develop an online tool for teachers to use to teach ethics in science. In 2007, as part of this project (Jones et al., 2007), I observed primary teachers teaching ethics in science in other schools. I found it took time for teachers to understand established ethical frameworks and to use these as the basis for an approach for teaching ethics in science. Linking frameworks with an issue and finding and using appropriate teaching strategies and learning activities were not easy tasks. As a teacher in my own classroom, teaching ethics in science, I found the InSiTE planners were extremely helpful. They helped me to break down my tasks and think about how to link each one to a specific learning intention, for example, to include a task that would require students to listen to and understand the viewpoints of others in the context of the issue being taught.

In 2008 I completed a directed study about bioethics education in New Zealand. This helped me understand the development of bioethics and the current situation with regard to bioethics education and ethics in science more generally. It was an area in which I could see potential for developing critical thinking, discussion and decision-making skills that would be useful for life-long learning and living. Teaching ethics in science had worked well in my room, where students developed these skills, and I can testify that primary-aged students can be engaged in discussing scientific issues. However, the initial concepts of ethics and ethics in science contexts were difficult for teachers. I wondered how they could be supported to include

ethics in their science programmes. I knew the ethics in science workshop and the InSiTE planners had helped me. At the beginning of 2009 I embarked on the research presented here, in which I sought to develop a subject-specific planning document that could support primary teachers to teach ethics in science.

1.3 THE CURRENT RESEARCH

The research presented in this thesis focuses on teaching ethics in science to Year 5/6 students (9-10 year old). Three teachers and their classes participated from one school. The teachers participated in teacher development in ethics in science, which included using a specially developed subject-specific planner for teaching ethics in science. The teachers incorporated an ethics component into their science unit on fire. Data were collected and analysed from these lessons.

The research had two main aims. One was to explore whether Year 5/6 students can engage in and enjoy ethical discussions in science. The other was to develop and then trial a subject-specific planning tool that would support teachers in teaching ethics in science and consequently enhance student learning. A positive outcome for teachers might include increased confidence in teaching ethics in science and improved PCK. The two research questions are:

1. Can Year 5/6 students engage in exploring ethics in science?
2. Does a subject-specific planner help teachers teach ethics in science?

The project is significant in that it contributes to the field of teaching and learning about ethics in science. Scant research has been done in New Zealand and internationally in this area and on how Year 5/6 primary teachers can implement ethics in science lessons. The research has potential to contribute to teacher development programmes. Secondly, NEMP (2008) pointed out that science education is weak in New Zealand primary schools. It is possible that this project may contribute in a small way to student engagement in ethics in science and science more generally.

1.4 OVERVIEW OF THE THESIS

This thesis is organised into six chapters. The literature review in the second chapter provides an overview of morals, values, ethics, bioethics and ethics in science education. Some arguments for teaching ethics in science are presented followed by an explanation of the development of values and ethics in the New Zealand science curriculum. Current teaching of ethics in science internationally and nationally are then considered, as is literature related to aspects of learning that may result in effective teaching of ethics in science. These include argumentation, scaffolding, use of narrative strategies and PCK development. This chapter, therefore, seeks to situate the research questions in the broader educational literature.

An interpretive paradigm was used to frame the research since it seeks to understand social constructs in the teaching of ethics in science and to explore teacher interpretations of how ethics in science can be taught, as outlined in Chapter 3. This chapter also describes the specific methods that were used to gather and interpret data.

The findings from the research are presented in the next two chapters. Chapter 4 describes two teacher development sessions and the development of the ethics-in-science planner.

Chapter 5 presents the classroom findings as three separate case studies, discussing the teachers' classroom programmes, aspects of student learning, the teachers' views of their own learning, and their use of the ethics-in-science planner. Examples of student learning are also presented. Common themes identified in a cross-case analysis included the importance of: collaboration, understanding established ethical approaches, using appropriate teaching and learning strategies, and that adequate teaching time is needed for the ethics in science learning to take place.

Chapter 6 discusses these findings in light of the broader literature on the teaching of ethics in science programmes. The first section posits that the teaching and learning of ethics in science is consistent with sociocultural learning theory, and that it is of a social and collaborative nature and embedded in real situations. Findings concerning collaboration, established ethical approaches, teaching and learning strategies (for example, engagement through authentic or meaningful contexts and argumentation skills) are also discussed in light of the literature, as is the view that ethics in science learning can result in a progression of ethical thinking and moral development. The importance of teacher support in terms of teacher development and the use of a subject-specific planner are also discussed. Finally, methodological constraints and limitations are considered followed by implications and recommendations for future research.

Chapter 2

A review of the literature

2.1 INTRODUCTION

Chapter 1 provided a background and rationale for the research project and highlighted its purpose to explore whether Year 5/6 students can engage in ethical discussion in science, and to determine whether support in the form of a subject-specific planner can help teachers teach ethics in science. The purpose of this chapter is to provide a rationale for teaching ethics in science in the primary classroom, and consider the support teachers need to do this.

First, values and ethics are defined, and situated in a science context. Arguments for including the teaching of ethics in science education are then presented (Section 2.3). The development and place of ethics in New Zealand science curricula (MoE, 1993; 2007) is outlined in section 2.4. Some common and well-accepted approaches for exploring ethical issues are then

introduced in Section 2.5, followed by an overview of teaching ethics in science and some of the resources that are available (Section 2.6). Also described in this section is a pilot study demonstrating that primary students can engage in ethical discussions. The next section (2.7) explores aspects of learning that are likely to enhance teaching ethics in science in the primary classroom. These include views of learning and strategies that relate particularly to ethics teaching and learning. Finally, Section 2.8 summarises the literature and concludes with the research questions driving this thesis.

2.2 WHAT IS ETHICS IN SCIENCE EDUCATION?

Current concepts of teaching ethics in science education have come about largely through the development of bioethics. This term was first coined in the early 1970s by Van Rensselaer Potter who used it to describe an ethic that related to our obligations not only to people but also to the biosphere as a whole (Kuhse & Singer, 1999). The term then narrowed from an ecological ethic to be more commonly used in the study of ethical issues arising from the biological and medical sciences. Varga (1980), though, contends that bioethics is concerned with the various ethical problems of life sciences, which are not primarily medical. Although bioethics is still evolving in definition and as a field that can be agreed upon, it can reasonably be argued that it involves ethics within the realm of science.

Bioethics is a branch of applied ethics, and so the nature of ethics and morality and values that relate to it need to be explored before delving into bioethics and ethics in science more generally. Socrates (*fl.* 469 BCE), Plato (*fl.* 428 BCE) and Aristotle (*fl.* 384 BCE) developed ethics as a branch of philosophical inquiry into morality and values (Johnstone, 2009).

2.2.1 Morality

Morals are deep-seated beliefs about how humans should live, expressed in human behaviour. Mehlinger (1986) points out that throughout history people have sought answers as to how people should behave. The pursuit of these answers is for the same purpose, “preservation of the society while promoting individual happiness and security” (p. 17). Morals (and moral law) have governed societies in all cultures and religious groups throughout time. For example, the origins of morality for Western (Christian) and some Eastern (Judaic and Muslim) thought can be traced through such books as the Bible and the Koran. The origin of morality in Christianity has had a major influence in western thinking and behaviour (Russo, Sunal, & Sunal, 2004).

People with a Christian perspective assert that the source of morality is God (Lee, 1987a) based on the Biblical account of God creating human beings according to His image (Genesis 1:27, Recovery Version). Being created in God’s image meant that human beings had aspects of the attributes of God – holiness, righteousness, love and life, for example. The Law of Moses was introduced because people were not able to uphold the attributes of God (morality) due to their falling away from God. The Law of Moses, or the Ten Commandments (also known as the moral law), composed of such statements as “you shall not murder”, “you shall not commit adultery”, was likened by Lee (1987b) to a sheep’s fold – something to hold people. It provided an outward set of laws that would support the original inner sense (or moral conscience).

Mehlinger (1986) agrees that laws are different from morality. People may follow laws without a sense of moral obligation. Conversely, people may have a sense of morality that has nothing to do with any law. Some aspects of morality are backed by the law and have legal consequences if they are breached, such as the consequences for murder. Others have no reinforcing law, such as whether or not to stop and help a person carry a heavy load (Reiss, 2001).

While both Christianity and Judaism have their moral roots in the Old Testament, Christians also believe in the teachings of Jesus Christ in the New Testament. Christ expressed the divine attributes of God (love, light, holiness and righteousness) through His human virtues. His teaching lifted the concepts of the moral law of the Old Testament to a higher plane. The outward law dealt with the act of murder, but Christ dealt with the motive of murder – anger (Matthew 5:21-22). This is deeper than the requirement of the law and requires a higher life to fulfil; God’s life lived out through people. Lee (1987a) describes this as a shift from following the Old Testament law outwardly to having an inward sense of God that could help govern the behaviour of the believers. This, however, can only be achieved by being filled with God, resulting in the divine attributes (e.g., love, life, righteousness) being expressed in human virtues (e.g., kindness, honesty, caring, patience). This is Lee’s understanding concerning morality presented in the Bible, which has been taught through Christianity, and which has until recently permeated the development of Western thinking about morals.

Nowadays not everyone in Western societies accepts that morality comes from God, or that the Ten Commandments are the moral law to live by. Levinson and Reiss (2003) discuss the pluralistic society of the West where there is no longer a single set of shared moral values. From a secular worldview, Mehlinger (1986) holds that the sources of what human moral behaviour should be (to preserve a society) emerge from a combination of custom, religion, ideology and rationality.

Underpinning all moral statements, regardless of the cultural or spiritual context, is a common principle – to respect other people and treat them fairly (incorporating notions of love, life and righteousness). These moral principles are defended by all societies regardless of their culture (Kohlberg, 1980). However, individual societies may not share the same beliefs on how they decide what is right or wrong. These beliefs are described by values.

2.2.2 Values

While underpinning moral principles are the same across societies, values are not. Reed, Turiel and Brown (1996) describe values as “patterns of regulation entered into by all persons in a given environment and incorporated into their thoughts and actions” (p. 1). Turiel (1996) describes values as what is considered to be good and desirable for a particular society and links them to the realm of morality. Morals usually underpin values. Cultures and societies are diverse and what is considered good and desirable may be different for different groups of people. This can create conflict in values (Jeffreys, 1962). Conflicts epitomise the transient nature of values. What was not acceptable in a society fifty years ago may be acceptable and valued positively today. Jeffreys cites the example of artificial insemination by a donor (AID) being condemned as a sin in 1958 by church leaders (because the resulting child had a different biological father from the man married to its mother). Today AID is valued and accepted by Western society as a positive reprieve for those unable to conceive naturally. New knowledge, and particularly changes in technology (such as artificial insemination), contributes to the clashes and subsequent changes in values (Turiel, 1996).

Values can be associated with a social group or with individuals. Turiel points out that individuals’ moral, social and personal concepts contribute to a cultural setting and reflect diversity within that culture. Interactions between people highlight shared understandings, points of conflict and development of new ideas. Over time, points of conflict and new ideas can be transformed into new sets of values for a society.

A society’s values are reflected in the education of that society. Kohlberg (1980) argues that education is not and never has been value-free. Values have been ‘taught’ since schooling began in what he terms the “hidden curriculum” (p. 18). Teachers, educators and peers unintentionally or intentionally pass on their values to others. These values become part of the moral education and development of the student. Science educators in the past have tried to remove values from science to make it ‘pure’ and separate

from morality. Researchers today appreciate that people are moral (Mehlinger, 1986) and have values acquired from their culture that are reflected in their work. This includes values reflected in the teaching of science (Corrigan et al., 2007). Hildebrand (2007) goes further, arguing that values in a society should be examined and desired values deliberately encouraged in students, for their growth and to benefit the community in which they live.

Values, associated with morals and ethics, have been given prominence in recent curricula around the world. The New Zealand Curriculum (MoE, 2007) describes values as “deeply held beliefs about what is important or desirable” (p. 10). They ought to reflect the moral ‘stand’ of New Zealand’s society and what is desirable for passing on to the next generation. In this curriculum the encouraged values are: excellence; innovation, inquiry, and curiosity; diversity; equity, community and participation for the common good; and integrity. These values are broad, whereas ethics formalise these guidelines by offering a framework to support reasoning and discussion.

2.2.3 Ethics

The word ‘ethics’ originates from the Greek word ‘ethikos’ meaning custom or habit. The Latin word for morality is ‘moralitas’ and also means custom or habit. Although some argue that morality and ethics mean the same thing (e.g., Johnstone, 2009), Reiss (2001) defines ethics as probing the reasoning behind morality. He describes ethics as “the branch of philosophy concerned with how we should decide what is morally wrong and what is morally right” (p. 1). Ethics, from this perspective, involves a viewpoint explaining your moral standing. For example, you might feel that it is morally wrong to eat animals, but if you have an ethical viewpoint on it, you must have some sort of argument about why it is wrong to eat animals, or wrong to eat some animals but not others (Reiss, 2007). Ethical thinking within the context of biological science and technology is called bioethics.

2.2.4 Bioethics and ethics in science

Bioethics is the meeting place of morals, values, ethics and science and technology, and it has a recent history. Initially bioethics began as an educational ideal in an effort to 'humanise' medical education and practice (Pellegrino, 1999). Human values and ethics were introduced into the medical curriculum because medical education had been perceived as 'dehumanised' due to an overemphasis on the rising power of science and technology. Ethics assumed a more dominant role as more complex dilemmas emerged as the result of the rapid pace of biological research (for example, genetics and molecular biology) and changes in the health system (relating to social policy and an ethic of care).

Pellegrino (1999) suggests bioethics was first used simultaneously at the Universities of Georgetown and Wisconsin in the early 1970s. The Wisconsin view embraced biology, ecology, and the environment along with ethics, while the Georgetown view centred on theories for ethical discussion such as principlism (moral decision-making), deontology (duties and rights), utilitarianism, virtue, feminism, caring, narrative, or a combination of theories. Examining ethical issues became very broad, drawing on disciplines such as law, religion, anthropology, economics and psychology. Medical morality was transformed into a formal systematic study of issues significant to humanity.

Bioethicists often disagree among themselves over the limits of their discipline (Chadwick, 2007). However, Levinson and Reiss (2003) point out that although there is no single definition of bioethics, in most countries it is now used to discuss all questions about ethics in biology and medicine. Macer, Asada, Tsuzuki, Akiyama and Macer (1996) adopt a broader view, defining it as the study of ethical issues arising from human involvement with life, while Macer et al. and Bhardwaj and Macer (1999) define bioethics as the love of life, which includes the concept of balancing benefits and risks. It is the desire to do good and the need to avoid doing harm, and includes ideas of respect, justice, loving others as oneself and sharing (distributive justice).

Reiss (personal communication, March 24, 2009) defines bioethics as being about moral philosophy applied to life, which includes human health, environmental education and the treatment of sentient animals.

Bunting and Ryan (2010) found that primary teachers may favour the use of topics such as environmental issues and the treatment of research animals for teaching bioethics, rather than biotechnology issues that tend to be used at the secondary level. However, many areas of science and technology have associated ethical concerns, including those beyond the scope of a broad definition of bioethics.

In this research project primary teachers taught ethical issues relating to the use of fire retardants. To broaden the scope of teaching ethics in science, especially for primary teachers, the teaching of bioethics is subsumed in teaching ethics in science. Research literature for the teaching of bioethics is explored because it *is* teaching ethics in science and the principles can be applied in a broader context.

As discussed in the previous chapter, values have been included in science curricula as a response to increasingly accepted goals of ‘science for all’ and to produce scientifically literate citizens (Bull et al., 2010; Jenkins, 2006). The following section explores some of the arguments for doing so.

2.3 ARGUMENTS FOR TEACHING ETHICS IN SCIENCE

The explicit teaching of ethics in science is relatively new (Reiss, 2003). Students are taught to think and reason ethically in contexts of science and society, exploring values within science in science education. Current literature discusses why the explicit teaching of ethics in science is becoming important. Some of these reasons are as follows.

2.3.1 Moral development

Most moral development and reasoning models in recent years have been based on, or derived from, the structural stage model of Lawrence Kohlberg (Jones et al., 2007). His research, conducted over the past several decades on moral development, has attracted much attention from, and debates amongst, researchers (Rich & De Vitis, 1985; Schrader, 1990; Zeidler & Keefer, 2003). Kohlberg (1980), initially influenced by the writings of philosophical researchers such as Dewey and Piaget, produced a theory that was fundamentally different from previous researchers. He stated that moral development is universal: the same for everyone, irrespective of culture and unrelated to relative values seen in culture groups. His theory is composed of six stages, divided into three levels.

The first two stages are at the preconventional level where the child is responsive to cultural rules, and ideas of good and bad and right and wrong, and interprets these in terms of punishment and reward. The conventional level of stages three and four involve conformity to personal expectations and social order. In the principled level of stages five and six, moral values are clearly defined and have validity apart from the authority of groups or persons. Stage six in particular is about justice, human rights and respect for the dignity of human beings as individuals.

Kohlberg proposes that every person passes through these stages in sequence. Moral education, he claims, will stimulate moral development and move people through the stages more quickly than if left to develop naturally. He also found that not all people reached the higher stages, but believed moral education could help them do this.

Moral development can be stimulated by promoting thinking and problem-solving (Kohlberg, 1980; Rich & De Vitis, 1985). Turiel (1996) postulates that cognitive conflict is the central 'motor' for upwards movement through the stages and Kohlberg asserts such discussions should concern welfare and justice. Welfare and justice are the ultimate goal in stage

six and discussions should involve real life situations where decision-making is practised. Attempts, he says, should be made to arouse cognitive conflict, exposing students to moral reasoning at a higher stage than their current level.

Ethics in science offers contexts in terms of situated learning (real life situations) (Lave, 1991); cognitive conflict for problem-solving and higher order thinking; decision-making; and topics that relate to human welfare, respect and justice (Reiss, 2007). It has been argued that, if ethical teaching in science incorporates these aspects, it may stimulate moral development and reasoning (Kolhberg, 1980; Rich & De Vitis, 1985; Turiel, 1996), thus fulfilling the role of moral education espoused by Kolhberg.

Other researchers have added to or adjusted Kohlberg's moral development theory in various ways. The 'ethic of care' is one such example, with Gilligan (1982) describing how caring entails nurturing students' ethical ideas through narrative discussion, practice and example (modelling). Zeidler and Keefer (2003) have also developed a model for moral development that has multidimensional aspects for promoting scientific literacy that incorporates emotive belief systems and moral character development, as well as moral motivation, moral values, moral behaviour, moral identity and meta-moral characteristics. Ethical issues (Socioscientific Issues (SSI) and Science, Technology, Society and Environment (STSE)) are part of the model, which resembles a micro-society and involves processes of inquiry, discourse, conflict, argumentation, negotiation, compromise, decision-making and commitment. Zeidler and Keefer argue that teaching bioethics in the context of this model helps students weigh up arguments about scientific issues, using critical thinking skills, to make balanced, well-informed decisions that can be justified. Jones et al. (2007) also point out the importance of integrating cultural aspects, and that for this model to be implemented in New Zealand greater emphasis would need to be given to cultural aspects, particularly Māori perspectives.

Zeidler et al. (2005) comment that recent international research in science education emphasises the importance of not only the nature of science and scientific inquiry but also the “development of broad conceptual frameworks... that entail a commitment to the moral and ethical dimensions of science education – including the social and character development of children” (p. 358). Statements such as this emphasise the importance of moral and ethical reasoning and development within the sphere of science education, where it is hoped that such development might heighten the ethical sensitivity of students (Reiss, 1999). Zeidler et al. conclude:

If we as science educators wish to cultivate future citizens and leaders who care, serve the community, and provide leadership for new generations, then we have a moral imperative to delve into the realm of virtue, character and moral development. (p. 373)

In summary, the teaching of ethics in science may act as a form of moral education, stimulating moral development, reasoning and ethical sensitivity of students, all of which is important for the survival of future generations. Such teaching can cultivate future citizens who are scientifically and technologically informed.

2.3.2 Education for informed citizenship

Society is constantly changing (Black & Atkin, 1996). There are new technologies, new issues and new pressures. Harrison (1986) associates social issues with quality of life, discussing the role of scientists and technologists in the search for solutions to problems and the negative and positive impacts technological change has on society. She discusses the role of the public in being able to express their personal values with regard to these changes. Today’s students will become the public that Harrison is referring to. They need to know how to discuss these issues, how to form an opinion about them and how to reach an ethical conclusion. Not only should young people be well informed regarding biotechnologies and new and old sciences, but they also need to understand decision-making processes and how to use knowledge. Frazer and Kornhauser (1986) believe students should be able to define main problems and trends, realise that materials and

resources are limited, take into account the interests of various stakeholders, and have an awareness of different needs in different parts of the world.

Informed citizens with scientific knowledge and ethical understanding may help prevent future undesirable consequences. A contemporary example of unexpected consequences has been associated with the promotion of biofuels, where efforts to reduce global warming by promoting biofuels have resulted in the opposite effect (Grunwald, 2008). Rainforests have been denuded (clearing ground for biofuel crops) releasing carbon into the atmosphere. Also now apparent are world food shortages (because crops are being used for fuel), resulting in escalating living costs and compounding world hunger problems. The teaching of ethics in science helps inform future citizens, enabling them to become aware of possible consequences and giving them the ability to make better ethical judgements (Reiss, 1999).

It is difficult to foretell what the students of today will be confronted with in thirty years' time, but the majority of them will be ordinary citizens having to deal with the consequences of science, rather than scientists developing and implementing science. Science and technology produce facts and ideas, but cannot tell us what to do about them. Black and Atkin (1996) urge science educators to consider the need to teach ethical thinking in science to help prepare students for decision-making as future citizens. For such preparation to occur students firstly need to be engaged in science.

2.3.3 Engaging students in science

Recent research (Milne, 2008; NEMP, 2008; Reiss, 2000a) has found that students' interest wanes in science as they get older. Reiss (2000a) suggests one of the reasons for this (at the secondary level) is that students do not perceive very much of what is learned in science to be relevant. New Zealand primary school students appear to learn little in science and show a declining interest, particularly from Year 4 to Year 8 (Bolstad & Hipkins, 2008; Crooks, 2008; Gerritsen, 2009; Milne, 2008; NEMP, 2008). These

researchers suggest that teachers do not consider science sufficiently relevant to teach regularly.

Ethics in science contexts are real and many are relevant to students, including those at the primary level (Bunting & Ryan, 2010). Levinson (2003) points out students are often interested when science is engaging with such contextual, contemporary issues. For example, vaccine development may not sound engaging as a science topic, however, vaccines are relevant to primary students and when the issues of possible consequences are raised, students become engaged (Reiss, 1999). Reiss points out that science is no longer just science but incorporates science, the scientists and their work, those who fund them, and those who are affected by their actions. Ethics is inevitably and inexorably involved with science in most cases. Teaching from the ethics aspect can engage students in the science. Dolan, Nichols and Zeidler (2009) found that when science is taught in a provocative social setting using socioscientific issues, science content that may seem boring or irrelevant to primary students is brought to life, becoming interesting. Macer et al. (1996) point out that a number of teachers at the secondary level want to teach bioethics to help engage their students in science while Dawson (1999) found that exposure to ethics in science favourably affected students' attitudes to science. Engagement in science, particularly ethics issues, has a number of cognitive benefits for students such as the development of critical thinking and decision-making skills.

2.3.4 Developing critical thinking and decision-making skills

Teaching ethics in science creates opportunities for higher-order, or critical thinking among students. This comes about through situated learning that requires authentic (real) contexts and where new knowledge is constructed in a social environment (Bereiter, 1992; Brown, Collins, & Duguid, 1989; Glaser, 1993; Hennessy, 1993; Solberg, 2005). Ethics in science contexts should, therefore, be authentic and relevant to students.

Levinson (2003) notes that students are often interested when science engages with contemporary issues. New knowledge is gained through the sharing of knowledge with others (Hennessy, 1993). As individuals acquire knowledge in this way they are empowered to think and reason (Glaser, 1993). Pass and Willingham (2008) and Solberg (2005) suggest this type of learning develops critical thinking. Solberg also suggests that because bioethics “emerges from real life intersections of science and ethics, facts and values [it] offers us teachers a first-class chance to examine our pedagogical intentions and re-vision our strategies” (p. 100), thus improving approaches to teaching.

Perkins and Salomon (1989) discuss the development of a disposition that seeks higher thinking and reasoning skills, and suggest that bioethics is an excellent forum for developing a disposition that seeks critical thinking and decision-making skills. Russo et al. (2004) argue that all citizens in the future will make bioethics (ethics in science) decisions as a result of today’s biotechnology (science and technology) revolution.

2.3.5 Understanding scientific and technological advancements

Bushweller (1999) and Russo et al. (2004) discuss the current biotechnology revolution. Bushweller points out that the science involved is new (compared with what is mostly taught in schools), is in the real world, and will undoubtedly affect young people at some point. He adds that many young people will not go to university, where they may learn about current biotechnology, but will go straight into the working world. Bushweller (1999) and Levinson (2003) advocate that all young people need to have a sound understanding in science and ethics before they leave school and enter the world. Levinson stresses that they need a background that will enable them to deal with the ethical, social and legal questions that will arise in their lifetime. He also advocates that schools offer a sound grasp of science and an awareness of underlying values that go with it. “School education in bioethics” he says, “is crucial for providing a forum in which to develop decision-making abilities about these issues.”(p. 25). Macer (2004) argues

that students should be equipped with an understanding of biotechnology and with the ability to balance the benefits and risks of science and technology. Lewis and Leach (2006) confirm that ethical thinking should be based on sound science learning.

Lehr (2007) also points out students should be able to understand and discern the ever-increasing reports and discussions of new science that appear in the media. He believes that learning about new science and the ethical issues surrounding it can help students decipher 'hype' from a more logical and reasonable presentation. As well as understanding science advancements, students also need to be aware of changing ideas in developing science.

2.3.6 Developing flexible thinking for changing ideas

Along with increasing science knowledge, ideas about science are changing. For example, science can no longer be relied on as 'facts' or truth (Bell, 2004). Recent discoveries threaten and change old ideas, such as, the recent manufacture of carbon skin one atom thick, defying historic laws of physics: "It is considered a feat once held as impossible and will have implications to revolutionise computing and medical research" (Scientists master atom-thick membrane, 2007). Students need science education that is not rigid but that will help them cope with new discoveries and changing ideas. Teaching ethics in science has the potential to prepare students to be flexible, and able to address conflicting ideas in science contexts (Pooley, 2005). Gilbert (2003) also suggests students extend their flexibility to valuing various points of view.

2.3.7 Valuing multiple perspectives

Reiss (1993) describes today's society as pluralist. This includes multiculturalism, different religions, different schools of thought, and gender differences. While moral development is considered to be universal, relative

values differ between people, groups and societies. Frazer and Kornhauser (1986) stress we:

Need to create awareness that different needs and cultures in different parts of the world produce different values. We need to become acquainted with these values, to try to understand them and to respect equally those which are common to us all and those which are not (p. 16).

The teaching of ethics in science in a pluralist society encourages students to consider and learn about others' viewpoints. It encourages tolerance, understanding, and acceptance of others' thinking that differs from one's own. As a result, Reiss (1999) argues the teaching of ethics in science makes students better, or more virtuous, people. Zeidler et al. (2005) support that ethical and cognitive growth appears to be tightly linked to the development of intercultural understanding. They claim that good teaching must include ethical and moral development (achieved through the teaching of ethics in science) for intercultural understanding. Students should be able to relate to the wider community, not only with respect to global issues, but at an intergenerational and interspecific level also (Reiss, 2003). Teaching ethics in science can also raise an awareness of and sensitivity to ethical issues.

2.3.8 Raising ethical awareness, knowledge and judgement in science

Few would deny that science raises a range of ethical issues. Dawson (1999), Reiss (2006) and Reiss et al. (2007) argue that students should have some understanding of these factors. Reiss (2006) suggests teaching heightens ethical sensitivity or awareness in students. For example, students may not have thought much about lambs having their tails removed (docked) or the living conditions of pigs bred for consumption. Ethical discussion of these issues cause students to be more aware and sensitive concerning them.

Ethical teaching in science also raises the ethical knowledge of students. As discussed, such knowledge is helpful in informing and preparing future citizens. It helps students identify fallacies in arguments. For example, appropriate teaching might help students understand rights and responsibilities concerning the notion of animal rights. As a consequence

students may be less emotive and more discerning and logical in their arguments.

Teaching ethics in science may also enhance the ethical judgement of students by teaching them to apply principles that can lead to decision-making. Reiss (2006) states that students who have studied ethics in science are better equipped to make decisions or judgements than those who have not. He also concludes that learning about ethics might make students better people. Such learning would cause students to be more caring, honest and reflective and more likely to implement normatively right choices.

2.3.9 Arguments against and the way forward

Whilst many advocate for the consideration of ethics in science education, some (e.g., Ogborn, 1995; Hall, 1999) have the view that science is fundamentally different to ethics and that they should not be taught under the one umbrella. Reiss (1999) reflects on two of these arguments against the teaching of ethics.

The first argument concerns the epistemological distinctions between the nature of science and the nature of ethics. Science concerns itself with matters of fact (with what is) whereas the nature of ethics is concerned with what ought to be. David Hume's view from the 1700s that there is no connection between what is and what ought to be is still perpetuated (Reiss, 1999). The two disciplines of science and ethics are concerned with two different areas of knowledge and therefore should not be taught together.

The second argument is that secondary science teachers are not trained in moral philosophy. Teaching ethics would result in less time to spend on science, lower quality teaching since teachers are not trained in this area, and lower levels of professional satisfaction among science teachers, resulting in fewer people wanting to become science teachers. Consequently there would be a shortage of science teachers. Reiss (1999) also points out that science teachers are less confident than humanitarian teachers in

teaching social and ethical issues. Conversely, it could be argued that primary teachers might have more confidence to teach ethics because they are trained to teach across all curriculum areas including humanitarian subjects.

Reiss (1999) suggests the way forward is to proceed on the basis that research argues in favour of science being taught in its social contexts and that, in doing so, these contexts raise ethical issues that are both of interest to students and of valid concern to them. The New Zealand Curriculum (MoE, 2007) reflects trends in society, integrating values and opening the way for teaching ethics in science as indicated in the following section.

2.4 ETHICS IN THE NEW ZEALAND SCIENCE CURRICULUM

While the provision for bioethics is probably more embedded in UK education than anywhere else, Willmott and Willis (2008) suggest that the heritage is actually longest in New Zealand, where social and ethical issues have been part of the core curriculum since 1993.

2.4.1 The 1993 New Zealand science curriculum

New Zealand's 1993 science curriculum (MoE, 1993) had a 'science for all' approach. It aimed to make science available to all New Zealand students, including those whose formal learning of science would cease when they left school. Science education for all students also "requires the removal of barriers to achievement and encourages continuing participation in science" (p. 11). It aimed to meet the scientific literacy needs of all students: "both female and male; of all races and ethnic groups; and of differing abilities and disabilities" (p. 11). However, there is debate as to whether these goals became an effective reality (Bell, Jones, & Carr, 1995).

In an effort to enhance engagement, the curriculum placed the teaching and learning of science in contexts that had meaning and relevance for students. Students were asked to "critically evaluate ideas and processes related to science and become aware that scientific understanding is

developed by people, whose ideas change over time”; to “explore relationships between science and technology by investigating the application of science to technology and the impact of technology on science”; and to “gain an understanding of personal, community and global implications of the applications of science and technology” (MoE, 1993, p. 24). For the first time in the science curriculum, ‘thinking’ was listed as a legitimate science activity (Benson, 1997). The ‘skills and attitudes’ section was designed to develop students’ investigative skills and attitudes within learning contexts of the scientific strands and “includes a positive and responsible regard for both the living and non-living components of the Earth’s environment, and a desire for critical evaluation of the consequences of the applications of scientific discoveries” (MoE, 1993, p. 43). One of the general aims was to encourage students to “explore issues and to make decisions about the use of science and technology in the environment” (p. 9). The concern in this document for science education to be inclusive, to consider the impact of science and technology on all aspects of the Earth and those who exist on it, and to help foster responsible decision-making, opened the way for the teaching of ethics in science.

2.4.2 The 2007 New Zealand science curriculum

The teaching of ethics in science is made more explicit in the revised curriculum document, particularly within the ‘nature of science’ strand (MoE, 2007). The Secretary of Education points out in her foreword to this document that there has been no slowing of the pace of an increasingly diverse population and of sophisticated technologies (Sewell, 2007). In response to this increased pace there is a need to produce scientifically literate adults who will use scientific knowledge and ways of thinking to make everyday decisions. Understanding the nature of science is a key to producing scientifically literate citizens.

However, Bell (2004) points out that the nature of science is difficult for students to grasp. Irwin (2000) equates understanding the nature of science with science literacy. Some of the aspects he includes in this are

understanding modern science; the nature of technological solutions to human problems; limitations and possibilities of technology; the interrelationships between science and technology; science and technology are products of their culture; science and technology are human activities that have creative, affective, and ethical dimensions; and decision-making is based on scientific and technological knowledge and processes. Although these ideas are expressed within the achievement aims of 'making sense of the nature of science and its relationship to technology' in the 1993 New Zealand science curriculum document (MoE, 1993), they are given greater prominence in the 2007 document, where they are presented as an overarching, unifying strand (MoE, 2007).

The 2007 science curriculum emphasises the nature of science, making specific links between scientific knowledge and everyday science. The document states that students:

Learn what science is and how scientists work; develop skills, attitudes and values to build a foundation for understanding the world; appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence; learn how scientists carry out investigations, and come to see science as a socially valuable knowledge system; learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions (MoE, 2007, p. 28).

The rationale for studying science is that it is able to inform problem-solving and decision-making in many areas of life. In addition, "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" (p. 28). At each educational level – including primary levels – students are expected to specifically "participate and contribute" in the exploration of science issues and in making decisions about possible actions.

Exploring issues and making decisions for the benefit of both people and the environment helps develop moral people – those who value positive outcomes. This is supported by the values in the New Zealand Curriculum (MoE, 2007) intended to produce life-long learners who are actively and competently involved in life and decision-making, including within the

sphere of science. The document encourages the implementation of learning experiences that develop students' ability to "express their own values; explore, with empathy, the values of others; critically analyse values and actions based on them; discuss disagreements that arise from differences in values and negotiate solutions; and make ethical decisions and act on them" (p. 10). These outcomes, which sit across all learning areas, are aligned with outcomes desired for teaching ethical reasoning in science education. They are outcomes designed to develop empathetic, moral people who will make the best decisions not only in their everyday living, but also concerning issues in science and technology that will have positive results for the present and future world around them.

Henderson (2002) indicated the need for individuals to move on from independent thought to have some common values and goals. The current curriculum supports this notion of commonality through, for example, "diversity" and "integrity" (MoE, 2007, p. 10). Both are intimately related to ethics in science. Students are encouraged to value diversity – respecting different cultures and heritages, which includes different approaches and thinking towards science and science-based issues. Integrity includes acting ethically and respecting oneself, others and human rights. To be effective for the people of New Zealand, these values need to be supported in schools within frameworks that can be taught. Ethics in science is one such framework, and an imperative one in the face of modern, burgeoning biotechnological advances within a pluralist society (Reiss, 2003).

2.4.3 The national curriculum and the enacted curriculum

Bell and Baker (1997) and Hume and Coll (2010) highlight differences between the national (mandated) curriculum and the enacted (taught) curriculum. Although the national curriculum (since 1993) has endorsed the teaching of ethics in science it is not always apparent in practice (Jones et al., 2007; Scott, 1997).

A literature review commissioned by the Ministry of Education on effective science education found that, apart from not addressing multiculturalism and 'science for all', a mismatch existed between the national curriculum and actual classroom practice (Hipkins et al., 2002; Jones & Baker, 2005). There was also a lack of consensus on the nature of science, insufficient curriculum guidance and classroom materials, and limited pedagogical content knowledge for teaching the nature of science. In addition, teachers had varying personal theories of learning, and the realities of classroom constraints impinged on teaching and learning programmes. The report recognised the need for professional development for teachers, and contains recommendations centred on raising achievement through effective pedagogy in science education.

A more recent survey involving 40 New Zealand secondary teachers found that, although many of these teachers addressed controversial issues in the classroom, it was more by way of a passing mention than an in-depth discussion using ethical approaches (Saunders, 2009). Many teachers did not believe ethical issues should be discussed in the science classroom. Others indicated they lacked confidence to teach controversial issues in science and to address the nature of science. Some said they lacked time to plan or teach controversial issues while others acknowledged a lack of personal scientific background knowledge, effective teaching and learning strategies and support in regards to teaching resources. The teachers who were teaching ethics in science reported using a narrow range of pedagogical strategies that are mostly teacher-centred or focused on individual research carried out by students. There were few student-centred, co-operative learning strategies. Saunders reported that there seemed to be a lack of understanding of ethical approaches and teaching ethics.

While secondary teachers struggle with the teaching of ethics in science, research shows that little science is being taught in the primary classroom (Bolstad & Hipkins, 2008; Bull et al., 2010; Cox, 2009; Crooks, 2008; Gerritsen, 2009; Milne, 2008). Science assessment results from the 2007 National Education Monitoring Project (NEMP, 2008) show little

change in primary school science results, including attitudes to science, since 1995. Although the curriculum since 2007 has had an ethics in science component, results indicate disenchantment with science in general, potentially leading to students who are less scientifically literate. It may be assumed then, that teaching ethics in science is not occurring to any great level in primary classrooms. One reason for this could be that primary teachers generally do not have science backgrounds and therefore tend to avoid teaching science at all (Wine et al., 2005).

However, Bell and Baker (1997) stress that changes in the curriculum take some time to become classroom practice. Although the way is open for teachers to teach ethics in science, and the nature of science has been made more explicit in the 2007 curriculum document, it may need teacher development (Bell & Gilbert, 1994), time, and possibly further changes to the curriculum before the teaching of ethics in science is commonplace in the classroom.

Jones et al. (2007), Keown, Parker and Tiakiwai (2005), and Scott (1997) discuss the importance of teachers at the 'coal face' being involved in the development of policy in order for them to be fully involved and committed to curriculum policy and values. Bell and Gilbert (1994) similarly suggest that teacher development works best when teachers are empowered to initiate development themselves. Teachers' ideas and innovations were taken into account leading up to the writing of the national curriculum in 1993 (Bell & Baker, 1997), but it wasn't until the 2007 curriculum that teachers have been given the opportunity to explore curriculum development for themselves within the context of their own school and community. This opportunity, recommended by Keown et al. (2005), allows teachers to implement the curriculum in ways that reflect the needs of their school and community (e.g., whether it is rural, coastal, predominately Māori, etc.) and that are meaningful to them. Thus, while the 1990s saw a significant development in teaching and learning of science within meaningful contexts, New Zealand teachers in the twenty-first century have greater scope to

develop classrooms programmes that stress the nature of science and values related to the teaching of ethics in science.

Whilst the New Zealand curriculum clearly supports the teaching of ethics in science, teachers may not be clear about expectations and implications of the curriculum. Teachers need to be engaged in ongoing teacher development in understanding the curriculum (Bell & Baker, 1997; Hewitt, 2006). They also need teacher development to understand ethics and ethical approaches and to explore teaching strategies and pedagogies for teaching ethics in science (Jones et al., 2007; Lundmark, 2002; Saunders, 2009; Slingsby, 2008).

In summary, the New Zealand Curriculum (MoE., 2007) mandates the teaching of ethics in science in response to recognised need. However, teachers need support to enact this curriculum in meaningful ways. The next section explores some of the well-established frameworks or approaches through which ethics in science can be taught.

2.5 ESTABLISHED ETHICAL APPROACHES

Although Reiss (2003) discusses ethics as a branch of knowledge, he acknowledges that ethical thinking cannot be proved in the way that mathematical theorems can. He holds that, to have validity, ethical conclusions must meet three basic criteria. Firstly, arguments need to be supported by reason. Secondly, arguments should be conducted within a well-established framework. Finally, a reasonable degree of consensus has to support the validity of the conclusions.

The literature discusses a number of well-established ethical frameworks or approaches to ethical decision-making. Consequentialism, rights and responsibilities, autonomy, and virtues ethics are well recognised, have been used in schools already and are therefore used in this research. Exploring multiple perspectives has also been added to this section as an additional approach to specifically address New Zealand's bicultural

(McKinley, 1998; 2005; Roberts & Fairweather, 2004) and pluralist society (Levinson & Reiss, 2003). Other approaches, including feminist ethics, ethics of care, justice, ethic of critique, intergenerational and interspecific ethics, also contribute to the framing of ethics discussions.

2.5.1 Consequentialism

A very common approach for deciding right or wrong is to consider what the consequences would be (Rao, 1986; Reiss, 2003). Some consequences may benefit some and harm others.

People who believe that consequences alone are sufficient to decide rightness (or otherwise) are called consequentialists. The most widespread form of consequentialism is known as utilitarianism (Byrne, 1998; Graham, 2004; Pellegrino, 1999; Reiss, 1999; 2003; Russo et al., 2004; Varga, 1980). The founder of Utilitarianism is generally thought to be Jeremy Bentham (1748 - 1832). John Stuart Mill (1806 - 1873) further developed the philosophy, resulting in its recognition as a philosophical theory. Utilitarianism is concerned that every action should lead to human happiness. Decision-making, then, is based on consequences leading to the greatest net increase in pleasure. If beneficial consequences outweigh the cost or harmful consequences then the action will be right. Reiss (2007) uses the example that if asked to comment by somebody on the appearance of a new set of clothing that had cost a lot of money, one might lie and say it looked great, when in fact that may not have been what that person really thought. In weighing up the costs and benefits, the (white) lie led to the greatest human happiness.

Reiss (1999; 2003) claims the greatest merit in considering consequences is that it provides a single framework or approach for answering moral questions. Another strength is that it considers pleasure. It is not just ethics that, as some people might propose, tells people what to do. But Reiss acknowledges that though there is merit in considering consequences, there are difficulties in using this as a sole arbiter in ethical

decision-making. In its extreme form it would be impossible to measure and consider the action of every single consequence. The question of how pleasure is measured is another consideration. Is it well-being or happiness? Is it intellectual or physical? There are also issues in decision-making for the greatest good (net pleasure). What is the greater good? Reiss (1999) gives the example of two people needing a single kidney. Should one person (with two kidneys) die so that two may live? Utilitarians might then argue that such a practice should not occur because people in society would live in fear that they might be killed so others could live.

2.5.2 Rights and responsibilities

An alternative approach to utilitarianism is an intrinsic ethical approach of right and wrong, regardless of consequences. It is what people intrinsically (or morally) believe is right or wrong. For example, someone may believe that it is morally wrong to kill others whatever the circumstances. Rights and responsibilities (or duties) involves the rights of one person, implying the responsibilities or duties of another. For example, a child has a right to be taken care of. Therefore, someone else has the responsibility to take care of that child (Reiss, 2007).

Although this thinking was made prominent in the eighteenth-century, Graham (2004) suggests the real origin emerged much earlier with Christianity. Verses from the Bible such as 'what shall it profit a man if he gain the whole world and lose his own soul?' (Mark 8:36) may suggest that it is better to suffer than to commit evil. Immanuel Kant (1724-1804) developed and refined the idea of a moral life as being the pursuit of a worthy life, as opposed to the 'pleasurable life' emphasised in utilitarianism. This philosophy focuses on using one's will to fight against an easy life of pleasure and to do what is good and right (Graham, 2004).

2.5.3 Autonomy

A third ethical approach identified by researchers is autonomy (Katz, Noddings, & Strike, 1999; Macer, 1994; Pellegrino, 1999; Reiss, 2007). Autonomy refers to an individual's right to make informed decisions for him or herself, for example, regarding medical treatment. An example of a controversial issue involving autonomy might be when a religious belief causes people to make a decision that may result in their death, as in the case of a Jehovah's Witness refusing a blood transfusion, even if their life depended on it. Singer (1993) presents arguments for voluntary euthanasia where the decision to take one's own life is based on clear rational thinking (e.g., inevitable death or living in immense pain). Singer argues that the strength of the case lies in respect for preferences, or autonomy, of those who opt for euthanasia, and in the clear rational basis of the decision itself.

An autonomous decision should be made with complete knowledge of all relevant facts, such as the risks involved and any available alternatives. When making a personal choice, consideration should be given to the effect of that decision on others. This could include family members and the cost to society (including financial and/or environmental costs).

2.5.4 Virtues ethics

Virtues ethics relates to the moral character of a person (Carr & Steutel, 1999; Pellegrino, 1999; Reiss, 2003; Russo et al., 2004), where people, in their characters and living, embody such virtues as kindness, honesty, care, thoughtfulness, loyalty, humaneness, truthfulness and patience.

Virtues are often associated with the early Christian church (with Jesus as the perfect example of someone living out the attributes of God, as seen in the four gospels). However, virtues ethics was also supported by Plato, Aristotle, the Epicureans and the Stoics (Pojman, 1990). Rather than seeing the heart of ethics as based on action or duties, virtues ethics centres

on the nature of the person – their character and disposition. It emphasises *being* rather than *doing*. It is about what sort of person to be. For some time virtues ethics was seen as quaint and old-fashioned while action-based ethics became more prominent. Recently, however, there has been a resurgence of philosophical interest in the virtues (Pojman, 1990; Stateman, 1997). Stateman suggests, for example, that moral experience (living out virtues) should take precedence over moral theorising, and so study should be made of moral character. Reiss (2007) and Zeidler et al. (2005) argue that education works well when part of it is to do with developing virtues in children. The New Zealand Curriculum (MoE, 2007) places a strong emphasis on values, some of which focus on moral character or virtues, for example, honesty, fairness and care.

2.5.5 Multiple perspectives

Unlike the previous four approaches, multiple perspectives is not a well recognised international ethical approach. It is included in this research as an ethical approach because understanding and respecting others' viewpoints is becoming increasingly important in our pluralistic world (Frazer & Kornhauser, 1986; Henderson, 2002; Levinson & Reiss, 2003; 1986; Reiss, 1993). Understanding, tolerance and respecting the views of others from different cultures, religions, and schools of thought, is an important part of ethics education. For this reason, Zeidler et al. (2005) claim the teaching of ethics can be a key to intercultural understanding.

Jones et al. (2007) recognised that ethical considerations are often closely related to cultural and spiritual values and developed the multiple perspective approach to address the New Zealand context, where, they assert, greater emphasis needs to be given to cultural aspects, particularly Māori perspectives such as *Mātauranga Māori* (traditional Māori knowledge) and concepts related to *tikanga* (traditional customs), *taonga* (Māori treasure) and *kaitiakitanga* (guardianship). Multiple perspectives as an approach is used along with the four previous approaches in a web-based thinking tool designed to support ethical decision-making in science

(http://www.biotechlearn.org.nz/biotechlearn/thinking_tools/ethics_thinking_tool).

Others' perspectives can also come from home. Moll, Amanti, Neff and Gonzalez (2001) use 'funds of knowledge' to refer to the "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (p. 133). Teachers can 'tap into' student knowledge that comes from their families and cultures to add other perspectives, enriching classroom discussions and making them more inclusive and resourceful.

The Quality Public Education Commission has expressed that perspectives, beliefs, values and religion of all students need to be acknowledged and no one value-system should have a monopoly on values in science education (Henderson, 2002). Incorporating multiple perspectives as an approach for exploring ethics in science allows for cultural differences and other worldviews to be explicitly promoted.

2.5.6 Additional ethics approaches

The five approaches outlined above were used in the current research. However, other ethical approaches exist, and many of the principles are aligned with the approaches already considered. Although the following ethical approaches will not be specifically used in the context of this research, many of the principles appear within the approaches that are used. Reiss (2003) concludes that it is safest when making an ethical conclusion to consider a number of well-established ethical principles or approaches.

Feminist ethics is concerned with revising traditional western ethics that depreciate women's moral experiences (Pellegrino, 1999; Zeidler & Keefer, 2003). The 'ethic of care' was developed by Gilligan (1982) and then Noddings (1992, 1999) to promote the notion of caring for self, family, community, ecosystems and the planet. Gilligan (1982) argues that feminist ethics (including an ethic of care) is fundamentally different to other

approaches in that early research on moral development and ethical thinking used only male subjects, who led the (male) researchers to conclude that ethics was about reasoning. Gilligan's view suggests that ethics is concerned with relationships and awareness rather than reasoning and decision-making. Although one of the aims of the research in this thesis is to help students reason with a view to possible decision-making, students should also be concerned with 'care', that is, with relationships and ethical awareness.

'Justice' as an approach promotes fair treatment and fair distribution of resources (e.g., educational opportunities) and is often included with autonomy ethics (Katz et al., 1999; Macer, 1994; Pellegrino, 1999). The 'ethic of critique' was included with justice and care in discussions by Starratt (1994) as a form of ethical consideration. It was developed from critical theory and considers the struggle between competing interests and wants among various groups, with consideration about who would benefit or dominate. It deals with issues of social justice and human dignity.

Intergenerational issues are also being recognised. Rao (1986) points out that current actions may affect future generations. For example, freely using oil now is not giving consideration to future generations. Another example relates to global warming – consideration should be given to the impact on future generations of decisions that are made today. Interspecific issues include the interests of non-humans such as animal rights and ecological issues (Reiss, 2003).

2.5.7 Summary

Although the ethical approaches discussed above have different origins and some of them seem may at times at odds with each other (e.g., consequences versus rights and responsibilities), Reiss (2007) points out that each ethical approach has strengths and weaknesses, and should be used in conjunction with others. Some ethicists do view all issues from one approach, but it would add rigour to an ethical debate if a number of

approaches were considered. Some ethical questions may 'fit' with a particular approach, for example, ethical discussions on using animals in research would work particularly well with rights and responsibilities. Jones et al. (2007) suggest teachers should be able to use any number of the well-established approaches offered for ethical discussion. The next section will explore how ethics in science tends to be taught.

2.6 TEACHING ETHICS IN SCIENCE

Although Dawson (1999) points out that a review of literature on bioethics education reveals a paucity of information, there is at least some literature on bioethics education in secondary schools. This is reported here to raise an awareness of teaching frameworks, topics and issues, activities and strategies, and resources currently being used in bioethics, albeit with older students. While there is a dearth of information for the primary sector, the section concludes with examples from a recent pilot study of ethics in science taught by primary teachers.

2.6.1 Teaching frameworks

Dawson (1999, 2001) notes that almost all literature related to teaching bioethics in secondary schools discusses a common format or ethical framework used by teachers. This format resembles a five-stage model developed by Burnham and Mitchell (1992). The model begins with the focus or observation (presenting the controversial issue to students) and works through stages of questioning/hypothesising (generated by the students or teacher), gathering information (collecting information about the issue, for example, as a case study), analysis and ethical deliberation (students weigh up and evaluate the issue), and decision-making (students choose an option from alternatives they have formulated in the previous stages).

A framework developed by the Hastings Center (1990) has also been widely used in secondary schools. Although similar to the Burnham and Mitchell (1992) model, it includes a component where the students must consider different stakeholders' viewpoints. This requires students to consider the 'other' side even if they disagree with it. The last step in this model asks the students to evaluate their decision: to check they used scientific facts and represented stakeholder views, that there is reference to ethical principles, and that alternate solutions are considered. Students are also asked to consider the process of decision-making to determine whether it was fair and just.

Chowning (2005) condensed the teaching of ethics into three main components: content, decision-making framework and ethical perspectives. The *content* component provides the 'hook' for student engagement, commonly a case study. It also includes understanding the science underpinning the issue. The *decision-making framework* helps students organise their critical thinking by providing a model for structured reasoning. This involves considering the ethical question and identifying stakeholders and their values. As with the Hastings Center (1990) framework, Chowning also suggests students "step into someone else's shoes" (p. 48). She claims this is particularly important for young students who struggle to view dilemmas from different perspectives. Students then generate options for solutions, which are analysed to consider which ethical principles are granted priority. Student reasoning is clarified through justifying a decision. The last steps consist of acting on the decision and evaluating the decision whilst being aware that they could change their decision should new evidence come to light. The third component, *ethical perspectives*, involves introducing ethical perspectives, such as autonomy and harms and benefits (consequences). Although Chowning divided the teaching process into three components, it is actually synergistic – taught at the same time or whenever appropriate for the learning. Teachers reported to Chowning that using these three components energises science students and engages those students who seem to find science uninteresting.

A New Zealand model for ethical inquiry into scientific issues has been developed by Saunders (2009). This model presents a pathway for the teaching of ethics in science that begins with teacher preparation. Students then: engage in the broad issue; understand the science involved; individually reflect on the issue exploration; are involved in group discussion; decide on a controversial statement or question; and think about the question or statement using one or more ethical approaches. Finally the students make an ethical decision that they justify and then evaluate. Questions and prompts useful to teachers and students for each stage of the model are included, as well as various activities and strategies for each stage. This model has been successfully trialled by four secondary teachers in New Zealand.

Whilst at least some teachers are using classroom programmes based on the frameworks described above, Slingsby (2008) has found that many pay 'lip service' to bioethics teaching, encouraging debate without the skills needed for ethical deliberation, and sometimes without a solid grounding in science. Lundmark (2002) also found that students may not have tools or strategies to evaluate bioethical issues.

2.6.2 Common teaching topics

Current teaching of ethics in science seem to relate mostly to bioethics issues in secondary schools. For example, Bhardwaj and Macer (1999) list some of the topics being taught in India, Japan and New Zealand: environmental issues (particularly to do with population growth, resources, waste and pollution), nuclear power, pesticides, biological pest control, acquired immune deficiency syndrome (AIDS), human immunodeficiency virus (HIV), in vitro fertilisation (IVF), abortion, contraception, artificial insemination (AI), antibiotics and vaccines, x-rays, transplant operations, reproductive technology, gene therapy, genetic engineering and DNA fingerprinting. Additional topics, taught in Australia, Japan and New Zealand, include animals in research, eugenics, future foods (genetic modification), euthanasia and genetic screening (Jones et al., 2007; Macer et al., 1996).

Some North American teachers believe that genetics and its ethical dilemmas are too important to overlook: “Our scientific expertise has outpaced our ethical concerns with it. That’s why a lot [of teachers] are pushing ethics. There are lots of questions these kids are going to have to face” (Bushweller, 1999, p. 64). Bushweller makes the point that the science concepts and ideas in these topics need to be taught well for the students to be able to engage adequately in an ethical discussion. As one student reflected:

The problem with discussing genetics is that most people don’t understand the science behind their arguments and react mostly on emotion. To best prepare kids to live in the age of biotechnology intelligently and responsibly teachers need to first teach the science of genetics. I don’t think I could have understood the ethical part of it without understanding the science. (p. 64)

2.6.3 Classroom activities and strategies

Teachers use a wide range of activities when teaching ethics in science (Dawson, 1999; Jones et al., 2007; Saunders, 2009; Sadler & Zeidler, 2004; Sherborne, 2004). Levinson (2006) notes that secondary teachers most commonly present students with a case study. That includes factual information about an ethical issue and raises some problems for consideration. Case studies may be documented or invented. Other ways teachers have introduced ethical issues into science classrooms are through using newspapers, internet, magazines, television documentaries and other media articles; inviting guest speakers; or arranging school trips (e.g., to waste treatment sites) (Dawson, 1999). Willmott and Wellens (2004) describe an exercise where students produced websites about bioethics issues, noting a broadening awareness of issues among students and an increase in their appropriate use of scientific terminology.

Conner (2010), Dawson (2010) and Saunders (2010) report on New Zealand secondary students engaging in brainstorm activities, mind mapping, class and group discussion, continuums, research, viewing videos and power-point presentations, writing position papers, and debating. Dawson (1999) notes that secondary teachers have also engaged students in role-play

(adopting a stakeholder's role and playing out that part) and drama and simulation games. The potential of these and other narrative pedagogies is explored further in Section 2.7.3.

2.6.4 Resources

Teachers need to be able to help their students discuss and evaluate ethical issues. At least ten years ago Dawson (2001), Macer et al. (1996), and Reiss (1999) found materials suitable for science teachers to include ethical aspects of science in their teaching were in relatively short supply. Although more material is being produced, it is still far from adequate (Jones et al., 2010).

Macer's (2004) book *Bioethics Education for Informed Citizens Across Cultures* covers bioethical issues, questions and activities and includes such topics as animal rights, genetic testing, euthanasia, terminal cancer, in vitro fertilisation, surrogacy and cloning. Levinson and Reiss' (2003) guide *Key Issues in Bioethics* discusses how to teach bioethics and covers topics such as cloning, in vitro fertilisation, surrogacy, genetics, farm animals' welfare and using animals for medical experiments.

A range of web-based resources also exists (Jones et al., 2007). These include such examples as *The European Initiative for Biotechnology Education* (www.eibe.info/) and the *The Bioethics Education Project* (<http://www.beep.ac.uk>), where the ethical issues are designed mainly for older students (16+ years). Such sites usually include quality activities designed to stimulate classroom discussion, but teachers would need to be confident teachers of ethics in science to deal with the issues given. *Biotechnology Online* (<http://www.biotechnologyonline.gov.au/>), produced by the Australian Government, includes reference to the different ethical frameworks, but doesn't provide exemplars of how to do this and is also still aimed at the secondary level.

The New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz) and *The Science Learning Hub* (www.sciencelearn.org.nz), both funded by the New Zealand Government, have sections that could be useful to both secondary and primary teachers, providing information sheets and video clips that explain how to analyse ethical issues as well as an interactive 'ethics thinking tool' that uses the five ethics approaches described above to scaffold students' decision making regarding a range of ethical issues.

Although some ethics teaching occurs in secondary science programmes and a range of resources are available to these teachers, Section 2.4.3 indicates there is little ethics in science teaching in the primary sector. The next section, however, is an example of a recent pilot study indicating that primary students are capable of ethics discussions and enjoy learning about ethics issues (Buntting & Ryan, 2010).

2.6.5 A pilot study: Ethics in science primary classrooms

Recent research conducted in primary schools in New Zealand indicates that very young students can engage in thinking about ethical issues in science (Buntting & Ryan, 2010). This small study is considered here as so little other research has been done in this area. It involved five teachers in three schools. The student groups consisted of two new entrant classes, a Year 3/4 class, a Year 5/6 class and an intermediate class of 11/12-year olds. The teachers were introduced, through workshops, to ethics in science and were asked to incorporate an ethics aspect into their science teaching. The research found that teachers needed teacher development to help them understand ethics and ethical approaches, and to get ideas for teaching strategies. Teachers found that collaboratin helped with the learning process and in planning their teaching. The teachers embedded the ethical components into their science, consistent with the views of Levinson and Reiss (2003) and Lundmark (2002) who argue the teaching of ethics should be incorporated in existing science teaching, not taught as an 'add-on'.

Teachers used a range of strategies, tools and artefacts to engage students in the learning tasks, including murals, role play, cue cards, photographs, tabulated summaries, debates, worksheets, sharing in groups, writing templates, research activities, continuum activities, whole class discussions and written work where teachers expected students to express their views with justifications. Teachers effectively sought to create classroom environments in which views could be safely expressed. This was reflected by the many different opinions expressed by the students. Teachers were pleased that young students could hold and justify their own opinions. However, Bunting and Ryan (2010) identified science knowledge as also being important for teachers, affecting their ability to facilitate discussion. Lack of content knowledge (by the teacher) hindered discussion and in some cases brought it to a close.

The main ethical approach used by the primary teachers was that of consequentialism. The teachers opted for this approach, largely because they felt it was the easiest one to use because the students understood a consequence of something happening. However, rights and responsibilities and virtues approaches were also introduced. Multiple perspectives were apparent in that all students were required to listen to others' views.

The examples demonstrated that students' understanding of consequences was broadened as a result of classroom activities, as well as their understanding that what benefits one may harm another. Students were able to engage with the particular issues being explored and develop a response that they could articulate and justify. Summative assessment tasks indicated students were able to form their own opinions and justify them based on ethical and science ideas that they had incorporated during class activities.

While Bunting and Ryan (2010) show that primary aged students can engage in ethical discussions, they also recognise that scant research has been done on the teaching of ethics in science in the primary classroom. With little science being taught, and therefore little ethics in science being taught,

primary teachers need to be supported to teach ethics in science – particularly now that teaching students how to make ethical decisions is mandated by the New Zealand Curriculum (MoE, 2007). The next section will explore some theories, pedagogies and aspects of teacher development that may contribute to the successful teaching of ethics in science in the primary school.

2.7 DESIGNING CLASSROOM PROGRAMMES

The research reported in this thesis is focused on incorporating ethics in primary science education. Since little other work has been published in this area, as mentioned above, it is necessary to draw on more general education literature. This section, then, will explore some key aspects that may contribute to the design of effective ethics in science programmes in primary science classrooms.

2.7.1 Views of learning

How learning is understood, has implications for outcomes that are valued and how these are brought about (Driver, Asoko, Leach, Mortimer & Scott, 1994). Processes of learning are viewed in different ways. Two broad views are distinguished: a cognitive constructivist view and a sociocultural view. Both views highlight different aspects of the teaching-learning process (Cowie, 2003), but the sociocultural view is consonant with social interactions that promote scientific reasoning and learning about ethics in science.

The cognitive constructivist approach focuses on knowledge as being personally constructed from the learners' interactions with physical events in their daily lives (Driver et al., 1994). The resultant mental representation is built up as the learner tries to make sense of their world. Osborne and Freyberg (1985) contend that during this process, misconceptions are developed but “unless we know what children think and why they think that way, we have little chance of making any impact with our teaching no matter

how skilfully we proceed” (p. 13). An understanding of students’ prior knowledge, then, is necessary for the teacher to be able to facilitate conceptual change and to further the construction of knowledge. Vosniadou (2002) says this should be improved knowledge (closer to scientific understanding), not just different. Vosniadou promotes intentional learning (a deliberate pursuit of understanding, internally initiated and under the control of the learner) as a means to facilitate conceptual change.

Social constructivism arose as a reaction to those who overemphasized the individual’s learning and neglected social aspects of knowledge construction (Duit & Treagust, 1998). Learning is still viewed as an individual process but is mediated by tools and social interaction. Social views of constructivism add that learning involves the situated social system as a unit of analysis (Lave & Wenger, 1991). The emphasis on social settings was drawn from the work of Vygotsky (1962, 1986), who proposed that social interaction plays a fundamental role in the development of cognition.

A sociocultural view, on the other hand, emphasises learning through doing or being. With learning occurring as students interact with people, objects (tools), and events in the environment (Vygotsky, 1986); the practices in which they participate constitute what they learn (Wenger, 1998). Wertsch (1991) explains, “A sociocultural approach to mind begins with the assumption that action is mediated and that it cannot be separated from the milieu in which it is carried out” (p. 18). This acknowledges that learning is situated within a cultural setting. For this reason, sociocultural approaches are increasingly being used “to make sense of classroom teaching because they acknowledge complexity and the impact of interactions between people, ideas, tools, and settings over time” (Cowie, Moreland, et al., 2008, p. 1). Such a view also recognises that students not only learn science but learn about science, consistent with calls for more inclusive and socially relevant ‘science for all’ and scientific literacy (see Section 1.1). This view therefore lends itself to an explicit focus on the nature of science, particularly in terms of how scientific ideas are approached.

Henning (2004) describes situated learning as learning that is essentially a social phenomenon that takes place at the juncture of everyday interactions. Problems for learning in the classroom should, therefore, be real and relevant and engage students' interests. Brown et al. (1989) emphasise that students work through these in real ways with no prescribed methods or answers, within a social context. According to Hennessy, McCormick and Murphy (1993) problems should also be embedded within a specific context if they are to be solved. Jones, McKim and Reiss (2010) agree on the importance of context, commenting that being scientifically literate includes "[being] discerning, knowledgeable and responsible, understanding science in its political, environmental, historical, social, cultural and economic settings" (p. 1). In addition, ethical discussions arise from science contexts: "In this socio-cultural milieu moral and ethical issues are embedded in the scientific decision-making process" (p. 1).

A sociocultural view posits, the teacher as the facilitator, assisting students to examine and evaluate controversial and authentic issues critically (Dawson, 2001; Jones et al., 2007). The teacher provides opportunities for students to talk, read and write using the language of science (Lemke, 1990) and to learn through argumentation.

2.7.2 Argumentation

Andrews (2009) refers to two broad definitions of argument: everyday spats and rows, and highly prized academic discourse. Tippet (2009) further classifies academic arguments as rhetorical (one sided persuasion), dialectical (examining differing perspectives during debate), or analytical (using logic). Driver et al. (2000) favour the use of dialectical and analytical arguments in science education while deemphasising rhetorical arguments traditionally predominant in the classroom. Andrews (2009) points out it is during the process of arguing – argumentation – that reasons and justifications are put forward to support an argument. Others challenge these ideas, and mutual understanding emerges (Osborne, 2008).

Argumentation incorporates recognition and respect and has characteristics that are of a social, reciprocal, supportive and purposive nature (Alexander, 2005). It is also authentic in that participants can see the purpose and value of such discussion. The process involves reasoning, which in turn requires describing, explaining, predicting, arguing, critiquing, explicating and defining. The work of Deanna Kuhn connected the importance of argument with science learning in 1993 (Tippet, 2009) and around the same time Driver et al. (1994) pointed out that learning science should include learning scientific ways of knowing, and identified argumentation as the epistemological basis of science.

Educational researchers agree that argumentation is a critical element of science *and* science education (Andrews, 2008; Driver et al., 2000; Franklin, Hwang & Leander, 1996; Kovalainen & Kumpulainen, 2005; Levinson, 2003; Mercer, Dawes, Wegerif & Sams, 2004; Miri, David & Uri, 2007; Newton, Driver & Osborne, 1999; Osborne, 2008, 2009; Tippet, 2009). Indeed Mercer et al. (2004) and Tippet (2009) claim argumentation has been called the language of science and has been identified as a tool for promoting conceptual change.

Kovalainen and Kumpulainen (2005) demonstrate the power and importance of argument in the primary school classroom, showing that young children are able to take responsibility for their own learning in science issues and engage in open-ended dialogue (argument). The extent to which this occurred, however, depended on the teacher's perspective and management of interactional practices. In another study of scientific discourse in primary classrooms, Mercer et al. (2004) showed that small groups discussing scientific issues outperformed control classes who were not given the same opportunity for such discussions. Likewise, Miri et al. (2007) found that students who were taught science in the context of real-world problems, in an environment that encouraged open-ended discussion and inquiry, showed significant increases in measures of critical thinking when compared with control groups who were taught science traditionally. Osborne, Simon, Erduran and Monk (2001) found that practices of

argumentation help students understand the nature of science, thereby creating room for ethical understanding. Levinson and Reiss (2003) feel classroom discussion involving ethics should be less about having students make up their minds on an issue, and more about respectfully exploring other points of view and perspectives with a view to sharpening one's arguments and deepening one's understanding of the issues.

Osborne (2008) and Tippet (2009) suggest the ability to argue well does not come naturally and has to be taught explicitly. Many teachers still tend to dominate discussion, not fostering the reflective discussion of scientific issues necessary for the social construction of knowledge. Some examples of reflective discussion or argument-based skills are identified by Osborne as: encouraging students to listen to others; recognising the elements of an argument and using appropriate language; taking a contrary position and challenging others' ideas; and justifying a viewpoint.

Newton et al. (1999) and Driver et al. (2000) agree that teachers' lack of pedagogical skill in organising argumentative discussions within the classroom is a significant impediment to developing argumentation in scientific discussion. Teachers need to know how to teach argument skills, introduce argument, manage small group discussions, collate resources for argument, evaluate argument, and model argument. Tippet (2009) concluded that for successful argumentation, teachers need teacher development in teaching the skills for fostering an atmosphere of scientific discussion and that students need to be explicitly taught the skills of engaging in scientific argument. Both Osborne (2008) and Tippet emphasise that argumentation needs well-established ground rules that are clearly defined and structured. Reasoning should not be aimless, and Levinson (2003) and Reiss (1999) state that to have some direction for argument the teaching of ethics in science needs to incorporate well-established frameworks. Such frameworks provide a scaffold for the development of reasoning and scientific understanding.

Other aspects of learning that may be effective for teaching ethics in science involve the strategies and activities teachers might use. A powerful teaching strategy for the teaching of ethics in science is the use of narratives.

2.7.3 Narrative strategies

In the everyday sense, narratives are stories told to various audiences for different purposes. The meaning conveyed in this thesis is more specific, concerning stories people tell about themselves, involving a personal sense of knowledge and knowing (Hipkins, 2004). People construct their own narrative accounts of the world within the context of their culture, interactions and experiences (De Luca, 2010). Barker (2001), Millar and Osborne (1998), and Solomon (2002) suggest narrative can be a powerful tool for drawing students into meaningful science learning. They state that it increases understanding of the nature of science and helps enable students to take part in ethical discussions.

Narrative pedagogy places science and science issues in a global and historical context, drawing on what it is to be human. Students identify with characters involved, “taking into account both the elaborate arguments of empathy and the concerns of the heart, the core of our being, which have such an essential part to play in our reactions to stories of human distress” (Solomon, 2002, p. 103). Learners are provided with specific content knowledge, the nature of science and historical documentation.

Shepardson and Britsch (2006) and Watt (2002) reiterate the theories of Vygotsky (1986), which consider the use of language in a social context as central to the development of thinking and learning. In addition, Hipkins (2004) believes narrative pedagogy transforms traditional science concepts by giving attention to contextual detail that is often neglected. She adds that such detail gives students the ability to learn science in ways that are personally meaningful. In this sense using narrative in teaching (narrative pedagogy) can help students see a place for themselves in the context of the big stories of science. Students also learn to ‘see the world through different

eyes', which Girod, Rau and Schepige (2003) say is important for developing insight. They suggest using narrative pedagogy provides a sense of connection, and that this can have a motivating effect on students. Using narrative pedagogy may also help students engage with science learning in a way that is more likely to develop an ethic of care for our environment (Hipkins, 2004).

Pellegrino (1999) suggests the narrative approach can easily be used in the classroom for presenting ethical decisions as problems. An example of narrative when teaching ethics in science in a primary classroom involved an inquiry on whether money should be spent saving the takahe, an endangered bird native to New Zealand (Appendix 1). The class acted out how the takahe became endangered. They could 'experience' what happened over a long period of time in a short space of time. The teacher also told historical stories of successes and failures of scientists who had tried to save the takahe. Students became engaged in the science issues as they put themselves in the stories and were able to see the bigger picture, including how the issues were connected.

Odegaard (2004) also reflects positively on the use of drama to tell stories in science issues. Her research showed students were more critical, reflective thinkers and had a better understanding of issues in biotechnology when they could portray the issues through a drama medium. Brock (1999) believes that by taking primary students into a creative space they are motivated and sustained by enjoyment. However, some of the challenges of the drama narrative include recall, applying scientific knowledge, working collaboratively, and sharing information in pursuit of a common goal. Adults provide the science language and support the students as thinkers.

The mantle of the expert (Heathcote, 2009) is another drama/role-play strategy for narrative pedagogy in which the class work as if they are an imagined group of experts. For example, they might be scientists working on environmental issues. Because they behave as experts, the students work from a specific point of view as they extend their learning. Through activities

and tasks, the students gradually take on the same kinds of responsibilities, problems and challenges that real scientists might do in the real world. The story puts the students 'in the picture' and they 'see through others' eyes'.

Levinson (2003) suggests that teachers start an ethics discussion with a focused, situated dilemma (narrative) and then invite students to discuss the issues. Reiss (1993) adds that the narrative should be case studies of real life situations. The teachers' role includes presenting resource materials and a range of different viewpoints that the students evaluate. However, Sherborne (2004) emphasises that teaching bioethics and, by extension, ethics in science is not just about running small group debates. He reported three different strategies using a narrative pedagogy. The first presented an issue as a card game that involved the students making 'real life' decisions. A second involved making a TV news report on bioterrorism where the students had to weigh up the risks and benefits of the dangers of bioterrorism against the medical benefits of research into viruses and bacteria. The third presented a real-life scenario involving parents who had to decide whether or not to have another child to save the life of their existing child. In this last example, a panel of scientists, ethicists and legal experts (invited guests or students in role), were interviewed by students, who then had to determine how ethical considerations should be set alongside scientific and legal arguments.

Kempton (2004) endorses the use of cartoons and paintings to tell science stories and the ethical issues involved. Concept cartoons (Keogh & Naylor, 1996, 1999) are a successful way of engaging and motivating students. The cartoons are designed to stimulate thinking about issues, develop problem-solving skills and elicit tacit scientific knowledge, making scientific ideas accessible. The pictorial presentation is significant in capturing attention. Kempton (2004) suggests paintings that can engage students in a new way to depict scientific issues or accounts of the past. Students view a painting and relate what it shows. They can then discuss the issues behind the painting. In the example of a painting by Joseph Wright called 'An experiment with a bird in the air pump', the students brought up a

diverse range of issues. These included: how scientific inventions can be used for good or evil; how scientists display awe and wonder at discoveries and may even idolise their work; care of the environment; responsibilities of manufacturers; and moral aspects of animal experimentation.

Anning (1997) stresses that drawings are a powerful mode for representing and clarifying thinking and for communicating to others. Young students in particular, she says, instinctively use drawing to converse with themselves (tell stories) when generating ideas. Incorporating drawings could be a useful strategy for engaging primary students in an ethics in science narrative. Puppets (Milne, 2009) are another way of telling science stories. The students could also use the puppets as a medium to discuss problems and make decisions. Millar (2008) described the use of playdough to model ideas while discussing ethics.

A number of teachers are also exploring the use and effectiveness of interactive boards for learning. For example, they provide lively, varied, complex and interactive lessons more easily than previously possible. Science concepts can be explained through the quick manipulation of images, thereby speeding up lesson time (Gillen, Staarman, Littleton, Mercer, & Twiner, 2007; Ryan & Cowie, 2009). Normally 'unseen' objects (e.g., cells) can be enlarged for observation. Animations (Mayer & Morena, 2002) can tell a science story while interactively engaging the students. Educational games (O'Day, 2008) could also be developed for ethics in science narrative, problem-solving and decision-making. Willmott and Wellens (2004) suggest students work in groups to produce websites about current controversial issues, telling their own stories.

The InSiTE project (Cowie, Moreland, et al., 2008) and Prain and Waldrip (2006) demonstrate that effective teacher-student interactions utilise multi modal representations of concepts to express ideas and enhance student learning in science. The use of narrative strategies, along with frameworks, tools and other forms of support can be brought together providing scaffolds for teaching ethics in science.

2.7.4 Scaffolding

Students and teachers need multiple forms of support in order to address learning needs (Roth, McGinn, Woszczyzna, & Boutonne, 1999; Sherin, Reiser, & Edelson, 2004; Tabak, 2004; Wine et al., 2005). Such support, called scaffolding, is described by Hennessy (1993) as “the help which enables learners to engage more successfully in activity at the expanding limits of their competence, and which they would not have been quite able to manage alone” (p. 12). Cowie and Moreland (2006) purport that although students need time and opportunity to explore their own ideas and interests, without teacher intervention and wider experiences they are unlikely to develop scientific understandings. Examples of such help include teacher modelling of appropriate frameworks, tools, and activities; the social sharing of tasks; artefacts; social configuration; and physical arrangement.

Hennessy (1993) uses the apprenticeship learning model to describe the scaffolding process whereby teachers initially make explicit their knowledge or model effective strategies through demonstrating desirable ways of problem solving in authentic ways, for example, modelling a framework of argumentation. The scaffolding process continues through the social sharing of tasks, supporting the learner and allowing knowledge to gradually build up. There is then a gradual withdrawal of help (scaffolding) as learner participation increases.

Roth et al. (1999) posit that artefacts that support student participation are important for discourse. These artefacts need to be well-designed and accessible (highly visible) for students to be able to engage with them, thus empowering them to increase the depth of their participation in science conversation. Cowie and Moreland (2006) add that appropriate artefacts can play an important role in anchoring and making visible the connections between ideas and activities across space and time, leading to a sense of continuity.

Roth et al. (1999) further note how the interaction of artefacts, social configurations and physical arrangements affect the level of engagement of students. For example, they stress the importance of small groups for higher-level student participation. Baines, Rubie-Davies and Blatchford (2009) agree group work is needed for sustained engagement but add that students need training in the skills required for argumentation if high-level discussion is to be achieved.

Tabak (2004) advocates for multiple scaffolds interacting together to address complex and diverse learning needs. She refers to this as 'distributed scaffolding', where different needs are met by different supports. Tabak notes that teachers play a key role in developing the scaffold - facilitating and modelling the use of tools, supports and activities - that results in students becoming "active members of a learning community engaged in constructing meaningful and defensible knowledge claims" (p. 330).

Levinson (2003) and Reiss (1999) suggest that any framework to scaffold the teaching of bioethics should be based on the assumption that ethical conduct is universal (Kohlberg, 1980; Levinson, 2003). This means that students do not take only their own interests into account; rather, all people should be considered. As already pointed out, Reiss (1999) suggests that teachers can be confident about teaching bioethics if arguments are reasoned with internal consistency and are conducted within well established approaches such as consequences, rights and responsibilities, autonomy and virtues ethics (see Section 2.5). He also stipulates that there should be a significant degree of consensus among the interested parties about the validity of the conclusions. Endicott, Bock and Narvaez (2003) comment that multiple frameworks can be used to facilitate or act as scaffolds for more advanced ethical problem solving.

The ability of the teacher to help and support students make the appropriate connections between their experiences and activities and (science) concepts has been referred to by researchers as the pedagogical content knowledge (PCK) of the teacher.

2.7.5 Pedagogical content knowledge (PCK)

Shulman (1987) coined the phrase pedagogical content knowledge (PCK) to describe “that special amalgamation of content and pedagogy that is uniquely the province of teachers” (p. 8). It is the teacher’s understanding of what is to be learned and how it is to be taught. Or, as Moreland, Cowie, Jones, and Otrell-Cass (2008) put it “knowledge that is developed when teachers blend content and subject matter knowledge and pedagogical knowledge in such a way that students can learn the idea being taught, yet at the same time, the integrity of the idea is maintained” (p. 38).

PCK for teaching ethics in science requires teachers to have an understanding of: the science knowledge involved, principles of ethics, their students, and which classroom strategies can be used to help students understand and clarify subject matter so that it can be grasped and evaluated; and an awareness of the intellectual journey the students could make. Questions for teachers to consider when planning to explore an ethical issue in their science class could include: What are the relevant science and ethics concepts? What shall I do (scaffolds, strategies and activities) with my students to help them understand the science and ethics concepts? What are my students likely to already know and what will be difficult for them? How shall I best evaluate what my students have learned? What materials are there to help me? PCK, therefore, includes the teachers knowing what to focus on at different stages of teaching, how to link ideas together, and how to respond to the students’ ideas and questions and capitalise on unplanned opportunities.

Levinson (2003) advocates the importance of knowing what questions to ask and when to feed in the knowledge and to what level. Teachers also need to be able to provide experiences and activities that guide students’ progress toward an understanding of key ideas or learning intentions (Wine et al., 2005), providing a context and focus for the ideas under discussion, and supplying activities to stimulate and support students’ thinking by posing problems, asking questions and modelling the use of new ideas (Asoko,

2002). Asoko points out that there needs to be a rationale behind the selection of activities.

The InSiTE project, – a longitudinal study involving 12 primary school teachers over a three-year period, – found that while primary teachers tend to have good pedagogical knowledge in the classroom generally, there is a gap between teachers orchestrating engaging science activities and having a sound knowledge of the underpinning science (Cowie, Moreland, et al., 2008). Wine et al. (2005) found that because primary teachers tend to lack science knowledge they research to gain science knowledge for their teaching topic. However, it is often superficial rather than in-depth knowledge and consequently, they struggle with PCK during the teaching. This was particularly apparent when students asked questions outside of the teacher's definitional knowledge zone. Teachers cannot provide the experiences and activities that guide student progress if they themselves have limited experience with science ideas. This is problematic with primary school teachers since many are 'generalists' rather than 'specialists' and often identify more strongly with literacy and numeracy (Jones, Cowie, Moreland, & Wine, 2005; Wine et al., 2005).

It seems primary teachers' PCK needs to be developed if they are to successfully teach ethics in science. Educators often use modelling and multimedia to show best practice of teaching to teachers, but Moreland, Cowie, Jones and Otrell-Cass (2008) found that teachers could reflect on their own practice to consider and improve their PCK. Those involved in the InSiTE project responded positively to help in scaffolding and planning, reflexive teaching and collective reflection, and were able to improve their PCK (Cowie, Moreland, et al., 2008). To develop effective PCK and use strategies successfully, Moreland, Cowie, Jones and Otrell-Cass found that teachers needed teacher development.

2.7.6 Teacher development

Teachers must become familiar with a subject area in order to plan and teach it. To do this they need support. Teachers seeking to incorporate ethical principles and approaches and to explore pedagogies for teaching ethics in science are likely to need additional teacher development (Jones et al., 2007; Lundmark, 2002; Saunders, 2009; Slingsby, 2008). In addition Ginns, Norton, Mc Robbie and Davis (2007) suggest teachers need various kinds of support to immerse them in a new area until they become confident to teach that subject.

Compton and Jones (1998) found teachers implementing the technology curriculum were influenced by past experiences and subcultures (teaching practise related to specific subjects). It was recognised that a common subculture needed to be developed, and to achieve this collaboration is vital (Stables, 1995). Schools that successfully implemented technology education had successful co-ordinators and teachers had the time to develop ownership of the programme, modifying, reflecting, implementing and collaborating together (Treagust & Reannie, 1993). Bell and Gilbert (1994) found that successful teacher development where there is time, reflection, collaboration and support are vital for new and on-going programmes. They encouraged teachers to view teacher development as a learning process rather than getting people to 'change'. Megacognitive awareness was an important aspect, where teachers became aware of subcultures and perceptions and were able to develop new concepts consistent with the curriculum.

Although the New Zealand Curriculum (MoE, 2007) clearly supports the teaching of ethics in science (see Section 2.4) and the nature of science (including the teaching of ethics in science) is given particular emphasis, Bunting and Ryan (2010) and Saunders (2009) found that secondary and primary teachers are likely to have little understanding of the teaching of ethics and there is no shared subculture for teaching ethics in science. They found that the teachers participating in their research projects valued

teacher development, to understand the language of ethics and established approaches, and to expand their repertoire of teaching strategies. Teachers also became more empowered to teach ethical thinking by collaborating together to develop their own programmes. They reported the teacher development was instrumental in increasing sensitivity to ethical issues, and introducing them to appropriate approaches for ethical reasoning and deliberation. As a result of the teacher development programme they felt more confident about trialling activities with an ethical component.

Teacher development in the InSiTE Project included teacher planning and the use of subject-specific planning documents (Cowie, Moreland, et al., 2008) as described in the next section.

2.7.7 Planning

The InSiTE project (Moreland, Cowie, & Jones, 2008) made a case for the importance of teacher PCK, acknowledging a distinction between teachers knowing a subject and knowing what to do subject-wise for classroom teaching. Teachers employ an intellectual process that changes their content knowledge into a form that is learnable for students. For this process to occur effectively, Moreland, Cowie and Jones advocate the use of subject-specific planning frameworks. They note that such frameworks impacted positively on science and technology teaching.

In particular, the planners helped teachers, identify what they needed to know to teach a topic, along with the associated ideas, skills and attitudes. By prompting teachers to articulate intended learning outcomes in precise terms, the teachers became more specific about what they wanted to teach and, as a result, more focused on classroom interactions (Moreland, Cowie, Jones, & Otrell-Cass, 2008).

There were two layers of planners. They were designed so that the teachers could work through them iteratively, helping to keep categories coherent, interconnected and consistent. In the first layer, links are clearly

made between the task definition, overall dimensions of science and more specific conceptual, procedural, nature of science and technical aspects (see Figure 2.1). The second layer of planning focuses teacher attention on linking pedagogy with content. It involves defining the activities in terms of macro, meso and micro tasks – nested and increasingly detailed tasks that contribute to the achievement of the main task. It also requires articulation of focal artefacts, planned interactions and key outcomes (see Figure 2.2).

Figure 2.1

The first layer of a science education planner (InSiTE Project, 2006)

SCIENCE EDUCATION PLANNER			
SCIENCE STRANDS: Living World Material World Physical World Plant Earth & Beyond	MACRO TASK:		LEVEL: 1 2 3 4 YEAR: TEACHER:
STRANDS: AOs Covered -			
KEY COMPETENCIES:			
INTENDED LEARNING OUTCOMES: The children will:			
Conceptual LOs	Procedural LOs	Nature of Science	Technical LOs
MANAGEMENT/MATERIALS: Resource – Artefacts –			
ASSESSMENT: Assessment Activity			

Figure 2.2

The second layer of a science education planner (InSiTE Project, 2006)

Science: Planning for Teaching and Learning

Macro Task:				
Meso Task:				
	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
Micro Task:				
Micro Task:				

The breaking down of the tasks in this way helped teachers to think about how they were going to link ideas, tasks, and lessons while maintaining a focus on the macro task. They were also able to engage more freely with students on issues while maintaining the integrity of the task. The focal artefacts, or resources, helped to focus attention and support development of ideas. Including this in the planning made teachers think about their choice and use of artefacts to support student learning. Identifying desired interactions helped teachers think about key questions they might ask and how they might group the students. Listing key outcomes helped the teachers focus on what they were aiming for in terms of what the students would know and be able to do as a result of the teaching and learning. The linking of these various aspects in a planner therefore helped teachers to think about ways they could help their students learn effectively.

Moreland, Cowie, Jones and Otrell-Cass (2008) stated that the planner described above focused teachers on analysing their own and students' understandings and was pivotal in helping teachers bring to mind, refine and develop the PCK they needed to effectively interact with students. It also became a tool for discussion with colleagues, providing opportunities for additional development of PCK.

Careful planning, then, is likely to be an important aspect influencing the teaching of ethics in science. In the research project reported in this thesis, the planner initially developed by the InSiTE team is modified for the teaching of ethics in science to assist teachers in their planning and implementation of an ethics component in their science programmes as outlined in Chapter 4.

2.8 SUMMARY AND RESEARCH QUESTIONS

This chapter introduced the reader to ethics in science education by first defining the development of morality, values and ethics in the Western world. The recent development of bioethics as a philosophical field was integral in bringing together morals, values, ethics and science and technology. For the purpose of this thesis, a more general reference is made to 'ethics in science', in order to include a broader range of issues.

Arguments for the teaching of ethics in science include its potential to help students to: develop moral reasoning; become informed future citizens; develop critical thinking and decision-making skills; understand scientific and technological advancements; develop flexible thinking for changing ideas in science; and understand other people's perspectives. The teaching of ethics in science also helps to engage students in science learning and to develop ethical awareness, knowledge and judgement in science. Although some researchers argue against teaching ethics in science, many agree that contextual science today raises ethical concerns that need to be considered and evaluated. In response to these arguments, the 2007 New Zealand Curriculum (MoE, 2007) mandates the teaching of ethics in science. It appears, though, that teachers are not always clear about the expectations and implications of the curriculum.

There are a number of well-established ethical approaches that teachers can employ to develop students' capability for decision-making in regard to ethical issues. Four well-recognised approaches – consequentialism, rights and responsibilities, autonomy and virtues ethics –

have been used in schools for discussing issues in science. A fifth approach – multiple perspectives – has also been used by teachers to reflect New Zealand’s pluralist society and looks at different viewpoints on issues.

Teachers in secondary schools have taught ethics using a variety of science topics and issues for some time. The Burnham and Mitchell (1992) framework encompasses many of the commonly used teaching strategies. However, whilst teachers do have a selection of interesting and engaging classroom activities, these need to be used in conjunction with sound ethics teaching practice. In addition, science teachers may not understand ethical principles and approaches and students may not have the tools or strategies for ethical discussion and decision-making. Teachers need teacher development and supportive resources to understand the principles involved. Whilst a number of internet sites relating to bioethics education have been developed teachers need more support and resources for effective ethics in science teaching. Although most research and resources on teaching ethics in science relates to secondary schools, a small New Zealand study supports the teaching of ethics in science with younger students.

To be able to teach ethics in science effectively in the primary classroom aspects of effective learning need to be explored. A sociocultural view of learning (where learning is situated and occurs as the student interacts with people, objects, ideas, and events in the environment) is consonant with social interactions that promote scientific reasoning and learning about ethics in science. It makes sense in the classroom because it acknowledges complexity and the impact of interactions. Argumentation – a critical element of science *and* science education – helps students understand the nature of science, opening the door for understanding ethics in science. Another aspect of learning involving the use of teaching strategies and activities is the narrative strategy, seen as a powerful tool for drawing students into meaningful science learning and for understanding the nature of science. The art of scaffolding brings many of these aspects of teaching together for successful implementation and learning of particular content. This is known as teacher PCK and is pivotal to successful teaching. Specific

teacher development is needed for developing PCK for ethics in science. The use of subject-specific planning that supports teacher PCK (Moreland, Cowie, & Jones, 2008) is also likely to be important and is a pivotal part of the research in this thesis.

There are two main questions central to this thesis. The first relates to the ability of young students, specifically Year 5/6 students, to engage in ethical discussion. The second relates to the importance of planning for successful learning. The questions are:

1. Can Year 5/6 students engage in exploring ethics in science?
2. Does a subject-specific planner help primary teachers teach ethics in science?

Further considerations include whether the planner helps to focus science concepts so that primary teachers can be confident with science ideas in ethical issues and whether it engages teachers and consequently students in science learning.

Such a planner would have to support teachers with science ideas and concepts, ethics approaches and questions, scaffolds, and various strategies and activities (thus developing PCK). Teacher development would be imperative for the implementation of an ethics in science planner.

Chapter 3

Research methodology

3.1 INTRODUCTION

The previous chapter argues for the inclusion of ethics in science and acknowledges that the New Zealand Curriculum (MoE, 2007) now mandates the teaching of ethics in science. It also highlighted the paucity of research in ethics in science teaching at the primary level and a need for ethics in science to be introduced to primary teachers. Specific teaching and learning pedagogies such as argumentation, narrative strategies and scaffolding were identified as being likely to support primary teachers teach ethics in science. Planning was identified as being of particular benefit. The purpose of the research presented in this thesis was to determine whether year 5/6 students engage in exploring ethics in science and whether a subject-specific planner helps primary teachers teach ethics in science.

Chapter 3 sets out the research methodology that guided the research. A research methodology not only describes and analyses the methods used to gather and interpret data, but also presents the philosophical framework within which the research project develops (Lather, 1992). This is important because “researcher beliefs about what can be known (ontology) and how it can be known (epistemology) influence the selection and use of different methods in the research process” (Buntting, 2006, p. 44). Thus, methodology guides the way predictions, inferences, interpretations and explanations are made (Cohen et al., 2000).

There are three significant lenses through which educational research could be examined: positivistic (scientific) methodologies, interpretive (naturalistic) methodologies and methodologies taken from critical theory (Cohen et al., 2000). The following section highlights these lenses, particularly focusing on the interpretive paradigm as the framework for this research. Case study, the approach used within the interpretive framework, is described along with issues involved with the trustworthiness of the approach in Section 3.3. The different methods used to collect data are presented in Section 3.4, while the setting and planning of the research, including a brief description of the participants’ and researcher’s backgrounds are described in Section 3.5. This is followed by the ethical considerations needed for the project, and the chapter summary.

3.2 INTERPRETIVE RESEARCH

Positivist methodologies are based on the traditional methods of scientific investigations where research is tested empirically (i.e., findings are objective and quantifiable). Subjective belief is tested against objective reality. It is based on the idea that truth is objective; that objects have an independent existence that is independent of the person. Positivism has been characterised by its claim that science provides the clearest possible ideal of knowledge. However, Cohen et al. (2000) argue that scientific methodologies are less successful in their application to the study of human beings.

Human beings are complex and cannot be compared to the order and regularity of the natural world. A positivist methodology regards human behaviour as passive and controlled, ignoring individualism and intention. It ignores the mind, emotion and will of people. Interpretivists, on the other hand, argue that the social world can only be understood from the standpoint of the individuals being investigated. The understanding of individuals' interpretations of the world around them has to come from the inside, not the outside. Social science is subjective, not objective. It is a means of dealing with the direct experience of people in specific contexts. Beck (1979) argues social scientists have to see the world as different people see it to demonstrate how their views shape their actions. He says that, while social science does not reveal ultimate truth, it does help us make sense of our world.

Interpretive researchers begin with individuals and set out to understand their interpretations of the world around them (Cohen, et al., 2000). Theory should emerge from such research data, not precede it. Lather (1992) describes the interpretive approach as a concern for individuals and understanding the subjective world of their experience within the context of social practice, history, and culture. It recognises that people and events are unique, situations are fluid and changing, and behaviour evolves and is affected by context. Johnson and Onwuegbuzie (2004) caution, however, that subjective reports are sometimes incomplete and can be misleading. The findings may not be applicable to other settings, as they are often unique to the research context. Researchers may interpret the participants' viewpoints according to their own and, Bernstein (1974) adds, researchers may impose their definitions of situations on participants.

Cohen et al. (2000) present a third approach to educational research, that of critical educational research. This paradigm includes a political and ideological context. It is concerned with the emancipation of individuals. Its purpose is not merely to understand situations and phenomena but to change them. It seeks to redress inequality and to promote individual freedom within a democratic society. Critical theory can be useful for

research in schools where the researchers are intending change. This, however, usually involves action research designed to empower and give voice to the weaker participant. It is also suggested by Morrison (1995) that it should be examined and tested empirically.

While there was an element of change in this research (developing teachers' PCK for teaching ethics in science using a subject-specific planner), it is not about power relationships as in critical research. Rather, this research strove to understand teachers as they underwent a professional team journey towards teaching science. It was not intended to test or examine outcomes empirically, but to collate teacher and student views as case studies.

This research, then, was carried out within an interpretive paradigm, seeking to understand social constructs in the teaching of ethics in science and to explore teacher interpretations of how ethics in science can be taught. A qualitative methodology was selected for this research in order to acknowledge the importance of the subjective experience of individuals in the social world, and of understanding the ways in which individuals interpret the world (Cohen et al., 2000). An interpretive paradigm was used to frame the collection and interpretation of data. From the outset, it was intended that teachers would be involved with the research. It was anticipated that they would contribute to the development of the planning tool, offering ideas in teacher development workshops. The teachers would then trial the planner and report if and how it supported them. The planned lessons were to be observed. Teacher pedagogy and student learning were to be discussed with the teachers. Student response to the lessons would be important, as would be the teachers' responses to the planner and strategies offered. The researcher would observe, but felt it important to also participate, to some extent, in student learning – talking to students and discussing issues with them during lessons – to understand how they were thinking. Ideas and best practice in teaching ethics in science would be sought. Student engagement and the consequent learning were important.

The research is presented in the form of case studies, with a cross-case analysis used to identify the commonalities within the individual cases.

3.3 CASE STUDY

Cohen et al. (2000) argue that the interpretive paradigm is most naturally suited to case study research with its emphasis on interpretive and subjective dimensions. Adelman, Kemmis and Jenkins (1980) refer to case study research as “the decision to focus on enquiry around an instance” (p. 48) and add that it involves “the study of an instance in action” (p. 49). This could be a child, a classroom, a school or a community. Such an approach describes a real and unique situation in detail, giving readers the ability to understand ideas and how they fit together. It focuses on depth rather than breadth. Cohen et al. suggest the specific instance may be designed to illustrate a more general principle. Social truths are recognised within their context (Atkin & Black, 2003).

The case study, therefore, provides an appropriate approach for this particular research, situated in the context of teaching ethics in science in three primary classrooms. The three participating teachers worked within the same school. The teachers were teaching the same science context in which the ethics teaching was embedded. Each teacher chose the same ethical issue. The research, focusing on teachers’ ideas and responses, can be described as qualitative and collaborative.

Case studies are more publicly accessible than other types of research reports, though this can be undermined somewhat by their length (Cohen et al., 2000). Case studies also serve multiple audiences (in this case, teachers and researchers) by being relatively easy to understand and accessible. In addition, they allow readers to judge the implications of the studies themselves. Often, the findings of case studies can be generalised beyond the particular situations of the research. Therefore, it is anticipated that readers of this research may see applications for planning ethics in science programmes in other contexts. Insights gained from the teachers involved in

this research may be useful to other teachers in introducing and establishing successful ethics in science teaching in the primary classroom.

Another aspect of case study research is the freedom to alter design. Initially there were to be two teachers involved; the third teacher was added at his own request. This improves trustworthiness for the research by strengthening cross-case analysis and giving further insight by including additional views. Another change in the design involved the classroom planner for teaching ethics in science. The teachers were busy and tired at the time of teacher development so there was not as much contribution toward the planning tool as had been envisaged. It also became obvious the teachers needed greater understanding of ethics concepts before they could contribute meaningfully to the design of the planner. The design of the planner, then, was based mainly on the InSiTE planners (Cowie, Moreland, et al., 2008) but took the teachers' comments into consideration.

Not all the lessons were observed as had been intended in the design. Due to school email problems, the researcher failed to receive dates and times of all the lessons. The reduced observation was made up through discussion with teachers, interviewing students, copying teachers' plan and students' work and attending other lessons.

Case study research is dynamic rather than fixed (Cohen et al., 2000). Data collection can occur at the same time as data evaluation. Aspects of data were analysed and used to refine the next stage of the study. Interview questions were refined in light of on-going data collection. The planner was designed as an important tool intended to help teachers grasp the concepts of ethics and to give ideas for teaching ethics in science and hopefully help teachers develop PCK in teaching ethics in science. However, only the teachers can determine how helpful the planner was, so interview questions were honed to try to understand how teachers interpreted the planner and how useful it was to them. The responses the teachers gave were considered significant and taken into account. Their contributions helped shape the research; if the tools supplied did not support the teachers then they were

altered or changed accordingly. Individual perspectives, personal constructs, and explanations of situations were actively sought.

The researcher took a participatory role during classroom sessions. While mainly engaging in classroom observation, there was interaction with students. One session involved the researcher in role as 'Nancy', the owner of a newly developed movie theatre. She had come to meet with the 'Council' to find out whether or not to use chemical fire retardants in the proposed seating. In another class the researcher took the role of Prime Minister, also seeking advice on the use of chemical fire retardants. Other involvement included guidance, answering questions (whole class and individually) and discussions with individual students.

The research was collaborative in that the teachers worked together to a certain degree and worked with the researcher, both as a group and individually. The researcher was responsible for the content and direction of the teacher development sessions, the type of data collected, the analysis of the data, and the reporting. The aims of the research, the methods of data collection, and the research findings were honestly and openly communicated to the teachers. The teachers shared their ideas concerning the planner, asked questions to clarify understanding of ethical approaches and informed the researcher of the support they received. The researcher shared interpretations with teachers so that they could be verified. These considerations show an awareness of research bias and the need for research to be valid or trustworthy.

3.3.1 Notions of reliability and validity

Guba and Lincoln (1989) cautioned that the case study approach does not preclude the researcher from considering issues of reliability and validity. Reliability refers to the extent to which the research would produce similar findings if repeated by another researcher or if repeated more than once (Bell, 1999). However, reliability is problematic in most educational research because the researcher does not try to control variables but rather

deliberately aims to provide an accurate picture of social realities, as they are perceived (Buntting, 2006). It is not intended that the same research would be repeated with similar findings. Human behaviour is never static and is highly dependant on the social context (Merriam, 2001). Merriam suggests achieving reliability within a social context is not possible. Lincoln and Guba (1985) propose an alternative for findings in interpretive studies is that they are consistent and dependable. If the research cannot be repeated then the researcher should explain how the findings were derived (Dey, 1993) and evidence should be provided so that the findings make sense, that is, they are consistent and dependable.

Validity refers to the extent to which the research reports or measures what it intended to measure. Whilst a positivist's view of validity focuses on results that are accurate, or reflect a single reality (Buntting, 2006), the interpretive view is of multiple constructed realities. Consequently Guba and Lincoln (1994) prefer to use criteria such as trustworthiness, transferability and authenticity for evaluating interpretive research. Bryman (2001) suggests trustworthiness reflects the credibility of the research account. Explanations and findings are supported by the data and an accurate description of the context being studied.

Concern about observer bias where the findings can be selective, personal and subjective (Nisbet & Watt, 1984) can be addressed through reflexivity, or a self-reflection of the ways in which the researcher's own social identity, background, beliefs and theoretical frameworks impact on the research process (Guillemin & Gillam, 2004). Guba and Lincoln (1989) also describe the process of 'member checks' as one of the single most crucial techniques for establishing trustworthiness. In this project the teacher participants were asked to read and confirm that interpretations of the data collected accurately reflected their teaching and responses.

Yin (2003) discusses the presentation of multiple case studies to increase the chances of producing more robust results than a single case, and thereby enhance the power of analytic conclusions. In this research, three

teachers and their classrooms were selected with a view to strengthening the findings and trustworthiness of the research through cross-case analysis (Nisbet & Watt, 1984). The classroom setting defined the context for the research, which sought to understand participants' experiences, thoughts and feelings as they endeavoured to explore ethics in science as a group of teachers and with their students in their classrooms (Neuman, 1991; Sturman, 1999). The classrooms were authentic settings, ensuring ecological validity (Cohen et al. 2000) – giving as accurate as possible portrayals of the realities of the social situations in their natural settings.

In order to allow others to understand the event and to show what it is like to be in a particular situation, case study research also requires rich, vivid descriptions of chronological events. 'Thick descriptions' (Geertz, 1973) are provided to help the reader understand action and behaviour embedded within its social context. Nisbet and Watt (1984) remark that the whole is worth more than the sum of its parts.

Case studies should have a 'wholeness' about them rather than being a collection of isolated events. An understanding of the unique, complex and dynamic unfolding interactions of events and human relationships in the context of this study was developed using multiple methods, including audio recordings of teacher development sessions and interviews, observation of classroom interaction, and teachers' and students' materials. Data were detailed and grounded in reality. There was a holistic quality to the research, and the complexity of social truths was recognised.

Triangulation of method (Cohen et al., 2000; Nisbet & Watt 1984), as used here, gives the researcher more confidence in the data and helps to build a rich and comprehensive picture. It involves using two or more approaches for data collection. Campbell and Fiske (1959) comment that triangulation is a powerful way of demonstrating concurrent validity (trustworthiness), particularly in qualitative research.

Another means of triangulating is to employ a multiple respondent approach to help minimise researcher bias (Cohen et al., 2000). The selection of participants, what they select to say, and what the researcher selects to record as research data, are all affected by bias. In this research, this was addressed to some extent by involving participants with differing lengths of teaching experience (three and 20 years). The inclusion of the third participant (also with three years experience) at his own request, helped counter any bias on the part of the researcher in the selection process.

‘Triangulation of level’ (Denzin, 1970) means data are collected at one level, that is the teacher, and then to ensure validity or trustworthiness they are collected at another level. For this research, data were also collected from the students to take into account their views, and to help understand whether their learning aligned with the teaching objectives.

‘Triangulation of construct’ or construct of validity (Cohen et al., 2000) occurs when the constructs of the researcher and of the participants are as closely aligned as possible. This means the researcher understands the constructs of the participants, or can understand how the construct of the participants may differ from their own. In this research, the researcher had been teaching as a colleague at the same school as the participants up until a year before the research took place. Therefore, the researcher had an intimate understanding of the social setting of the school and of what the participating teachers were likely to know and understand, having an awareness of their pedagogy. Teachers’ constructs concerning the introduction of a new subject, young students’ ability to debate issues, what constitutes high levels of student achievement, and strategies for learning were closely aligned with those of the researcher. This alignment was further confirmed by informal conversations between the participants and the researcher.

In summary, reflexivity, member checking, multiple case studies, thick description, authentic settings and triangulation all help to address issues of bias and trustworthiness. The specific methods used within the research

methodology are addressed next. Ethical considerations, also important for trustworthiness, are discussed in Section 3.7.

3.4 METHODS

Methods refer to the techniques and procedures used in the process of gathering data (Cohen et al., 2000). Multiple methods were used in this research, including observations and interviews (with field notes and audio-taping), surveys, and the collection of primary documents. These were analysed and compared. Ongoing dialogue between the researcher and the teachers helped ensure the analysis was valid from the teachers' perspectives.

3.4.1 Observations

Bell (1999) suggests careful observation can often reveal characteristics of groups or individuals that would be impossible to discover by other means. Interviews reveal how people perceive what happens, rather than what actually happens. Observations may be more reliable than what people say in some instances (Nisbet & Watt 1984).

The researcher was a participant observer in each of the three classrooms, participating in some class activities and discussions. The observations were semi-structured, focusing on the teachers' pedagogy and student responses. Field notes were taken during the observations. Lesson processes and content were noted. Questioning techniques and interaction between individuals were also of interest, as was anything related to support mechanisms for teaching ethics in science. The notes served to trigger the researcher's memory for impressions gained, and allowed for triangulation with data from interviews and written surveys in order to increase trustworthiness. The researcher was aware of possible bias, so interpretation was cross-checked with teachers and students in informal and formal

interviews, and with member checking after the observations were written up.

Cohen et al. (2000) note that behaviour may change under observation. The researcher had taught at this school less than a year previously and knew the students. After a polite greeting, they continued with their work as they normally would, indicating that they were not affected by the observation. Two teachers noted and verified this.

All of the classroom lessons that the researcher attended were also audio-taped, as were the teacher development sessions and the interviews with teachers and some students. The transcripts, in conjunction with the field notes and other data, were used to write up the case studies, which were later checked for accuracy by the teachers.

3.4.2 Interviews

An interview is a conversation initiated by the interviewer to obtain research information. One advantage of an interview is that the information may be explored in greater depth. However, awareness of researcher bias and subjectivity is necessary.

Interviews with the participating teachers formed an important part of this research, and provided many significant benefits. Firstly, the interviews provided a quiet and reflective time where teachers expressed their feelings honestly and openly about the support given for teaching ethics in science. Secondly, they also verified whether information from observations was accurate. Thirdly, the researcher was able to follow up on, and seek explanation for, some of the teaching practice. Fourthly, the interviews gave the researcher the opportunity to be 'filled in' on relevant incidental lessons, conversations and lessons where the researcher had not been present. Fifthly, the teachers were able to reflect on the use of the planner and supports, and provide feedback as to how helpful these were.

Finally, the interviews added a greater degree of depth and detail to the case studies than would otherwise have been obtained.

One interview was also conducted with a group of five students from one class, because the researcher was only able to observe one lesson in that classroom and the class was unable to complete the survey referred to below. It was helpful to interview a random selection of students to gain an understanding of what they had learned and enjoyed during the ethics in science lessons. This interview, in conjunction with copies of the teachers' planning documents and the students' work, and the researcher's observations, provided opportunities for data triangulation in this classroom.

3.4.3 Surveys

Surveys were distributed at the completion of the ethics in science lessons to the students in two of the three classes. The survey asked the students about their learning and enjoyment of tasks during the exploration of ethics in science (Appendix 2).

The teachers were also given a survey (Appendix 2) at the conclusion of the research lessons, and this survey formed the basis of a final interview. The survey questions asked the teachers how they felt about teaching ethics in science in the research lessons, and what was helpful to them in this process. They were also asked specifically whether the planner was helpful and if they had any suggested changes. The teachers were given a significant amount of time to complete the survey, and to formulate their views in writing prior to the interview. The researcher was able to refer to these answers during the interview, and to engage the teachers in a more in-depth discussion on their experiences.

3.4.4 Primary documents

Collecting documents, particularly the completed planning documents, was an integral part of this research. The teachers' planning demonstrated

how the teachers interpreted the planners for teaching ethics in science and used them. The teachers' planning also gave insight, through the questions, strategies and activities used, into teacher pedagogy. Visual scaffolds, such as A3-sized Benefit/Harm lists and Pros/Cons mind maps showing effects of the ethics issue on stakeholders revealed how the teachers developed concepts and constructs for learning. Examples of students' work included lists of stakeholders and the particular consequences for them, Plus-Minus-Interesting (PMI) matrices and transactional writing on the ethics issue. These gave insight into students' understanding of the ethical issue.

3.5 RESEARCH SETTING

The research for this study took place from July to November 2009. As previously stated, three classes and three teachers from one school were involved. Two teachers were initially selected; the third was included at his own request. This provided an opportunity to further strengthen the trustworthiness of the research while enhancing the development of a young and enthusiastic teacher. The researcher, having previously taught at this school, had a reasonable understanding of the background of the teachers, their general pedagogy and their background in science. This, along with the fact that the principal was supportive of teacher development in science, was helpful in preparing for teacher development for teaching ethics in science.

The research began with two teacher development sessions, facilitated by the researcher. These were based on the researcher's previous experience in assisting to develop a bioethics teaching programme. The teachers were introduced to the concept of ethics in science through power point presentations (Appendix 3; Appendix 4). The second session took place seven weeks after the first session, due to school holidays and for the convenience of the teachers. In the second session the material was revisited and the ethics-in-science planner, which had been designed for this research, was distributed to the teachers. The lessons, observations, surveys and interviews followed over the ensuing weeks, dependent on teachers' timetables.

Prior to and independent of this research, six senior teachers of the school undertook professional development in teaching science. This resulted in the senior school teaching a science unit on fire. The three teachers involved in the current research incorporated their ethics in science exploration at the end of this unit.

In terms of the wider setting, the school is a medium to large-sized primary school with a decile nine ranking. Students are predominantly from a medium to high socio-economic background. The school is well regarded by the community and is known for its innovative practice and quality of staff. The school is often involved in academic research projects. In designing the research, consideration was given to the participants and the background of the researcher was acknowledged as is discussed in the following sections.

3.5.1 The participants

Lynda (a pseudonym) is an experienced teacher with over 20 years of classroom experience. She is extremely well regarded in the community and within the school and has won a 'best teacher' award. Having previously worked with her as part of a teaching team, the researcher was aware of her style and pedagogical approaches within the classroom.

Amy (a pseudonym) is a young teacher in her third year of teaching. She was selected because of her interest in science and her willingness to take risks and to try new ideas.

Anton (a pseudonym) is a young teacher also in his third year teaching. Anton asked if he could join the research because he desires to develop science education in his classroom. His presence gave the research a male perspective. This was significant in terms of reducing bias, particularly since the support offered by the researcher is from a female perspective and may be more appealing to, and 'user-friendly' for, females.

The particular teachers were selected to participate in the research to demonstrate how teachers with varying levels of experience might teach ethics in science, using the support provided by the researcher. Of particular interest was the way each teacher might interpret and use the ethics-in-science planner.

3.5.2 The researcher

In research it is important to understand the viewpoint and subculture of the researcher, as these may have an effect on the validity of the research due to possible strengths and bias of the researcher. In this instance, background experience was instrumental in enabling the researcher to create and facilitate the teacher development programme. She was able to draw on her primary school teaching experience of more than 16 years, including two years of specialised teaching in science and technology. The researcher completed a postgraduate diploma in science and technology education, and at the same time was involved in research in science and technology education, including the development of an online tool for teaching ethics. That research included assisting in providing a professional development programme for teaching bioethics. In addition, the researcher has written online biotechnology unit plans for teachers and has facilitated professional development for primary teachers for science teaching.

The researcher was also well known to the participants. This meant that a rapport was already established and the participants were relaxed about being observed, and comfortable in expressing their opinions in a friendly and supportive environment. The researcher acted mostly in the role of participant observer; this participation reduced the possible 'observer effect', contributing to a relaxed classroom atmosphere.

The researcher also developed the classroom planner for teaching ethics-in-science, the focal point for this research. This was based on the InSiTE science planners (Moreland, Cowie, & Jones, 2008), other researchers'

suggestions (Bunting & Jones, personal communication, 20 July, 2009) and some input from the teachers.

3.6 ETHICAL CONSIDERATIONS IN EDUCATION RESEARCH

Since education research involves human participation, ethical consideration is vital. Some current literature on research ethics (e.g., Denzin, Lincoln & Giardina, 2006; Groundwater-Smith & Mockler, 2007; Labaree, 2003; Powell & Takayoshi 2003; Pring, 2001; Trochim, 2006) alludes to an ideal: a harmonious, collaborative and respectful relationship between researcher and participant. The principle of respect is enhanced when researchers show a willingness to view a situation from others' perspectives (House, 1990). This recognition of others' viewpoints is consistent with the interpretive research paradigm. Johnson and Onwuegbuzie (2004) and Cohen et al. (2000) further suggest the move toward interpretive type research in education corresponds to the need for a more ethical research practice.

The aspects of research ethics that were addressed in this research included informed consent, the participants' right to privacy and confidentiality, protection of the participants from harm, and compliance with legal requirements.

3.6.1 Informed consent

An ethical principle regarded as central to ethical research practice is that the researcher obtains informed consent from the participants (Heath, Charles, Crow & Wiles, 2007). Ethical principles also dictate that parental/caregiver consent is sought on behalf of students up to 16 years old, but Finch (2005) argues that the students themselves should be informed as much as possible about the research and that consent be sought from them as well.

Initially the principal of the school was approached to request permission to carry out the research within the school, and was asked if two specific teachers could be approached about participating in the research. This gave the principal an opportunity to disagree with the choice of teachers, for example, should she feel they were already over committed. Informed consent was then sought from the principal, the teachers, the students, and caregivers and parents. A covering letter sent to all of these people explained the research and requested their involvement in the research (Appendix 5).

3.6.2 Privacy and confidentiality

A second ethical principle relates to the unprecedented growth in the collection, use and disclosure of personal information, which led to the development of the Privacy Act 1993 (Longworth & McBride, 1994). The principles incorporated in this Act protect individuals' rights to privacy of their personal information. This is in stark contrast to the researcher's purpose, which is to publish the outcomes of the research. Care, then, needs to be taken that the individuals' rights to privacy are not violated. In this research, the participants' rights to privacy were maintained through the use of pseudonyms.

All information and materials received and produced are held securely by the researcher and will be kept for the five-year mandatory storage period (University of Waikato, 2009).

3.6.3. Protection of participants from potential harm

Ethical research also requires that harm to participants be minimised. According to the Ethical Conduct in Human Research and Related Activities Regulations (University of Waikato, 2009), harm includes pain, stress, emotional distress, fatigue, embarrassment, and exploitation. Researchers need to be aware of potential harm to participants and take steps to reduce it as much as possible. For example, reported information can be perceived by

participants to be misleading or harmful. To minimise the risk of this occurring, Fine, Weis, Weseen and Wong (2003) suggest that researchers ask themselves if they are willing to show the text to the participants before publication. Bishop, Berryman, Tiakiwai and Richardson (2003) highlight how even sensitive research can avoid harm through an open and honest relationship with participants.

In the current research, openness and honesty were actively fostered and encouraged by providing a copy of the case studies to the teachers, and by open communication with them at all stages of the research. The researcher operated on the basis that the more the teachers knew about and were involved with the research methods, the more effort they were likely to put into planning for teaching. This meant the students were more likely to display enhanced learning outcomes, which in turn reduces the potential for teachers to suffer harm from being perceived as having poor teaching practice based on poor learning outcomes.

In case the teachers might feel that any 'less successful' lessons reflect on them personally, teaching and student work were linked as much as possible to the success or failure of the planner. This is justified because the focus of the research was on the effectiveness of the planner, not on the ability of the teacher. While it was conveyed to teachers that the focus of the research was on the planner, successful pedagogy was acknowledged.

Already facing time pressures from day-to-day school and classroom commitments, the teachers were made fully aware of the extra commitment associated with this project (teacher development time, discussions, lesson preparation and interviews) before it began. Every effort was made to reduce the amount of time the teachers were required to commit to the project and it was hoped that any possible harm suffered by the teachers was outweighed by the benefit they received from gaining confidence in teaching ethics in science.

The different cultural and social backgrounds of the students and teachers became more apparent during the ethical debates and views that were shared. Although Levinson (2003) suggests that many students find ethics discussions highly engaging, sharing ethical views can also result in students and teachers feeling uncomfortable because of their varied backgrounds and beliefs. Discussions concerning ways to manage the classroom environment, such as respecting all views, were included in the teacher development. It became apparent, however, that the teachers knew their students, had already given much thought and effort to establishing safe classroom environments, and managed the classroom activities and discussions accordingly. Differences between the researcher's views and those of the teachers and the students were responded to with appropriate sensitivity.

3.6.5 Other ethical concerns

Awareness of personal bias is important for researchers. In this research, examples of possible personal bias included viewing the planner as being more effective than it actually was because of the positive relationships with the teachers, and the pressure to report more positively about the planner so as not to offend the participants and because of personal investment in its design.

It was also possible that already established relationships could make the teachers more casual toward the study, but this did not appear to be the case. Conversely, the teachers may have felt the need to put an excessive amount of work into these lessons to please the researcher. The time and effort given to this project was similar to the commitment these teachers would give to other areas of the curriculum.

Although the researcher took the lead in the project, care was taken to ensure that the teachers did not feel that the researcher was exercising any power of authority over them in the sense of the researcher being 'right' and 'knowing the answers'.

Ethical research allows participants the right to withdraw from the project at any time (University of Waikato, 2009). Participants were given contact details of the researcher and the project supervisor for contact if necessary.

3.7 CHAPTER SUMMARY

This chapter has presented the interpretive paradigm as the underpinning methodology for the research project. This view guided the research – the data collection and the interpretation thereof.

The research was conducted in the form of case studies, where in-depth explorations were carried out with due care for trustworthiness for example, using reflexivity, member checks and triangulation. The methods used for data collection (observation with field notes and audio-recordings, interviews, informal discussions, surveys and primary documentation) are associated with the interpretive paradigm and were carried out with due ethical consideration of all participants.

The next two chapters present the findings of the research. Chapter 4 describes the teacher development sessions, and teacher responses to these, and Chapter 5 describes the case studies of the classroom programmes and presents a cross-case analysis of these. The findings are then discussed in relation to the literature in Chapter 6 followed by the project conclusions, limitations, implications and recommendations for future research.

Chapter 4

The teacher development programme

4.1 INTRODUCTION

The two development sessions attended by the teachers prior to the implementation of the research lessons were entitled 'Introducing ethical thinking into science classroom programmes'. The second session was almost seven weeks after the first (see Section 3.5). The teachers reported in post-observation interviews the gap was helpful. Comments from the three teachers were quite similar:

Lynda: It was good to come back to, to go over it again and help consolidate the learning.

Amy: It meant I could go away from the first session and absorb it and consolidate ideas.

Anton: In the first one [session] I got my head in the game and in the second one I started to 'get it'. It was good to have the break in between to mull it over and then for it to consolidate.

The time gap between sessions, therefore, gave teachers an opportunity to consider the content of the first session. Revisiting the material in the second session helped to consolidate the learning for them.

A prototype planner for teaching ethics in science was introduced in session one and discussed by the teachers. As a result, this planner was modified and reintroduced in session two as the planner to be trialled by the teachers. The findings from the first teacher development session, the modification of the planner and the findings from the second session are described in this chapter.

4.2 SESSION 1: INTRODUCING ETHICAL THINKING

A power point presentation (Appendix 3) used in this session was designed to introduce the teachers to ethics, ethics approaches, and exploring an ethical issue in a science classroom programme. At the outset, it was explained that the sessions were preparing the teachers to trial a planner for teaching ethics in science. The importance of the links to the curriculum (MoE, 2007) concerning teaching ethics in science, particularly the nature of science strand (see Section 2.4.2), was made clear to the teachers.

4.2.1 Defining ethics and reasons for teaching ethics

A news article on designer babies and genetic engineering was referred to by the researcher as an example of an ethical issue in science. This initiated a discussion by the teachers over a wide range of ethical issues. A definition of bioethics was given because, at that stage, it was thought that the teachers might develop a unit in bioethics. However, because the teachers taught a science unit on fire before doing the ethics teaching they decided that it seemed more logical to develop classroom programmes exploring ethical issues relevant to this unit. Therefore, it became more relevant to talk about 'ethics in science' rather than bioethics. When discussing why ethics should be taught, the conversation focused on:

- how ethics relates science to people;

- how scientific issues affect people personally, that is, have relevance to the students;
- why students need to learn to be responsible citizens (using the example of producing biofuels and consequent effects on rainforests, world food supplies, carbon footprint, etc.);
- the strong link between ethics and the nature of science strand in the curriculum;
- possible aims for teaching ethics, including developing ethical sensitivity (questioning common and accepted practices such as docking lambs tails), increasing ethical knowledge and learning how to justify viewpoints;
- student engagement. Lynda commented that “this teaching might stimulate students’ interest in the nature of science – how and why scientists do what they do.”

To give this discussion a context, the researcher then referred to a unit on conservation of the takahe, which she had previously taught. This unit included the ethics question ‘Should money and effort be spent understanding and saving the takahe?’ The ethics exploration was used to exemplify the teaching of ethics in science.

4.2.2 The takahe example

To model how ethical discussion might be incorporated in a science unit, the unit on the takahe (an endangered New Zealand bird) (Appendix 1) was used. The teachers were told in some detail how the unit was taught: the science concepts; why the takahe became endangered; and what was currently being done to save them. The teachers were keen to see resources and scaffolds that were used for the ethics aspect of the unit. They were shown:

- A Plus, Minus and Interesting (PMI) worksheet (Appendix 6). This strategy is commonly used to analyse the pluses, minuses, and implications of a decision or action.

- A noisy round robin activity (Appendix 7). This activity is a classroom management tool for generating ideas quickly from small groups of students. The students used the PMI sheets as the basis for this activity.
- Class summary chart (Appendix 8). This chart was constructed during a whole-class discussion, identifying stakeholders and recording the harms and benefits to stakeholders in terms of consequences. Both Lynda and Amy commented later that they would have liked to retain the chart to help with their own planning.
- An assessment activity worksheet 'What do you think?' (Appendix 9). This included questions requiring justifications for answers about saving the takahe and a further question applying the same thinking to a different threatened organism, the native snail (*Powelliphanta sp.*).

The teachers were also shown how common ethical approaches could be used as frameworks to explore the ethics question.

4.2.3 Introducing the ethics approaches

The ethical exploration in the takahe unit was used to introduce teachers to common ethics approaches. It was explained that the ethics discussion in the takahe unit predominantly used a consequentialist approach, with some rights and responsibilities questions as well. Virtue ethics was also included, in that students considered whether helping to save the takahe caused people to become more caring and supportive of environmental protection and restoration. An emphasis was placed on the need to have a framework with which to work and that several approaches could be used, depending on the issue to be discussed and the pedagogical approach of the teacher.

The five approaches used in this research – consequences, rights and responsibilities, autonomy, and virtues ethics – were presented, and it was explained why these approaches have been chosen for teaching in our

schools (four of them being well established and recommended by researchers, while the fifth, multiple perspectives, was to specifically acknowledge the needs of our bicultural and multicultural nation, see Section 2.2.5). Video clips (Reiss, 2007) were used to explain the role of frameworks in ethical thinking and deliberation. Specifically, these video clips covered the following areas:

- the four common ethical frameworks;
- choosing an ethical framework;
- whether ethical agreement necessary and how it can be reached; and
- introducing ethics in teaching.

The videos stimulated some discussion among the teachers, particularly about whether class agreement is needed at the end of an ethics discussion. Lynda acknowledged that for some issues it would be difficult to reach an agreement. Anton thought this might be frustrating for some students. Lynda was concerned that “Fred (a pseudonym) would force his opinion onto others because he’s so strong. I’m worried that he will be so strong. He’s so opinionated. That might threaten others.” Anton pointed out the personal nature of ethical decision making, and that this could make some students feel very vulnerable: “Some will struggle to be strong. It is dangerous to be different. This thinking is dear to them. Some will pull back. It’s their belief; it’s dear to them.” It was agreed that ethical consensus would not always be necessary, but rather that students should be able to state and justify their individual positions.

The teachers learned to distinguish between the five ethics approaches through the video clips and discussion, and became aware of the sensitive nature of teaching ethics. In order to plan their own classroom programmes they also needed to be able to identify ethical issues.

4.2.4 Identifying ethical issues

In order to identify ethical issues, the teachers were given a worksheet entitled ‘Ethical sensitivity – being able to identify ethical issues’. Themes (individual human rights, genetics, environmental or conservation

issues, animal rights and health) were listed on the left hand side and teachers were asked to identify specific examples of each. The activity was designed to help the teachers consider the wide range of topics that might have ethical dimensions.

At first the teachers found it difficult to identify ethical issues. One of them suggested genetic modification for the genetics category. That led someone else to say stem cells. Amy looked down the list and said, “They [the students] care about animals – I think it would be good to start with animals.” From that, the teachers generated ideas about zoos, battery farming, endangered animals, whaling and using animals in research. A summary of what the teachers identified as issues is presented in Table 4.1.

Table 4.1

A summary of what the teachers identified as ethical issues.

Ethical sensitivity - being able to identify ethical issues	
Themes	Examples of issues
Individual human rights	Abortion IVF Sperm donor Euthanasia Blood transfusions Life support Organ donor Organ transplants Cosmetic surgery Artificial limbs Equality – food, housing, education
Genetics	GM Stem cells GE Cloning Eugenics
Environmental/Conservation	Pollution Waste management Biofuels Population – planning Future generations Deforestation Global warming Animals Green issues
Animal rights	Whaling Zoos Battery farming Animals for teaching or research Endangered animals
Health	Xenotransplantation Drugs – use and abuse Psychosurgery Vaccinations Insect spraying

The bold-type words were given by the researcher during the discussion to help stimulate thinking. The teachers identified animals and environmental issues as likely to be the most appropriate teaching contexts for primary school students.

Anton raised a concern that he had heard recent science teaching material was indicating teachers should be teaching 'pure' science. The teachers were reassured that the 'pure' science was within a context, and ethics is often part of that context. This led to a discussion about different science contexts. Lynda questioned whether ethics should be taught in every science context. The others agreed it should only be included if it was particularly relevant to that science topic.

4.2.5 Activities and strategies

A range of teaching activities were introduced to initiate discussion about ways ethics could be taught, such as mind mapping, values continua, role play, round robin activities, PMI sheets and discussions, and debating. This included activities used in the ethics component of the takahe unit and in other ethics lessons the researcher had encountered. The teachers also discussed strategies for introducing and reading scientific material together for understanding. They recognised that the students needed the science "so they can justify their arguments."

Lynda remembered that her class had been involved in some drama on behalf of a new entrants' class that had been exploring ethics issues around the Waikato River two years earlier (Jones et al., 2007). Lynda's students acted out a scene where someone wanted to build a factory on the riverside and the five-year olds decided whether or not to approve the request. She felt the drama had portrayed a powerful scene for the younger students. Lynda also remembered that they used a teacher-in-role strategy: "The teacher had a scientist role. It was very powerful. It creates the tension." In addition, Lynda and her class were trialling ideas from Dorothy

Heathcoat's (2009) mantle of the expert. Lynda recognised that this role-play would be a successful strategy to engage students in ethics issues.

The teachers also commented that the values continuum (where students express their view on an ethics question in a continuum from absolutely agree to absolutely disagree) could be a way to carry out pre- and post-testing on student thinking. The teachers were particularly interested in 'hands-on' activities where students were actively engaged. Anton expressed concern that "if the activities were not hands-on it will switch quite a few off."

4.2.6 Introducing the classroom planner for teaching ethics in science

When the teachers were introduced to planning for teaching ethics in science they were shown a prototype of the ethics-in-science planner (Table 4.2). It was explained that input was being sought from them on how the planner could be improved. An additional lesson sequence plan (Table 4.3) was shown to stress the importance of planning classroom interactions, particularly because teaching ethics in science in a structured manner was new to the teachers. The ethics-in-science planner and lesson sequence planner were based on the planning work done by Cowie, Moreland, et al. (2008) as part of the InSiTE project (see Section 2.7.7). The components of the planner were discussed with the teachers, including the idea of dropdown tabs for 'ethical approaches' and 'activities and strategies' to access additional information (Table 4.2).

The teachers seemed enthusiastic about the potential for ethics teaching and learning, and about using the planners to support this. They liked the "dropdowns" and Lynda commented "I think it will be great. I'm thinking of the able children. They will enjoy the whole debating issue. They will want to do it. We could tap into this." Amy appreciated that the students would "become informed and therefore confident to have a viewpoint." She added that it was a good way for students to learn to listen to others.

Anton was impressed that students could “have their own view, they don’t have to agree with others” and Lynda added that “sometimes you might want them to view from someone else’s viewpoint. You could role-play and tell them they have to come to a decision.”

Table 4.2

Prototype of the ethics-in-science planner

ETHICS-IN-SCIENCE EDUCATION PLANNER		
SCIENCE STRANDS: Living World Material World Physical World Plant Earth & Beyond	Ethics question or problem:	LEVEL: 1 2 3 4 YEAR: TEACHER:
STRANDS: AOs Covered:		
KEY COMPETENCIES:		
INTENDED LEARNING OUTCOMES: The children will:		
Science concepts and ideas	<u>Ethical approaches</u>	<u>Activities and strategies</u>

Table 4.3

Prototype lesson sequence plan for teaching ethics in science.

ETHICS IN SCIENCE: PLANNING FOR TEACHING AND LEARNING				
Macro Task:				
Meso Task:				
	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
Micro Task:				

4.3 MODIFYING THE ETHICS-IN-SCIENCE PLANNER

As a result of discussions about enhancing the planner (the teachers not wanting “anything too wordy”, “the smaller and less reading the better”), it was decided to merge the two planning documents. The final planner (Table 4.4) needed to be brief for ease of writing and reading, yet sufficiently comprehensive for teachers to plan and teach a new area of the curriculum.

Table 4.4

The ethics-in-science planner

CLASSROOM PLANNER FOR TEACHING ETHICS IN SCIENCE				
Science context:				Year:
				Level:
				Teacher:
Science curriculum links:				
Ethics question (often begins with should...)				
Relevant science knowledge				
Ethical Approaches and questions	Activities and Strategies for intended learning			
Ethics focus questions	Activity	Planned interactions	Resources	Learning intentions
ASSESSMENT:				

The planner became an electronic resource rather than a paper copy, as teachers are increasingly using computers for planning (Cowie, Jones, Harlow, Forret, McGee, & Miller, 2008). Being electronic also means that extra items can be easily incorporated through the use of hyperlinks. The teachers appreciated the hyperlinks, both for clarity of the planner presentation (less material on one page) and being given examples to choose from.

The planner was reformatted to fit a single page, with a layout that was easy to view, and to include vital components needed to teach ethics. The first heading requires the **science or technology context** to be identified. Teaching science and technology within a context was fairly new to the teachers, and it was important for teachers to have a clear understanding of the context in which the science and the ethics is embedded. The **science curriculum links** are important since this is the first year (2010) that teachers are required to teach from the revised curriculum (MoE, 2007) and

many teachers are not yet familiar with its contents. This is also an area where key competencies could be considered. The **ethics question** is the 'big question' the students will consider and both teachers and students need to have a clear understanding of it to be able to identify the relevant science concepts and the ethics approaches they could use to discuss the issue and make informed decisions concerning it.

The planner is designed to support an approach where the ethical discussions are embedded in the science context, drawing on relevant science concepts. To have an informed discussion means understanding the science behind the ethics issue; teachers need to be clear about the science to be taught. There is therefore space in the planner for all **relevant science knowledge** to be listed to help teachers identify what the students need to know.

In addition, teachers need to be aware of **ethical approaches and questions** that can be used to facilitate discussion on the issue. To provide additional support material for teachers, a hyperlink has been incorporated instead of the intended dropdown tab in the earlier version. In an electronic version of the planner, teachers click on the heading and the five approaches and questions that can be used for each approach appear (see Appendix 10; compiled from Jones et al., 2007). This material is designed to help them decide which approach to use. The teachers can then select and modify the questions as **ethics focus questions** that they can put into their planner.

Besides needing to understand the relevant science and identify suitable ethical questions, teachers need rich pedagogical content knowledge – they need to know how best to teach specific concepts. This can be articulated in the activities and strategies for intended learning. This section is divided into four headings: activity, planned interactions, resources and **learning intentions**. It draws on work by Moreland, Cowie, Jones and Otrrel-Cass (2008) which examines the need for teachers to break down their teaching into small chunks so they become aware of what they need to do step by step and how they will link ideas, tasks (activities) and lessons. Thus,

once an ethics focus question is identified, teachers should ask themselves, 'What activity could I use to help answer this question?' Again, a hyperlink has been incorporated in the electronic version so that clicking on 'activities and strategies for intended learning' gives examples of activities and strategies that have been successfully used in ethics teaching (Appendix 11).

This table was derived from current activities and strategies that have been used effectively to engage students, encourage critical thinking and develop thoughtful discussion in ethics in science teaching (Buntting & Ryan, 2010; Saunders, 2010) and also from strategies known to develop critical thinking (e.g., Heathcote, 2009). It was also intended that new activities introduced by the teachers would be added to the list for future use.

As further support to teachers, activities and strategies designed for ethical issues around fire were included as specific examples. The PMI worksheet (Appendix 12), the noisy round robin activity (Appendix 13) and the 'What do you think?' worksheet (Appendix 14) from the takahe example were modified to show teachers how they could be used for different issues. These examples were added as hyperlinks in the activities and strategies section.

Within the ethics-in-science planner, the **planned interactions** heading helps the teachers plan how they will use each activity and identify key questions they might ask to stimulate thinking. The **focal artefacts** heading in the original planner was changed to resources, as teachers commented they are more likely to use and understand this term. Identifying the key resources when planning helps teachers think about how each resource can be used to support student learning. **Learning intentions** provides a space for teachers to articulate what they would like the students to know and/or do as a result of the teaching and learning.

The linking of the five headings in the boxes - ethics focus question, activities, planned interactions, resources and learning intentions - is deliberate, designed to help teachers to think about ways they can help their students engage in ethics in science effectively. This helps teachers develop

their pedagogical content knowledge. The final box focuses the teachers' thoughts on possible summative **assessment** activities.

The teachers specifically commented positively on the layout as being clear and easy to follow, although for Anton it was only after additional conversation that he appreciated the layout and items included in the planner.

4.4 SESSION 2: INTRODUCING THE CLASSROOM PLANNER

The aim for the second teacher development session was to introduce the modified planner described above to the teachers. This was achieved through a power point presentation (Appendix 4). Firstly, it reminded the teachers what constituted ethical thinking, and then the five ethical frameworks chosen as teaching approaches were again presented before exploring the planner in more detail, using the takahe example.

4.4.1 Exploring the takahe issue in the science-in-ethics planner

The ethics component of the conservation of the takahe unit was rewritten into the modified planner to use as an example of a plan for teaching ethics in science. The researcher used a power point presentation and paper copies of the ethics-in-science planner: 'Should money and effort be spent understanding and saving the takahe?' (Appendix 15). The teachers were guided through the headings on the planner. With reference to the first heading, the teachers were shown that the **science context** for the issue was the conservation of the takahe. The next heading showed teachers the **science curriculum links**: the science involved (ecological interactions) and the nature of science, inherent in the ethical exploration of whether to spend money saving the takahe. The **ethics question** was 'Should money and effort be spent understanding and saving takahe?' It was pointed out that 'should' is a common beginning for an ethics issue. If teachers are aware of this it helps them formulate their question. The **relevant science knowledge** identified

the science understanding needed for an ethics discussion around whether money and effort should be spent saving the takahe:

- what it means to be endangered
- what it means to be a native species
- the takahe is an endangered, native bird that became endangered through the effects of a changing ecosystem (e.g., the introduction of predators and non-native competitors)
- conservation efforts (creating predator free areas, culling deer, fertilising tussock grass and specialised breeding facilities)

The teachers then identified which **ethical approaches and questions** had been selected and matched these **ethics focus questions** with the **activities** chosen to address them. The **planned interactions** were deliberately detailed so that teachers could follow the thinking of the researcher, and included questions the teacher might ask and possible students' responses. Anticipating possible responses showed the teachers that the researcher had 'played out' some of the possible classroom interactions in her mind, helping to evaluate the effectiveness of the questions. The **learning intentions** specifically identified what the students were to learn, for example, to identify that a range of stakeholders are affected by conservation efforts and that whilst some benefit, others might be harmed. The **resources** needed for the activities were clearly identified and, finally, there was an example of an **assessment** activity, requiring a written report.

4.4.2 Why teachers might use this planner

Key points as to why teachers might use this planner were emphasised to the teachers:

- The planner is consistent with the New Zealand Curriculum (MoE, 2007), including space for science curriculum links including nature of science elements to be identified.

- The planner helps focus teachers, requiring them to identify what they need to know in order to make connections between the ethics, the science and classroom interactions.
- The planner prompts teachers to articulate intended learning outcomes in precise terms. The teachers become more specific about what they want to teach and more focused on classroom interactions – leading to successful student learning.
- This type of planner has been shown by researchers (Moreland, Cowie, Jones, & Otrell-Cass, 2008) to be successful at developing PCK in teachers in science teaching.

4.4.3 Exploring the planner

As well as a copy of the ethics-in-science planner: ‘Should money and effort be spent understanding and saving the takahe?’ the teachers were also given in paper copies and electronic format on a CD-ROM:

1. A blank classroom planner for teaching ethics-in-science (Table 4.4);
2. A copy of the **ethics approaches and questions** (which is accessed by a hyperlink in the electronic planner) (Appendix 10);
3. A copy of the **activities and strategies of intended learning** (which is accessed by a hyperlink in the electronic planner) (Appendix 11);
4. A **PMI worksheet** (which is accessed by a hyperlink in the **activities and strategies of intended learning**) to identify stakeholders and harms and benefits when adding chemical fire retardants to furniture (Appendix 12);
5. An adapted version of the “**noisy round robin**” (which is accessed by a hyperlink in the **activities and strategies of intended learning**) for generating ideas about using chemical fire retardants in furniture (Appendix 13); and
6. A worksheet ‘**What do you think?**’ (which is accessed by a hyperlink in the **activities and strategies of intended learning**) about regulating furniture to have chemical fire retardants in them (Appendix 14).

It was stressed that the activities and strategies given were only examples, and there were many more that could be used. The teachers asked if they could add to the list and were encouraged to do so

4.4.4 Planning a classroom programme

As the teachers and their colleagues had been trialling a science unit on fire, they agreed that it made sense to have the ethics content related to fire for the purposes of the research lessons. After some discussion they identified four issues:

- Should farmers be able to burn off their own land?
- Should people be allowed to incinerate their own rubbish?
- Should there be restrictions on what may be burned in household fires (e.g., should people be allowed to burn nappies)?
- Should people be allowed fireplaces – when considering global warming?

The researcher had observed experimental burnings of furniture with and without chemical fire retardants and had talked with scientists who work in this field at the University of Canterbury. This was shared with the teachers. Some of the resources (worksheets) had been designed with this issue – of using chemical fire retardants – in mind, although it was not intended to specifically direct teachers towards this as an issue. However, after a discussion around chemical fire retardants the teachers wanted to explore this issue, particularly because it was “so new and we want all the help we can get”. In retrospect, Anton and Amy felt that the ethics concerning chemical fire retardants would not have been an issue they would have taught in terms of being of real ‘personal’ interest to the students (see Section 5.5.1.5).

Having established a context (fire) and an ethical issue (whether chemical fire retardants should be used in furniture), the teachers worked through what they might write in their planners. Science curriculum links were identified and discussed. The teachers identified the ‘material world’ as

the appropriate strand for the context. They then agreed on the following two Level 3 and 4 objectives:

- compare chemical and physical changes. Compare the effects of chemical retardants in materials when burning with those without; and
- relate chemical fire retardants to their technological uses in society.

The objectives related to the overarching nature of science strand, and particularly pertinent to the lessons, were for the students to:

- use their growing knowledge when considering issues of concern to them; and
- explore various aspects of this issue (the use of chemical fire retardants in furniture) and make decisions about possible actions.

The teachers then discussed what relevant science knowledge the students would need in order to explore this issue. Some of the comments were:

They would need to know about the chemicals

What they [chemicals] are made up of

What they [chemicals] do

What effect they [chemicals] have when burning

How does smoke work?

How does smoke affect us?

What are the benefits of the chemicals?

Why have them [chemicals]?

Discussing these raised issues around some of the fire concepts, for example:

Smoke is confusing me right now. Is smoke a result of not having one of the three things [fuel, oxygen, heat] you need for a complete fire - because when you put it out you're taking one away aren't you and that leaves smoke?

Smoke is the result of unburnt particles

From lack of oxygen

The more [oxygen] you get the more it becomes a blue flame doesn't it?

Smoke is because there is insufficient combustion going on - means it's not burning clean. You have unburnt particles. There are all sorts of stuff in it. Methane is clean burning. There's no smoke.

Is a candle creating methane gas?

No, it creates a paraffin gas from the wax. Gas heaters use methane gas

Oh, is that why you don't get smoke in gas heaters?

This highlights the importance of teacher knowledge. The teachers were also grappling with new ethics ideas. They revisited the ethical approaches and suggested consequences, rights and responsibilities and autonomy as possible approaches for this issue. They decided that consequences would be the more relevant in this case, followed by rights and responsibilities and autonomy (“concerning peoples’ rights about what kind of furniture they have”). The teachers appreciated that the noisy round robin activity could be used to explore consequentialism. After some discussion, the teachers commented they would be able to “get a good debate going” with this issue.

There was a sense of hesitation as the discussion came to a close, the teachers asking, “So now do we have to go and write our own [plan]?” The researcher responded by briefly reiterating what they needed to write under each heading in the blank planner. It was suggested that bullet points could be used for relevant science knowledge to help limit writing.

The teachers were not given copies of the power point examples that were made in collaboration because the researcher did not want the teachers to transfer the ideas discussed straight into their planners. She wanted the teachers to consider each box again – to see if it could be understood and logically followed by each individual teacher. Also, not filling in the boxes immediately might give the teachers the freedom to change to a different issue should they wish to. However, the teachers did keep a copy of the takahe example, demonstrating the use of the ethics-in-science planner for a different ethical issue.

4.5 CHAPTER SUMMARY

This chapter reported on two teacher development sessions teachers participated in before they explored ethics their science programmes. During these sessions, teachers were introduced to ethics, ethics approaches, and planning and teaching ethics in science. The teachers were introduced to a prototype planner for teaching ethics in science during the first session. This was discussed and information from this discussion was used in conjunction with work done by Cowie, Moreland, et al. (2008) to produce a modified version of the classroom planner for teaching ethics in science (Table 4.4), the ethics-in-science planner, which was presented to the teachers in the second teacher development session. The individual components were discussed in light of an example, 'Should money and effort be spent understanding and saving the takahe?'.

For this research, the teachers discussed and agreed to use an ethics issue related to their current science unit on fire – should fire retardant chemicals be used in furniture? Planning for this issue was also discussed and the teachers collaborated on how this might best be done. The following chapter reports on the findings from each of the three classroom programmes, presented as three case studies. A cross-case analysis then explores common themes that emerged from these case studies.

Chapter 5

Classroom findings

5.1 INTRODUCTION

Chapter 4 describes how Lynda, Amy and Anton explored the teaching of ethics in science through two teacher development sessions. The support included a classroom ethics-in-science planner to help the teachers plan and trial an ethics in science unit. This chapter reports on the classroom programmes that were developed and implemented. Data were collected through classroom observations, surveys, teacher discussions and interviews (see Section 3.5).

Lynda, Amy and Anton (see Section 3.6.1) taught mixed ability classes of Year 5/6 students at a decile 9 inner city primary school. The classes had been studying the chemistry of fire in their science unit prior to exploring ethical issues relating to the use of chemical fire retardants in furniture.

Individual classroom programmes are presented below as three separate case studies.

This is followed by a discussion of the key themes in a cross-case analysis of the classroom trials. The themes include how teachers explored ethical perspectives in science, student learning and teacher development (including their use of the ethics-in-science planner).

5.2 LYNDA'S CLASSROOM PROGRAMME

Lynda's class of 32 students comprised 16 Year 5 (9-10 year old) and 16 Year 6 (10-11 year old) students of mixed ability who had diverse cultural backgrounds (New Zealand Pakeha, New Zealand Māori, Fijian, Indian, Sri Lankin, Chinese, Indonesian, and South African). Lynda explored the ethics of using chemical fire retardants in furniture in a series of five one-hour sessions over a week.

Lynda used the ethics-in-science planner to plan her classroom programme. The teaching and learning activities included:

- *Introductory brainstorm*: Discussion to identify what in the classroom would fuel a fire.
- *Exploring flammability*: Class discussion on flammability of fabrics; student groups to list fabrics and predict an order of increasing flammability; 'The flammability of fabrics' article (Appendix 16) used to re-organise order of lists; laminated fabric cards set up in a continuum of flammability; decisions justified to the class.
- *Researching fire retardants*: Students discussed articles 'The flammability of fabrics' and 'What is a fire retardant?' (Appendix 16), 'Chemical fire retardants' (Appendix 17) and 'Slowing the burning' (Appendix 18) and used computers to find out more about fire retardants before sharing ideas.
- *Introducing consequentialism*: Students used a space-jump activity (Section 5.1.2.1) to explore the concept of consequences.

- *Identifying stakeholders using think-pair-share and discussion:* Who and/or what might be affected by the use of chemical fire retardants?
- *Considering benefits and harms:* Round robin strategy (Appendix 13) to determine harms and benefits to stakeholders; ideas prioritised as a class.
- *Stakeholder analysis of benefits and harms:* Each student group chose a particular stakeholder group (e.g., airline personnel, accident and emergency workers, etc.) and recorded plus, minus and interesting points associated with the issue from the perspective of their stakeholder group before reporting back to the class.
- *Understanding alternative views using mantle of the expert:* Role-play in which a movie theatre owner considered whether chemical fire retardants should be used in the seating at a new movie theatre. Students represented a range of interest groups (e.g., teenagers, firefighters, etc.) and carried out research in order to represent relevant views.
- *Justifying a personal view:* Worksheet requiring students to articulate and justify individual responses (Appendix 14).
- *Transactional writing:* An assessment exercise requiring students to respond to the question 'Should chemical fire retardants be used in furniture?'

The following sections describe the classroom programme in more detail, showing how Lynda incorporated the ethics into a science context and developed a range of teaching and learning activities to help students explore ethical perspectives and formulate an argument. Student learning as a result of the classroom programme is examined and finally the classroom programme is viewed in light of teacher development and the support she felt she needed.

5.2.1 Links with the science learning

Having completed a science unit on the chemistry of fire (Appendix 19), Lynda extended the learning by engaging the students in an ethical

discussion about the use of chemical fire retardants in furniture. She used a brainstorm activity in which students identified what would burn in the classroom as a bridge between the previous science learning and introducing the ethical issue. Having identified furniture as common fuel for fire, Lynda drew student attention to fabrics in the room. Subsequent discussion focused on the flammability of fabrics. Lynda reported in her final interview that she would have liked to have carried out some experiments to show the flammability of various fabrics but had felt restricted by time constraints. Instead, the class shared their ideas about flammability and then worked in groups to predict an order of flammability from lists they had devised. They had the opportunity to revise this order after reading an article on flammability (Appendix 16). To strengthen their understanding of fabrics burning at different rates, student groups set up a continuum of the flammability of fabrics using laminated cards before explaining their decisions to the rest of the class.

To learn about man-made chemical fire retardants and where and why they are used, students read, took notes and then discussed research articles 'Chemical fire retardants' (Appendix 17) and 'Slowing the burning' (Appendix 18) in groups as directed by the teacher (taking turns reading, having a note taker and discussing the parts not understood using listening and speaking skills). Lynda worked with a group she identified as needing support while the others worked independently. To understand current views on the benefits and harms of chemical fire retardants, the students found and read articles on the Internet and shared their ideas with the class. Lynda considered the information and articles crucial "because without this science knowledge we couldn't discuss the issues".

5.2.2 Exploring ethical perspectives

The ethical exploration in Lynda's classroom focused on whether chemical fire retardants should be used in furniture and was approached largely through a consequentialist framework, although the autonomous rights of people to make their own decisions about what directly affects them

was raised in discussion. For example, one of the students asked: “Whose right is it to choose? Is it ours or the government’s?” Lynda said she would like to have developed ideas about the rights of an individual but felt restricted because of time constraints. She reported that she had chosen to focus instead on a consequentialist approach, which she felt may have been the easiest for the students to understand. She also considered that “rather than try and do two [approaches], it would be better to do one well.”

In order to identify the consequences, the students needed to first understand the concept of consequences. Class discussion revealed that the students had the notion that a consequence was a punishment or a negative result. Lynda used a familiar activity called a space-jump to help students understand the concept of consequences. Noisy round robin and PMI activities were then used to identify consequences for stakeholders, as described below.

5.2.2.1 Using a ‘space-jump’ activity to understand consequences

The space-jump activity was familiar to the class, having previously been used as a drama activity. Seated in a circle, an elected first student stood in the middle and acted out an action (e.g., eating an ice cream) and then froze. The next student repeated the action and added another one depicting a consequence of the first action (positive or negative) then froze. This was repeated until five students had moved sequentially through the actions. Class discussion helped re-inforce that consequences result from actions and can be positive or negative.

5.2.2.2 Using a noisy round robin activity to identify consequences for stakeholders

Having expanded their understanding of the notion of consequences, pairs of students discussed who would be affected by chemical fire retardants. A class list was then made of the various stakeholders. Next, Lynda placed the students in mixed-ability groups and each group wrote down on a chart the positive and negative consequences for a particular

stakeholder (e.g., 'What effect would using chemical fire retardant furniture have on firefighters?'). Lynda then employed a noisy round robin activity (Appendix 13) to get groups to contribute to each of the charts in succession.

Ideas generated during the noisy round robin (see Appendix 20) suggest that the students were predominantly concerned about health issues and the environment (e.g., causes brain damage, burns eyes, gives a rash or eczema, chemicals get into the environment and poison animals, pollution). These concerns had been picked up from web articles such as 'VPIRG wants to ban fire retardant chemicals' (Porter, 2009), 'Controversy over fire-retardant chemicals' (Andrews, 2008) and 'Furniture flame retardancy' (United States Environmental Protection Agency, 2010), which discuss the controversial use of particular types of chemical fire retardants, such as polybrominated diphenyl ether (PBDEs), and had been accessed during the earlier research task. It appears the students may have incorrectly understood that all fire retardant chemicals are PBDEs, and have picked up on possible problems linked to PBDEs by the articles (e.g., they affect the developing brain, cause serious health problems in young animals, and are found in human tissue and the environment). For example, one student told the researcher that she read an article suggesting fire retardant chemicals have been found in the environment, including in fish; this may explain the comment "Chemicals may get into piping and then run out into the sea". Some responses were also very absolute ("Causes brain damage", "people with asthma get worse", and "new born babies would really suffer"). As the unit progressed, the students became less absolute and emotive and many changed their view on the chemicals. (This is discussed in greater detail in Section 5.2.4).

Positive consequences for most of the stakeholder groups were that chemical fire retardants help to slow the burning, giving people time to escape and/or giving time to put the fire out, thus saving lives. For the environmentalists, a consequence of slowing the burning was that there would be fewer fires spreading to and destroying the environment. Financial

gain was seen as a positive outcome for scientists, workers and manufacturers. Prestige was also an outcome for scientists.

Lynda felt the noisy round robin activity was very effective in identifying beneficial and harmful consequences and in generating a productive sense of urgency amongst the students: “The noisy round robin was one of my favourites. It was a really good one to do because it focused the children and they came up with ideas quickly.”

5.2.2.3 Using a PMI (Plus-minus-interesting) analysis to identify consequences for stakeholders

A Plus, Minus and Interesting (PMI) activity (Appendix 12) was used to identify consequences for further stakeholder groups - companies or groups of people identified by class groups as being concerned parties (see Appendix 21). Working in groups a table was completed for a chosen stakeholder group. Because the activity was similar to the noisy round robin in requiring a consideration of the consequences for different stakeholder groups, it offered students another opportunity to consider how the issue might affect different groups of people. As with the noisy round robin, the main issues identified by students were toxicity of chemicals versus slowing the burning to give time to get away from a fire. Creating space for ‘interesting ideas’ helped students consider possible further consequences from their stakeholders’ viewpoints. For example, a predominant thought concerned the release of chemical fumes even in the absence of fire, and the detrimental effects of this. This concern was possibly prompted by some of the earlier reading of concerns about PBDEs on the Internet, as discussed above.

Lynda liked the way the students were engaged with the task, stating in the end-of-programme interview that she “really liked both the PMI and noisy round robin. They were so effective. No one was off task.”

5.2.3 Formulating an argument through role-play

A range of activities and strategies were used to support students to use both their science learning and their understanding of the issue to formulate arguments from both others' viewpoints and their own.

5.2.3.1 *Mantle of the expert (role-play)*

One of the activities used by Lynda to help students weigh up alternative views was a role-play requiring students to select a role of a stakeholder and argue (in a meeting scenario) from the perspective of that role either in support of, or against, using chemical fire retardants in furniture. As part of the role-play the class received an email inviting community organisations to attend a meeting to consider a question raised by someone building a movie theatre in the community: "Should I use chemical fire retardant seating in my new movie theatre?" The activity incorporated Heathcoat's (2009) mantle of the expert format, which emphasises "an active, urgent purposeful view of learning in which knowledge is operated on, not merely taken in" (para. 1). Individuals were required to specialise in knowledge from a particular viewpoint, becoming an 'expert' in that area.

After a class discussion to identify affected groups (teenagers; firefighters; scientists, including chemical engineers; environmentalists; parents; human rights commission; reporters; town council members) the students selected a role and made a name tag for themselves that would give them their new identity. The researcher was assigned to be 'Nancy', the movie theatre owner. The students reviewed previous work (Noisy round robin and PMI results charts, articles and the Internet resources) according to their role to gather evidence for their argument. On the day of the meeting Lynda set the scene by telling the class they "had some serious issues to discuss" and invited them to "take a seat around the [imaginary] board table" (on the floor). She welcomed attendees, saying they had convened to discuss the issue of chemical fire retardants in the theatre seating, and introduced

Nancy, the movie theatre owner (the researcher). Lynda made the scene more real by describing where the theatre was being built. The students appeared to take their roles very seriously, with one of the 'councillors' asking if they could not put their hands up during discussion (because adults did not). Lynda suggested they "could try and see if it works", and the class worked 'like adults' for the duration of the 'meeting'.

The first person to speak was 'Rachel Greendale' from the Human Rights Association, which was concerned about the health of those working in the chemical factories: "We have issues with the use of child labour in the production of the chemical fire retardants in poor countries. We don't agree that you should use children to work. Also we have concerns about people's [workers'] health involving the chemicals. We believe they could be toxic and further investigation is needed." A councillor argued in response: "Yes, there are factories in poor countries but they are owned by rich companies who pay workers well – and they are old enough to work", although this view was not substantiated in any way.

Another example of the role play involved 'Mick', a 'manufacturer of the chemicals', who said "We're [indicating two companions] chemical engineers and we've just flown in from Europe. We install the chemicals into fabrics by spraying them in. When the fabric burns it just melts and gives people time to get out of their house". The concept of spraying the chemicals into fabrics was inferred from an article they read (Appendix 16). Lynda clarified this by asking what would happen to her furniture if it caught fire and had that particular fabric on it. Mick told her it would burn slowly and enable her to get out of the house. The science behind these chemicals – they slow down the fire by melting rather than burning was later reiterated by the students in the role of scientists.

The 'environmentalists' argued that the chemicals concerned have been found in trees and in human tissue, showing how easily they are transmitted through the environment. Another environmentalist said he had read research suggesting that some of the chemicals are toxic and emit fumes

without burning. This led to concern that chemicals may get into patrons, particularly if they were eating food in the theatre (chemicals may get onto their hands). It was suggested that more research was needed to identify how toxic the chemical retardants are.

The issue of cost and the high price of the chemical fire retardant furniture was raised by a councillor. Some attendees felt it to be too expensive.

After hearing all these points of view, Nancy (the movie owner) talked about regulations in other countries and in the aircraft industry. She also talked about the need to save lives and described to the group what she had seen when scientists compared burning times between a sofa treated with a chemical fire retardant and one that was untreated (the untreated sofa was burning fiercely within seconds). She told them that as the movie theatre owner, she knew there were issues about the chemicals and that was why she had sought their views.

The chairperson invited questions, giving students an opportunity to learn more about the emotive and technical aspects of the issue:

Student: Are you opposed to chemical fire retardants?

Nancy: While the first priority is to save lives, it seems that a number of people are opposed to using man-made chemicals as fire retardants. I want to know more about why, and what research had been done in this area.

Student: Is smoke from chemical fire retardants more toxic than 'normal' smoke?

Nancy: I was talking to a scientist who said all smoke is toxic – but at least by using these chemicals the fire burns more slowly allowing people to get out and away from both the fire and the smoke.

Student: Are there different kinds of chemicals and if there is [sic], are you considering one particular one?

Nancy: There are, and some chemicals have been banned in the United States. Scientists are working on producing chemicals that are not harmful to people, but will still slow the fire down.

Town councillors decided to request an investigation into various chemical fire retardants to see what was available and to compare harms and benefits of different ones. A suggestion was made to make the seating from natural fire retardant materials (e.g., leather) but this was opposed because of the cost.

Someone brought up the regulation of chemical fire retardant furniture in Europe and stated that if other governments felt it should be regulated, maybe we should follow their directive. Someone suggested that filters/fans could be fitted to deal with any possible toxic fumes from the chemicals. A query was made as to whether the toxicity could be taken out from the chemicals. That caused participants to think about the workers in the factories producing the chemicals and the health risks associated with this work.

The focus was returned to personal decision-making when Nancy was asked to choose between a wool couch and a couch with chemical fire retardants – if it was for herself. She responded that she would be interested in investigating the potential of natural fire retardant materials. A council member then asked what her decision would be for the seating based on what she had heard. In order to avoid making a unilateral decision and imposing her view on the students, she said she needed to go away and think about what they all had said and weigh up the benefits and costs.

Lynda (as the chairperson) suggested that all present should indicate by a show of hands their personal preference in order to give Nancy an overall view of opinion. She reiterated some of the main points for and against using chemical fire retardants in the seating, stressing this was their personal decision. One student suggested voting for or against using natural fire retardant materials, and then voting a second time for or against using chemical fire retardant materials. The responses (presented in Table 5.1) show a strong favouring of incorporating fire retardants, with 90% supporting the incorporation of chemical fire retardants and 80% supporting the incorporation of natural fire retardants. That slightly fewer were in

favour of natural fire retardants rather than chemical fire retardants may have been because the student announcing the vote stressed that students should keep in mind the cost of natural fire retardants.

Table 5.1

Results of vote for fire retardant seating in movie theatre (n=29).

Using natural fire retardants		Using chemical fire retardants	
For using natural fire retardant materials in furniture	23 (80%)	For using chemical fire retardant materials in furniture	26 (90%)
Against using natural fire retardant materials (because of cost)*	6 (20%)	Against using chemical fire retardant materials in furniture	3 (10%)

A council member thanked Nancy for coming and wished her the best in her decision making. After the group had disbanded, removed name tags and regrouped as themselves in another classroom space, the teacher welcomed them back and then shared with them that she felt they had had “a very powerful discussion”. Specifically, the activity enabled every student to consider the issue from a particular point of view, and the teacher was pleased that nearly every student had contributed to the discussion. At the end, every student expressed an opinion in the informal vote, with several who had at first been against chemical fire retardants changing their mind during the ‘meeting’. Student feedback in an end-of-unit survey and in discussions with the researcher demonstrate that they felt they had learned a lot by listening to others during the role-play. The success of the activity may also have been because Lynda had attended a workshop using mantle of the expert as a learning activity, and had already used this as a learning medium with her class. Lynda felt “the mantle of the expert was a superb way to bring their learning together and allow authentic voice. The children spoke and justified their views.”

5.2.3.2 What do you think? worksheet

In order to formulate and justify a personal view, students were given a worksheet and Lynda asked them to reflect on previous discussion (the role-play) and to consider whether New Zealand should have a law requiring that fire retardants be added to foams and fabrics in furniture, and whether these should be manufactured in New Zealand or not. The students were also required to explain their answers. The students' reasons were glued onto a chart under the questions for display.

Table 5.2
What do you think? worksheet responses

Worksheet questions	Number completed*	Yes	No
Most western countries in the world have a regulation that says that fire retardants must be added to the foams and fabrics in furniture. New Zealand does not. Do you think New Zealand should have such a regulation?	24	8 (33%)	16 (67%)
If there was such a regulation in New Zealand, should we manufacture the retardant chemicals needed to put into foams and fabrics for furniture?	16	5 (31%)	11 (69%)

* Some students paired up, giving one response between them and not all students completed both questions.

All eight responses supporting a regulatory change in New Zealand gave similar reasonings, relating to the chemical fire retardants slowing down the burning, giving people time to leave, and saving lives (e.g., "Yes – because it saves lives by giving people more time to get out from a fire"). Amongst the opposing group there were four areas of concern about having a regulation in New Zealand: people's rights to choose; people's health (toxicity of the chemicals); the costs involved in the manufacture and consequent purchasing of the furniture; and there should be alternatives to chemical fire retardants.

The responses to these questions were more in-depth than the previous noisy round robin and PMI activity responses. Thought had been

given to alternatives to chemical additives, such as using naturally fire-retardant fibres. The health issues were less emotive (discussing possibilities rather than absolutes), and students were thinking about people's rights. Costs were considered as more of an issue. More students also appeared to appreciate the potential benefits of including chemical fire retardants in furniture, although twice as many were still against having a regulation in New Zealand.

Just over twice as many students were against producing the chemicals in New Zealand than for. There was a concern about consumers' rights, health issues for workers, cost and pollution (revealing students' prior knowledge about pollution in the atmosphere). One student, who supported producing the chemicals here, was concerned about causing pollution in another country and at sea:

because it is not fair to use other companies' resources – and to affect their environment and wildlife community. Also it costs a lot to ship the chemicals to New Zealand (it would be cheaper to make them here). And there might be a chemical spill into the sea (killing sea life) if they were shipped.

Other students saw saving lives as being a top priority and believed it worthwhile to produce the chemicals that might do this: "...even if they are toxic because they slow down the fire and save lives". Lynda said the in-depth thinking could be due to having had the 'meeting' where a number of students reported learning from each other and finding out things they didn't know before.

5.2.3.3 *Transactional writing*

Students were asked to complete a transactional writing task as a summative assessment activity to evaluate how well they could formulate an argument in relation to an ethical issue. Lynda first prepared students for transactional writing, taking them through a step-by-step process and scaffolding them toward the final outcome. The preparation was very thorough, including:

- *Using prior knowledge:* Lynda initiated the lesson by referring back to argument writing that the students had done earlier in the year (about whether or not the mantle of the expert was a powerful learning tool). Lynda's questions included: "How did you start? What was in the middle? How did you end?"
- *Key points for argument writing:* Lynda reintroduced some cards from the earlier transactional writing which reiterated the importance of stating the issue; providing some background; explaining what side you are on; giving reasons; using powerful words (therefore, in addition to, it's obvious, because of, equally important, there is evidence, furthermore, in conclusion); and summing up ideas.
- *Paragraphing:* It was decided that at least four paragraphs were needed, with an introduction, the reasons in the middle, and a conclusion at the end. Students were encouraged to use *I* statements, but to vary sentence beginnings so they didn't all start in the same way.
- *Clarifying the ethical question:* Lynda checked the students were clear about the ethical question ('Should chemical fire retardants be used in furniture?'). There was some discussion about the word chemical, which was not initially included. One student said, "We should put 'chemical' in there because there are natural fire retardants but we're talking about the chemicals".¹
- *Content discussion:* The class discussed some of the reasons that might go in the paragraphs. Lynda made suggestions for students who might be struggling with the structure of writing.
- *Planning:* Students had ten minutes to write down a plan for their writing while referring to a self-assessment handout that had objectives for structure, style and skills (Appendix 22).
- *Class sharing:* Students shared their planning, some of which had been drawn up as mind maps (a representation the students were already familiar with).

¹ Natural agents are also chemicals but the class reference to chemical fire retardants was to synthetic chemicals used specifically for fire retardants.

The students used their plans to write their arguments, which they then were asked to self-assess on completion (Appendix 22). While students were writing Lynda circulated around the class, identified examples of student work that met the criteria for good transactional writing and shared these with the class. These particularly highlighted the use of an initial sentence stating a chosen point of view, and subsequent sentences explaining what chemical fire retardants are.

The completed student work showed that most students referred to the science ideas and were beginning to present an ethical argument. Students were able to make a decision and formulate an argument with reasons. This is presented in greater detail below.

5.2.4 Student learning

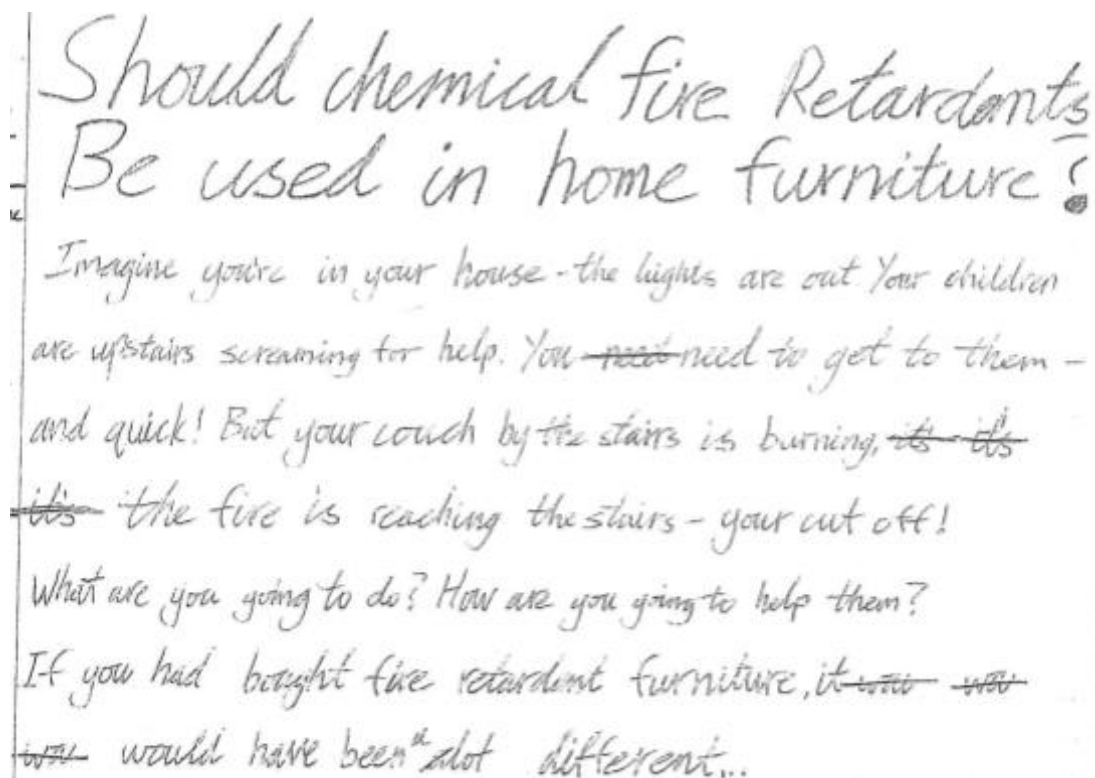
A picture of students' learning was developed by analysing their transactional writing as well as by a class discussion on what was learned, comments in the student surveys (Appendix 2), and comments from Lynda. These data suggest that, by participating in the classroom activities, students developed an understanding of consequentialism and the need to support a view with scientific evidence.

5.2.4.1 *Transactional writing*

Examples of student transactional writing are presented in Figures 5.1-5.4. These represent a sample of work chosen by Lynda as "quality examples of both Year 5 and 6 children". The first three show understanding of the issue and the use of science to support an ethical viewpoint, providing evidence that young students are beginning to formulate ethical arguments. The fourth example was included to show that while students are beginning to reason ethically, they are still developing morally and their writing can be emotive, reflect personal bias and use unsupported statements.

Tim's argument (see Figure 5.1) begins with an emotive image of a burning couch preventing you from reaching your children upstairs. He then suggests that if you had chemical fire retardant furniture, things would be a lot different. He discusses the science, explaining what chemical fire retardants are and how they work, using research data to back up his argument ("research shows..."). He presents detail in his explanation – "fire retardants slow down the burning by up to 60%". He then presents and refutes two counter arguments for the use of chemical fire retardants in furniture: that the chemicals are toxic and increase the cost of furniture. He uses persuasive language ("think about it" and "...is your life worth a thousand dollars?") with science knowledge to argue that every gas is toxic – depending on the amount of it – and concludes that the extra cost of the furniture is worth saving your life.

Figure 5.1
Tim's argument



Should chemical fire Retardants
Be used in home furniture?

Imagine you're in your house - the lights are out. Your children
are upstairs screaming for help. You ~~need~~ need to get to them -
and quick! But your couch by the stairs is burning, ~~it's~~ ~~it's~~
~~it's~~ the fire is reaching the stairs - your cut off!
What are you going to do? How are you going to help them?
If you had bought fire retardant furniture, ~~it would~~ ~~was~~
~~was~~ would have been a lot different...

What is fire retardant? Well, fire retardants are special chemicals that you spray ~~on~~ on to the interior and exterior of furniture and ~~manchester~~ to slow down the burning.

They work in 5 different ways. One way is they melt around the ~~burning~~ burning area and form a hard + tough + carbon char to ~~hold the fire from spreading,~~
cease

~~Research~~ Research shows that fire retardants slow down the combustion process by almost 60%; In an experiment, a couch ~~with~~ without fire retardants took 7 seconds for the fire to spread all over the couch - ~~while~~ while the couch with fire retardants took more than 2 MINUTES!!!

Some people might ~~think~~ think: 'What about the ~~toxic~~ toxic gas and ~~the~~ ~~expensiveness~~ ^{the} expensiveness of this product?'

Every gas is toxic; Even oxygen! If you breathe large amounts of it. Everytime you burn something, the smoke is toxic! Think about ~~it~~ it! And so what if it costs a ~~thous~~ thousand dollars more, is your life worth a thousand dollars?

Overall, I ~~that~~ recommend we all have fire retardant furniture - for the safety of our family and ourselves.

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Peter began his argument by stating the issue and then strongly agreed that chemical fire retardants should be used in furniture (see Figure 5.2). His writing depicts decision-making that is backed by some science knowledge (e.g., chemical fire retardants interfere with the flames and slow down the burning; he also refers to chemical fire retardant fabric melting). He is thus beginning to formulate arguments that justify his position, which is stated at both the beginning and end of his piece. He gives a convincing argument about chemical fire retardants slowing the burning. He also refutes health issues about the toxicity of chemical fire retardants although his argument needs further explanation to be understood. Peter wrote in his self-assessment that he “had lots of good reasons in his argument that were convincing”.

Figure 5.2
Peter's argument

Should chemical fire retardants be used in furniture?
25-01-07 furniture?

I would say yes, they are a very good way to keep your house safe. Fire retardants are chemicals that you can spray into your furniture, they interfere with the flames and slow down the burning ^{process} so you have enough time to evacuate. When the couch get to a certain temperature they ~~seaches~~ start to melt.

Without chemical retardents your house could be in flames within seconds. Chemical retardant slow down the burning by about 2 ~~to~~ minutes.

Most retardants are only toxic when they are burning, so you can spray them onto your furniture without masks or anything. You can even get retardents without toxic gases.

In conclusion to this, I think chemical fire retardants should be used in New Zealand infact all over the world...

Like Peter, Julie made her view apparent in her first paragraph (see Figure 5.3). She raises the issue of the toxicity of chemical fire retardants for firemen and then refutes this with explanations of their protective clothing and oxygen breathing apparatus. Her concern (and knowledge) regarding firefighters may be due to the fact that her father is a firefighter. Julie included a paragraph explaining the science of how chemical fire retardants work. She also refers to the significant difference that fire retardants can make to the burning rate of furniture (slowing it down to give you time to get out) as the main reason for supporting their use. However, she failed to support her initial statement with a concluding statement and discussed health and environmental risks without refuting these arguments (she was arguing for the use of the chemicals). In her self assessment she wrote, "I was able to see two different sides of the story. Before I could only see one. I changed my opinion because of the information we got."

Figure 5.3
Julie's argument

Some say that chemical fire retardants give off toxic gas but all smoke is toxic isn't it? I ^{recommen} ~~recommen~~ chemical retardants for furniture worldwide as it slows down the ^{combustion} ~~combustion~~ process therefore allowing you more time to get out of a fire. ~~What?~~

There is concern for the firefighters who need to go into the burning house to put out the fire and may inhale toxics. But firefighters have chemical fire retardants in their clothing and have oxygen tanks to breathe through, so it's not really a problem is it?

Fire retardants ~~are~~ have three different ways of slowing down the combustion process...

Some chemical ^{retardants} retardants break down the ^{Polymers} ~~polymers~~ so they melt and flow away from the flame. Others cause a layer of carbon char to

form on a polymer surface, the carbon char is very difficult to burn. Some ^{interrupt} ~~interrupt~~ the chemical reaction in the gas phase of combustion e.g. Halon and ^{phostex} ~~phostex~~.

^{scientists} Scientists have performed tests to determine how fast a couch burns compared to a couch with chemical retardants in it. I can tell you right now, there is a big difference.

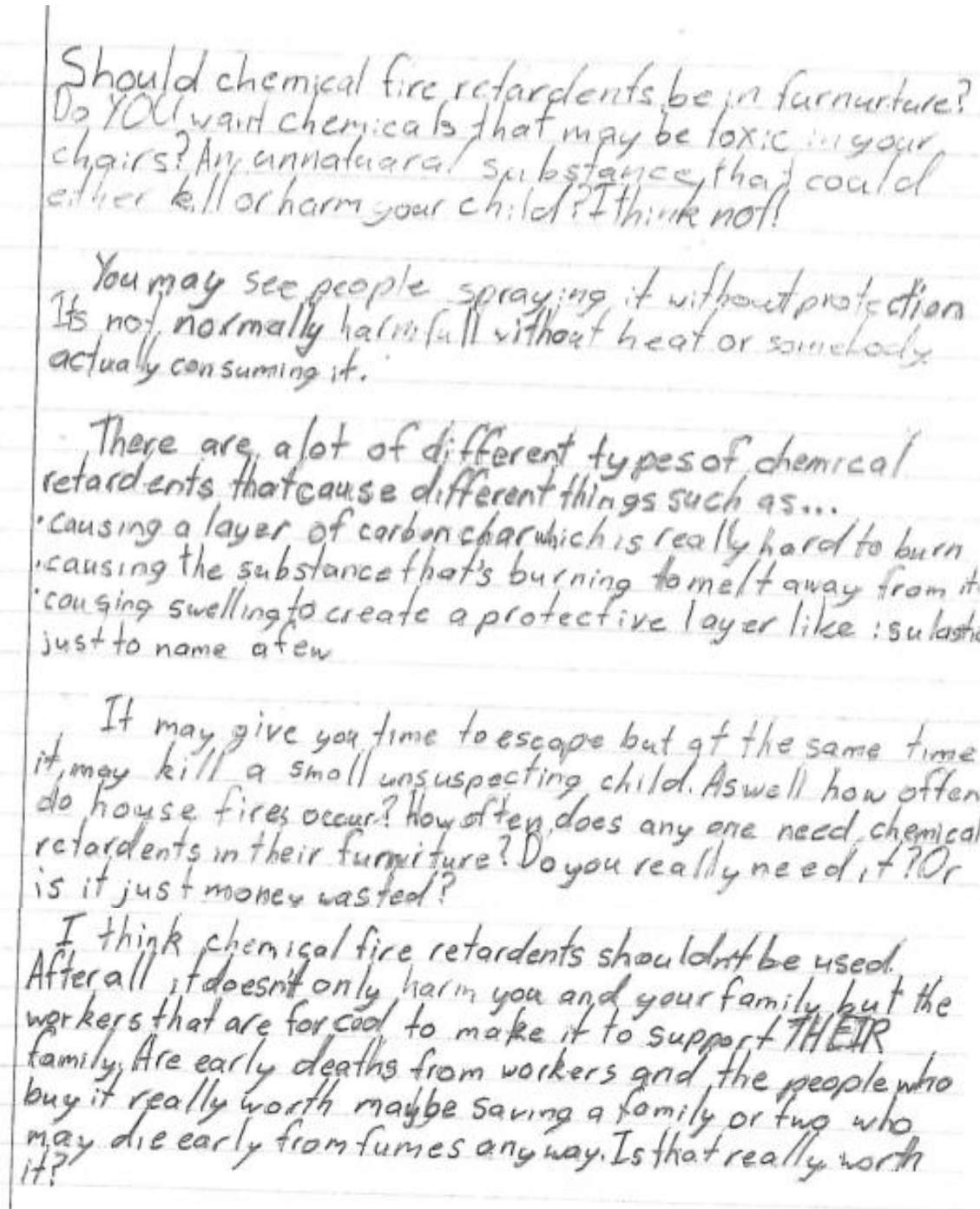
There is concern that the production of ~~fire~~ chemical retardants can result in poor human health and a risk to the ^{environment} ~~environment~~.

Studies have shown that toxic chemicals have been found in the ^{environment} environment and human tissue where the retardants are produced (not in NZ).

Note: The underlined and rewritten words relate to a self-editing process the class is encouraged to carry out to check their own spelling.

James did not agree with using chemical fire retardants (see Figure 5.4). Unfortunately, he wrote from an emotive, biased view rather than presenting a well thought-out ethical consideration. He personalised the issue by asking "Do you want chemicals that may be toxic in your chairs?" He emotively states chemical fire retardants are an "unnatural substance that could kill or harm your child".

Figure 5.4
James' argument



Should chemical fire retardants be in furniture?
Do YOU want chemicals that may be toxic in your chairs? An unnatural substance that could either kill or harm your child? I think not!

You may see people spraying it without protection
It's not normally harmful without heat or somebody actually consuming it.

There are a lot of different types of chemical retardants that cause different things such as...

- causing a layer of carbon char which is really hard to burn
- causing the substance that's burning to melt away from it
- causing swelling to create a protective layer like: sulastric just to name a few

It may give you time to escape but at the same time it may kill a small unsuspecting child. As well how often do house fires occur? How often does any one need chemical retardants in their furniture? Do you really need it? Or is it just money wasted?

I think chemical fire retardants shouldn't be used. After all, it doesn't only harm you and your family but the workers that are forced to make it to support THEIR family. Are early deaths from workers and the people who buy it really worth maybe saving a family or two who may die early from fumes anyway. Is that really worth it?

His second paragraph refers to people spraying the retardants onto their furniture (this was substantiated in articles found on the Internet and in the flammability article). However, James shows some confusion, refuting his own argument by saying the chemicals are not normally harmful. Further on in the narrative he concurs on one hand that the chemicals may give you time to escape but then uses emotive and unsupportive statements (“it may kill a small unsuspecting child”) on the other. He argues against the necessity for chemical fire retardants when fires occur so infrequently.

James’ conclusion reiterates his original statement and then adds a supporting statement about the chemicals being harmful for the health of families (who own the furniture) and workers (who make the furniture). James appears to have developed a tightly-held belief about the potential harms of the chemicals and uses emotive and unsubstantiated statements again by asking if the early deaths of workers and people involved with the chemicals are worth the production of the chemicals.

James’ example shows that some young students can become confused and that statements can often be emotive and unsupported when learning about ethics writing. James’ argument contains some science facts (though they did not support his case) and looks at possible consequences. He is beginning to formulate an argument, but needs further practice in coherent reasoning.

Apart from James, the arguments above show students are able to use relevant science concepts to support an ethical view. Although students varied in their understanding of the science involved, all students understood the question and were able to form and justify a viewpoint.

At the end of the ethics learning the students were given opportunities to think about what they had learned and to share this in a group discussion. The following section explores student thinking about their learning.

5.2.4.2 Student views of their learning

The students were able to articulate some of their learning in a summing-up class discussion. They also responded anonymously to a short survey in which they were asked what they had enjoyed; whether they'd done anything new; what they'd learned, including learning about other people's views; if they'd thought about their own views; and if they thought they'd learned enough on the topic to make a decision about it (see Appendix 2). An interview with Lynda supported comments made by the students. The findings are discussed below in student views relating to science learning, considering multiple viewpoints, confidence in decision-making and thinking about ethics.

Conceptual learning

In the class discussion students were asked what they had learned. Some of these, as recorded by audio-tape, focused on the science concepts: "About fire retardants"; "How carbon char is formed"; "That chemical fire retardants may have some side effects"; "About other people's work - making chemical fire retardants"; "That there is more than one chemical fire retardant"; "I learned about everything to do with chemical fire retardants - I didn't know anything before" (the latter quote was from a GATE² student who usually gave the impression that he knew 'everything' and was the fount of knowledge for the class).

Similar concepts about science learning were also made in the student surveys. Almost half the students (13 out of 32) said the main thing they learned was about "chemical fire retardants and that they slow down burning". Eight students focused on "how chemical fire retardants work" (including comments about carbon char, polymers breaking down and insulation). Other learning recorded included: natural retardants (leather, wool, cotton), the speed of fire and how fabrics burn differently, good and

134_____

² Gifted and talented education. Very capable students are assessed by teachers and recognised as being part of this group.

bad things about chemicals and chemical fire retardants, the application of chemical fire retardants to furniture, and the toxicity of smoke.

Considering multiple viewpoints

When Lynda asked the class if other people had different views from them, they all responded positively. This was corroborated by responses to the survey, which asked students if they learned about other people's views. Comments included: "Everyone has different opinions"; "We all have different ideas"; "People are unique", and "I learned about the work and passion of scientists, ethics and, that you can learn from your classmates". Students were also able to identify their view and compare it to others' views: "Some people thought that retardants were bad and vice versa. I personally thought that some retardants are good like natural ones"; "In my debate people wanted chemical retardants, I wanted natural". However, some students struggled with this, often seeing their view as the 'right' one: "I found it really hard that people had different views to me"; "I had to listen to other people's views"; "I was amazed at how many people thought fire retardants were bad"; "Some people are still against chemical fire retardants".

The students were asked (in the survey) if listening to others made them think about their own view and why they believed it. Two students said no: "I just made my mind up and fought for what I believed", and "I stuck with my idea and I still agree on it". The others, however, demonstrated they were interested (and sometimes amazed) to see that others had logical ideas about their viewpoint, as evident in the following comments:

Yes because sometimes what I'm thinking has a bad side to it.

Yes because when I listened to other people's views I learnt about both sides.

First I thought that chemical fire retardants were a bad thing but when I learnt more I realised it [sic] was a good thing.

I tried to learn from other people.

Yes and I changed my mind once because of my classmates.

Yes because I then began to question my judgement.

Students also realised it was acceptable to be able to change their view as they learned more about the issue. For example, one claimed, “I actually changed as a person by realising changing views is ok” and another reported, “I thought about things differently”. Some of the students reported that they listened to others and thought about their view but did not change their mind: “Yes [I listened to others], but I didn’t change my views”. During the class discussion almost all the students acknowledged that they had changed their view during the course of the lessons: “I thought chemical fire retardants were all bad but now, after all our learning, I’ve changed my mind”.

Confidence in decision-making

The students were asked to consider whether they knew enough about the topic to make a decision about it. One quarter (eight out of 32) said no to this question, believing that they needed to know more about the chemicals (the manufacturing process, effects on people and the environment) before they could make an informed decision. The rest (75%) seemed confident about being able to make an informed decision as a result of their learning, for example:

I have learnt heaps about fire retardants now that ethics in science is in our school. I knew nothing about it and didn’t know it existed.

I did the research and I listened.

I kept on taking in information.

Everyday we learnt more and more.

During the class discussion one student acknowledged she still couldn’t make her decision because she felt she did not know enough about it. She still had some questions and wanted to know more about what research had been done on the harmful effects of the chemicals.

Thinking about ethics

When asked what ethics was about in the class discussion, students commented it was “to debate”; “debate a side I didn’t agree with”; “when scientists make us aware there are harms and benefits so we can make choices” and “it’s about learning about sides of an argument and then making

a decision.” Comments about ethical learning from the surveys supported these statements, for example, “it’s about learning there are good and bad things about chemical fire retardants.”

One student in the class discussion focused on the action component, demonstrating an awareness of the world around him and the need for change:

Student: It’s about people.

Lynda: What do you mean, ‘about people’?

Student: We direct the world in how we want it to be and if we don’t change the way we act soon it could be disastrous for us.

Lynda: How do we change?

Student: One person has an idea and they use their voice to make it heard.

Lynda suggested someone look up ethics in the dictionary. One student read out “Moral belief about right and wrong.” Lynda then asked the class “So what is ethics?” A student responded with “Learning what’s right and wrong. Giving two sides and deciding.”

An ethical viewpoint must be justified, however (Reiss, 2007), and by the end of the ethics teaching every class member had an opinion about chemical fire retardants and could justify that opinion. Lynda initially “thought it [ethics teaching] might be too high for the students, but changed my mind very quickly about that when I saw how quickly they [the students] grasped the ideas.”

At the end of their classroom programme, the students were thus able to articulate their learning about the science concepts concerned and to demonstrate an awareness of ethics and some of what is involved in ethical decision making. Lynda reflected:

The ethics was a wonderful addition to the science unit – adding a richness, a depth and a high level of thinking. Even the students that usually need a lot of support gained a lot at their level. The whole class knew they had to make choices and that to do so they needed to learn about both sides of the argument. The students surprised me all the time with the depth of thinking this teaching produced.

The students also commented (in the surveys and class discussion) on the learning activities that they felt helped them to gain knowledge. The following section explores these responses.

5.2.4.3 *Activities for learning*

The students encountered a range of learning activities during the component on ethics, many of which they had not previously encountered in their classroom programme. For example, 30% revealed in the surveys (in which students were asked if they had done anything they hadn't done much of before) that debating was a new area. 'Debating' was what the students referred to during the mantle of the expert role-play when they expressed their views and others responded. They particularly valued being able to form and present a view while at the same time they learned others' perspectives: "We haven't done that much in debating and it made me think differently."

Other activities that students reported not having done before included learning to research ("I've never before sat down and highlighted [research] articles and then had a big discussion around it"); making use of a continuum ("learning about and making a continuum"; "drawing a continuum about the flammability of different materials"); the space-jump (although Lynda reported this activity had actually been previously undertaken by the class); and watching DVDs.

Student engagement and enjoyment of activities can be indicative of learning taking place, so the students were also asked which activities they particularly enjoyed in the survey. There were two main activities students reported enjoying the most: the debate (mantle of the expert) and space-jump.

The meeting (mantle of the expert) was an extremely popular learning medium: half the students (16 out of 32) reported it as being the activity they enjoyed the most, and a further seven said they enjoyed it a lot. All students were engaged and acted in a 'grown-up' manner, ostensibly because they

were role-playing adults who they reported were 'experts' in their field. The students enjoyed taking on these roles and some shared in the final class discussion that they had participated when normally they wouldn't have. Those who would normally struggle to engage in high level thinking were given manageable roles (teenagers, reporters) by the teacher, where they could engage at their level. One student reported he could participate because "it wasn't really me, but a scientist". Lynda also reported the students were keen to research so that they had something to present at the 'meeting' because they were 'experts'. The role-play seemed to focus the students for listening and engagement and proved to be a powerful medium for learning about ethics in science. Some of these students reported later that they had learned a lot about chemical fire retardants and the issues involved by listening to the other 'experts' in the class.

Seven out of 32 students (22%) reported in the survey that the space-jump was the activity they enjoyed the most with a further 13 (41%) saying that they had enjoyed it. Students reported that space-jump was popular because it was fun, new to some students, and it made the meaning of 'consequences' clear to them. Several students made comments about how they enjoyed learning "about the ethics approach of consequentialism", which was a new concept to them. Previously many of the students had associated consequences with 'bad' things ("a consequence was when you were sent to your room for being naughty"). Through the space-jump activity, the students understood that consequences were outcomes that could be negative or positive. They were comfortable thinking about consequences/consequentialism and used these words following this activity.

Lynda often used drama as a learning strategy in the classroom, which could be a reason for the students' enjoyment of both mantle of the expert and space-jump. Other enjoyable activities reported by students were learning about consequentialism as a new term, learning about the flammability of fabric and the noisy round robin activity – "because it got you lots of ideas". The students appreciated the activities that made them think.

For example, one student specifically reported: “The deep thinking that was included in all the activities was amazing and it made it fun to learn – especially about how things burn with chemical fire retardants.” Some students appreciated the quieter and more independent reading and writing activities such as the research to learn about the science involved, the ‘What do you think?’ worksheet, and the argument writing where “we wrote what we thought about having chemical fire retardants”.

It seems that students appreciated the range of activities, as well as participating in activities that were new to them. The debating (mantle of the expert) activity used in an ethics context was new to the students, where they could express a viewpoint and learn about different perspectives and was considered to be particularly enjoyable, as was the space-jump. Students recorded examples of learning as a result of each of these two activities (e.g., debating an ethical issue and understanding consequentialism). The following section explores the potential for overlap between school learning and conversations at home when the topic is one that is meaningful to the students and their families.

5.2.4.4 Home support

Many of the students reported discussing their learning with their parents. This support in the form of discussions at home appeared to enrich the learning experience. In particular, students appeared of their own accord to discuss whether their home furnishings were fire retardant. For example, one student seemed relieved that their leather couch at home was fire retardant and another discovered her parents had deliberately bought chemical fire retardant furniture. One mother told her daughter she knew about chemical fire retardants but didn’t know how they worked. She was impressed by her daughter’s science knowledge: “Mum was amazed I knew all about chemical fire retardants. I told her they cause the [burning] material to form a carbon char and slow the burning down”.

The students appeared to value learning about something that was relevant, in the sense that they could go home and discuss the issue with their parents. They were able to engage in ethical discussions about 'everyday science' (is our furniture fire retardant?), reinforcing the value of authentic science contexts when undertaking an ethical exploration of a scientific issue.

5.2.5 The teacher development programme

A teacher development programme introduced and prepared Lynda for ethics in science teaching. Although at first daunted by it (because it was new to her), Lynda appreciated the necessity for the intervention programme. She based her planning on the classroom ethics-in-science planner that was introduced and explored over two teacher development sessions. The next two sections explore, consecutively, Lynda's perceptions of the teacher development followed by how Lynda used the planner.

5.2.5.1 *Teacher development*

Lynda reported that when "I first heard about ethics in science I had no idea what it was about, but I was keen to learn. The first teacher development meeting we had on ethics was mindboggling – a lot to take in. It felt foreign." Although it was a "huge amount to take in" Lynda felt that the two teacher development sessions were very necessary. She said she "couldn't have picked it up any other way". Lynda was also pleased that there had been time (seven weeks) between the teacher development sessions. She appreciated the thinking time that this allowed, and felt it "was good to come back to, to go over it again and help consolidate the learning".

Lynda reported that one of the most important aspects was exploring what ethics in science actually was. She said she "looked back at the notes a lot" later when planning and teaching. Lynda also appreciated the example of the ethics-in-science planner: 'Should money and effort be spent understanding and saving the takahe' (Appendix 15) that formed the basis of

much of the second workshop. She used this unit as an example to plan her own.

5.2.5.2 Use of the classroom ethics-in-science planner

One of the key aspects of the professional development sessions was the introduction of the ethics-in-science planner. Lynda reported that using the planner helped her understand what she was going to teach – “especially with such a new topic”. She liked the way the planner stepped her through her lesson sequence. She said it had a “nice, logical flow to it”. She particularly found the activity suggestions very helpful. Lynda said she appreciated the layout, saying “it was visual”. She liked the boxes and the use of hyperlinks leading to examples of questions and activities. She summarised: “The planner was great.” Details of her planning (presented in Appendix 23) are as follows.

Science context

Lynda recorded ‘fire retardants’ as the context. Since this was part of the fire unit, the greater context of exploring fire retardants was ‘Fire’.

Science curriculum links

Lynda said that initially she was unsure how to use the planner and found the example planner ‘Should money and effort be spent understanding and saving the takahe’ (Appendix 15) useful to see what was meant by the terms in the boxes, particularly ‘Science curriculum links’. She collaborated with Amy (over the telephone) to help clarify requirements. Once Lynda could see what was being referred to she said it was straightforward. Lynda was able to include the ‘nature of science’ emphasis (in the 2007 curriculum) that underpins the teaching of ethics in science.

Ethics question

Lynda’s ethics question was ‘Should fire retardants be used in furniture?’ She later modified this, clarifying the synthetic nature of the fire retardants: ‘Should *chemical* fire retardants be used in furniture?’.

Relevant science knowledge

Lynda's understanding of relevant science knowledge needed by the students was based on concepts from the fire unit, as well as additional knowledge relating to the ethics question such as 'how scientists can slow down burning'. Lynda realised that this would need to be researched and taught first before the discussion could take place.

Ethical approaches and questions

Lynda said that having specific places to articulate the ethical approaches and some questions was very helpful. Lynda had not heard of ethical approaches before doing this unit and appreciated them being kept "up front" on the planner so that they could be used.

Ethics focus questions

In the 'Ethics focus questions' box Lynda wrote some questions that were not directly related to a particular ethical approach, but that helped to set the scene for the science learning needed for the ethics discussion, for example, 'What in our classroom would fuel fire?'. Lynda used these questions to create a sequence that would lead from one activity to the next. Lynda then used the ethics questions focusing on the actual issue, for example, 'Should (chemical) fire retardants be used in the seating at the movie theatre?' Although it had been intended that these boxes contain 'ethics focus questions', Lynda felt they should be understood more broadly as 'focus questions' in order to create a more coherent flow through the activities. She suggested a change on the planner from ethics focus questions to focus questions.

Activities and strategies for intended learning

The columns (and rows) in this section were designed to work together in a connected fashion. Each column would support another. Lynda's activities, planned interactions, resources and learning intentions were linked so that the ideas, tasks and learning intentions had a main focus and they all supported each other, and the ethics focus question. For example, when Lynda needed the students to consider which groups of people may be

affected by chemical fire retardants she planned to use a PMI activity to generate ideas. This was supported through the use of PMI sheets (a key resource) and further supported by the learning intentions which were for students to “consider the harms and benefits [to people] of [chemical] fire retardants in furniture” (which related back to the ethics focus question). Lynda used eight of the suggested activities (incorporated in the original planning documents) in her lessons.

5.2.6 Summary

Findings from the data collected from Lynda’s room demonstrate that the 9 and 10 year old students in her classroom were able to engage in ethical exploration and decision-making. The learning was evidenced through transactional writing, observed and recorded student engagement in ethical discussion and student reporting.

The learning was achieved through a classroom programme devised by Lynda as a result of the teacher development programme, including the use of the ethics-in-science planner. Her programme included activities that helped to explore the science involved (research activities, brainstorm, continua) and activities to explore consequentialism as an ethical approach (space-jump, think-pair-share, round robin and PMI worksheets). Students were able to formulate an argument, justify their views and make ethical decisions through the mantle of the expert (debate) and in writing.

Lynda reported needing the support of the teacher development to help her understand ethics, ethical approaches and teaching ethics in science. The classroom ethics-in-science planner guided Lynda to structure her programme in a way that scaffolded the necessary learning for ethical decision-making. It linked the ethics to the curriculum (particularly to the nature of science strand) and helped Lynda to determine the relevant science knowledge that the students would need and to choose ethics questions that would guide student thinking as they discussed the issue. Lynda appreciated the design of the planner, which enabled her to plan interactions and link

them with activities and strategies for intended learning. She reported that she had “learned along with the students”.

Lynda also appreciated how the ethics teaching fitted so well into the science context and found it added a richness to the science learning – particularly when taught at the end of the unit: “I love it. It’s so much richer having come at the end of the science unit. We already had a passion going, so it added depth.”

Lynda said she would teach ethics in science again and could see an understanding of ethics as being useful in other areas of the curriculum (particularly social studies and English) as well. She was pleased she now understands something about the ethics approaches and intends to use this knowledge in future teaching. Lynda felt “this unit worked particularly well in terms of developing critical thinking. I don’t know how you could get a richer discussion”.

5.3 AMY’S CLASSROOM PROGRAMME

Amy’s class of 30 students comprised 15 Year 5 (9–10 year old) and 15 Year 6 (10–11 year old) students whose cultural backgrounds were predominately New Zealand Pakeha with some New Zealand Māori, Asian and the Middle East. The ethics unit was the last part of the Fire science unit where Amy explored the ethics of using chemical fire retardants in ten 30 - 45 minute sessions spanning four weeks. Amy often didn’t write the word ‘chemical’ when referring to chemical fire retardants in planning or writing on the board. Her initial understanding of fire retardants when speaking to the class was that they were man-made chemicals that had been added to fabrics and foam to make them fire retardant (as evidenced in her introductory lesson when she defined fire retardants as “chemicals added to furniture”; she also repeated this understanding in a later interview). During the course of teaching, Amy became more aware of natural fire retardant fabrics and, having made the distinction, subsequently used the word ‘chemical’ when referring to man-made chemicals as fire retardants when

discussing the issue. The issue explored was “Should [chemical] fire retardants in furniture be a regulation in New Zealand?”

Amy used the classroom ethics planner to plan her classroom programme. The teaching and learning activities and their purpose within the programme included:

- *Introductory brainstorm:* What ‘fire retardant’ means and why would you make furnishings fire retardant.
- *Exploring rates of burning:* DVD showing different rates of burning; class discussion to establish that furnishings burn quickly and different furnishings burn at different rates.
- *Researching flammability:* Student groups read and then came together as a class to discuss an article on flammability, including focus questions (Appendix 24).
- *Introducing consequentialism:* Class discussion defining consequentialism; students wrote consequences for familiar scenarios (presented on charts).
- *Identifying stakeholders:* Class discussion to define stakeholder; student groups identify stakeholders – associated with regulating the addition of chemical fire retardants to furniture.
- *Prioritising stakeholders:* Class discussion about what makes some stakeholders more important than others; groups prioritise stakeholders and write consequences for the first three.
- *Learning about viewpoints and considering benefits and harms to stakeholders.* From a range of given viewpoints students identified stakeholders involved and whether the view was a harm or benefit to them (Appendix 25); learning was consolidated through a PMI activity.
- *Undersanding alternative views through debate:* Student groups were asked to present an argument to the prime minister from the view of a stakeholder group they were given.

5.3.1 Links with the science learning

Science knowledge gained in the preceding fire unit was recapped in the introductory lesson, including what fire is, how it can be stopped. Amy introduced fire retardants through questioning. The following interaction shows how students integrated learning from the previous science unit with concepts about fire retardants:

- Amy: A fire retardant is something – could be a chemical that you put into a product – like a couch. Why would I do that?
- Student: So it won't catch on fire.
- Student: A couch is easy to catch alight so it should have a fire retardant to stop it catching on fire.
- Student: If it does catch, it will slow it down or stop it spreading.
- Amy: What's good about that – adding it to furniture?
- Student: You would know your house is on fire before it burns down completely.
- Teacher: Why would it be good to slow it down?
- Student: So you can stop it.
- Student: You can stop it before it does any real damage.
- Student: If a fire starts on a couch it won't spread.
- Student: Combustion keeps the fire going. The fire retardants don't let the combustion happen so much – it stays small rather than coming into full combustion.
- Student: Things burn more because they have a bigger surface area like the flour in the exploding flour experiment. We need retardants to stop the spreading onto other surface areas.
- Student: When something heats up enough it changes to something else through a reaction. The retardants might stop this.

In the next session, Amy presented a DVD depicting the speed of fire and differences in the speed of fire for different fuels (a Christmas tree inside a house, a lounge suite and office furniture) to stimulate further discussion. Amy pointed out that none of the fuel (tree and furniture) in the fires contained chemical fire retardants. One student said he thought the slower fires would have had chemical fire retardants in them. This caused a

discussion about fuels burning at different speeds and how some were naturally more 'fire retardant' than others.

An article about the flammability of fabrics and what makes them less flammable (Appendix15) was read by small groups of mixed ability students. Amy provided written questions to help the students to find appropriate information, for example, "Find three things that change how combustible a material is". The students then discussed their findings as a class. Before the class discussion Amy read the article to them, asking questions (e.g., What does this tell us about what the word combustible means?) to help clarify student understanding. The students used previous knowledge to answer some of the questions, for example:

Amy: Why will loose-weave materials ignite more easily?

Student: Loose-weave materials will catch on fire more easily because the oxygen can get around it – around all the surface areas – and fire needs oxygen to burn.

The discussion identified fabrics such as wool and leather as naturally fire retardant materials because they were hard to ignite and burned more slowly. The students talked what 'natural' meant and about the weight, weave and surface texture of a material affecting its combustibility. They discussed the effects of burning a fire retardant material such as wool - it chars. Students realised that the addition of chemical fire retardants changes the combustibility of fabrics.

5.3.2 Exploring ethical perspectives

The ethical exploration in Amy's classroom - whether there should be a regulation to have chemical fire retardants in furniture - was approached through both consequentialist and rights and responsibilities frameworks. Consequentialism was demonstrated in class discussion of consequences and in the writing of consequences to familiar scenarios (on charts). The rights and responsibilities approach as well as issues of autonomy were introduced by the students through class discussion on the priorities of stakeholders (rights of stakeholders).

Amy chose the consequentialist approach because she said it was the easiest for her to understand and believed it may have been the easiest for the students to use for the first time learning about ethics in science. Amy also suggested her choice may have been influenced by the example of the consequentialist approach given during the teacher development sessions. She followed the example of the ethics approach in the planner on the conservation of the takahe (Appendix 15) for her own planning. She said that:

the rights and responsibilities unfolded when we started to talk about stakeholders. We discussed who had rights as a stakeholder and, if they had rights, whose responsibility was it to see they were carried out. For example, if we had a right to choose our own furniture, was it the government's responsibility to see that our rights were upheld by not bringing in a law of regulation concerning chemical fire retardants in furniture?

Discussions on consumer choice meant autonomy was touched on as well.

Before being able to identify the consequences, students needed to first understand consequentialism.

5.3.2.1 Understanding consequentialism through class discussion

Class discussion revealed that the students had the notion that a consequence was a punishment or a negative effect of an action or decision. By discussing familiar scenarios, Amy helped the students to understand that consequences can be positive or negative. First, Amy asked the class if they could identify the big question that was being discussed. Her intention was for the students to eventually link the issue to why they were learning about consequences. Some of the responses were:

What chemicals are fire retardants?

What makes fire retardants?

Why are chemical fire retardants in our furniture?

What are the pros and cons of having chemical fire retardants in our furniture?

Amy then wrote "consequentialism" on the whiteboard. The students were asked to pronounce it and then suggest its meaning. One student said it was close to consequence, so Amy asked what consequence meant. The

responses were “It means you’ve done something wrong” and “It’s a punishment”. When Amy asked the students to give examples, one student said she is sent to the bedroom when she backchats her dad. Amy asked if anyone wanted to challenge this.

Student: Well, consequences might not be just a punishment, it could be like feeling guilty as well.

Student: Well it’s not really a punishment but it could be. It’s anything that happens to you.

Amy: Consequences are not always negative.

Student: Say you do something for someone and they give you something back – that’s a consequence. You get a good thing out of it. Say you clean someone’s house and they give you a box of chocolates. The consequence is that you get a box of chocolates.

Amy: So consequences are the result of an action.

This example demonstrates how Amy was able to expand students’ understandings that consequences are not necessarily negative and even told the students that, whilst she often thought of consequences as something negative, she was realising that they can be positive as well. She also pointed out that there can be more than one consequence to an action. She once again asked students to define consequences. Some examples were:

When you do something wrong or good and something happens.

It’s the result of what happens.

There can be more than one consequence and they can be good or bad - like if your house burns down - that’s a consequence and if you get insurance, well, that’s a consequence as well.

5.3.2.2 Using familiar scenarios to identify consequences

In order to reinforce their understanding of consequences, students worked in small groups to list consequences for familiar scenarios, prewritten by Amy on charts. During the activity there was student discussion about consequences not always being an ‘action’ but that they are sometimes “something that happens on the inside”, for example, “guilt” or “good feelings”. Some examples of students’ ideas are presented in Table 5.3.

Table 5.3

Some examples of consequences identified by student groups in response to a given scenario.

Scenario	What are the consequences?
You decide to wash the dishes every night of the week without being asked to.	<ul style="list-style-type: none"> - I feel pleased - I'm praised - I could get money - Save power because I'm not using the dishwasher
You see a teenager, at a dairy, steal chocolate bars and you choose to tell the owner what happened.	<ul style="list-style-type: none"> - The teenager could get caught - You could get a chocolate bar for telling that the teenager was stealing stuff - You feel good for telling the truth
You choose to play cricket inside your house and break your mum's favourite (and very expensive) vase!	<ul style="list-style-type: none"> - You get smacked - You pay with your pocket money - You feel scared and run away - You worry about making mum angry
You choose to train really hard, eat healthily and get lots of sleep the night before your cross-country race.	<ul style="list-style-type: none"> - You think you have a chance of winning - You get fit and feel good - You get something you like - coke
You choose to drop your rubbish from eating your lunch on the ground	<ul style="list-style-type: none"> - You feel guilty about it - You might have to pick up rubbish all around the school all lunchtime - You might have to say sorry to the whole school - You might have to do extra work at lunch time - You may have to sit in a spot where you can't play or see anybody play

Amy reported the students went a lot further than she expected. Not only did they understand that consequences could be positive ("I'm praised") and negative ("You pay with your pocket money"), but they also understood there could be multiple consequences for an action and that they could be extrinsic ("I could get money") or intrinsic ("I feel pleased").

That most consequences centred around impacts on the individual demonstrates the ego-centric nature of students at this age. For example, in response to the scenario "You choose to drop your rubbish from eating your lunch on the ground", the consequences were about the effects concerning them. There were no comments regarding the effects on the environment, or on the greater good/health of the school. Some students did widen their view

from 'I' to 'We' to include their family, for example, when saying "we have a tidy home" (when I do the dishes every night). However, the scenarios were also written to the students personally (each beginning with 'You'), which presumably encouraged them to think about consequences to them personally.

At the end of this lesson Amy wrote on the whiteboard "A consequence is a result of an action. Consequences can be positive (e.g., you can do really well in the cross-country because you trained hard), or they can be negative (e.g., you came last because you didn't practise)". Subsequent lessons applied the learning about 'consequences' to stakeholders involved in the issue. Students learned about stakeholders, who they were, how to prioritise them and to identify benefits and harms to them concerning the use of chemical fire retardants.

5.3.2.3 Defining stakeholders through class discussion

Before introducing the concept of stakeholders, Amy reminded the students of the issue that they were considering: "Should chemical fire retardants in furniture be a regulation in New Zealand?" She wrote the question on the board and asked the students to explain what it might mean. Some responses were:

Should chemicals be added to the furniture?

Some people want them because they help but some don't because they might cause issues.

Maybe people will have to change their furniture if we have a regulation.

A student asked if there was already a regulation that chemical fire retardants had to be in furniture in New Zealand. Students were told that there are regulations in some other countries (but not NZ) and that there is a regulation in aircraft (world wide) to have fire retardant seating.

In order to develop the issue further, Amy pointed out that they needed to know about the stakeholders involved. The students did not appear to be familiar with the concept of 'stakeholder'. By way of an example,

Amy suggested that some builders arrive and remove the windows. When Amy asked who would have a say in that, students realised that the principal, the Board of Trustees, the builders, the teacher and they (the class) would be affected. One student concluded that stakeholder might mean people who are against an idea. Amy clarified that stakeholders could be against or for an idea. At the end of this discussion a number of students expressed that they were helped by this (“Oh, I get it now”; “I didn’t know what you meant by stakeholders before”; “So, it’s all the people that have something to do with it”.)

Amy referred the class to the question on the board and asked who the stakeholders were in the issue. The students gave suggestions – some with reasons as to why they would be involved. For example:

John Key [Prime Minister] because he would say for New Zealand what could be done – well about using money for it.

People who put chemicals into furniture because it could have health consequences for them.

Scientists who have to test and trial the furniture with and without chemicals.

People who make furniture in factories.

People who can afford to buy the furniture and people who cannot afford to buy it.

The discussion continued about people who would not be happy about the chemicals because of negative (toxic) effects they might have on people and the environment. Amy concluded by asking “So what is a stakeholder?” Comments included: “A person who has a responsibility”; “The people involved in the situation”; and “People who have an opinion about it”.

At the conclusion of this lesson Amy reported, “The more I got into a discussion on stakeholders the more I realised that I was not that clear about what a stakeholder was and I found it hard to articulate to the class what it was.” Despite this, it appears the students understood what it meant, in that they were able to appropriately name stakeholders involved in the issue in the following lesson. Although it took a whole lesson to establish the meaning of this word, students were able to use it in future discussions.

5.3.2.4 Listing the stakeholders

Before listing the stakeholders involved in the ethics issue Amy recapped the definition of a stakeholder and wrote on the board: “A stakeholder is someone who is involved in making an ethical decision. A stakeholder will have their own opinion and may have some responsibility in making a decision.”

Student groups listed as many stakeholders as they could think of around the issue. They regrouped as a class to share their ideas, which Amy collated on the board (see Appendix 26), deleting any repetitions. As can be seen, there was a wide range of ideas, perhaps because of the in-depth discussions students had had previously about stakeholders – making them more aware of all the people who could be involved. They also considered how chemical fire retardants might be used, asking questions such as “Do they put chemical fire retardants in Batts? Because if they do then builders would be stakeholders.”

5.3.2.5 Prioritising stakeholders and introducing rights and responsibilities

The following lesson focused on prioritising stakeholders – those who were affected more than others. This led to discussing about who had rights and who had responsibilities. Amy began by reading out who the class had chosen as stakeholders and then asked “so who are they?” The students responded that they were people who have problems with chemical fire retardants in furniture or help to make the right decisions. Amy then asked if they all have the same consequences. The students realised that the consequences were different for the stakeholders depending on their motives. For example, a student said “ John Key [New Zealand prime Minister] was about money. Firemen want them [chemicals] to save lives”. The students realised that some stakeholders appreciated the chemicals for slowing down the fire, while others were concerned about the cost. Amy then asked the students to prioritise the stakeholders – “ Is someone’s opinion

more important than others? Who has more rights than others as a stakeholder?" The students suggested it would be people who had responsibility for people (John Key, firefighters) or who were directly affected by a decision (furniture manufacturers).

Amy guided the discussion in such a way that the students could see that there could be many opinions, but that some might be more important. In addition, some people might have more rights than others as stakeholders because they might be more affected by the issue.

Amy suggested that if some have rights, it could be that others need to be responsible to uphold those rights. For example, babies have the right to be protected from harm, so parents have the responsibility to make sure furniture is safe for their children. The right of autonomy was addressed briefly at this point. The students concluded that if people had the right to choose what furniture they wanted, then the government had a responsibility to uphold that right.

Amy asked the students to choose three important stakeholders from their lists and to discuss how the issue would affect them – whether negatively or positively, or both. All students could identify and prioritise stakeholders (most groups identified similar stakeholders as being important - firefighters, John Key and furniture manufacturers) but not all groups reported consequences for stakeholders (see Appendix 27). Some of the students showed some in-depth thinking (e.g., chemical manufacturers have financial benefits but their health could be harmed), while others struggled to see how the issue affected the stakeholders. Because of the differences in student thinking Amy felt at this stage that “ethics in science would be a good extension for a science topic – but only really for top kids.”

Amy’s concern that students struggled to identify consequences for stakeholders led her (in the next lesson) to introduce viewpoints of stakeholders she had found on the Internet to give students more ideas.

5.3.2.6 Identifying benefits and harms in various viewpoints

In order to help students develop their knowledge base, Amy provided students with 'actual' viewpoints of stakeholders she had obtained from the Internet. Amy said the reason for this lesson was to prepare the students for a debate by exposing them to others' views on the use of chemical fire retardants.

Amy introduced the session by making explicit an aspect of the nature of science - that scientists need to think not only about their work in making the chemicals, but also about environmental and societal issues that may result. This led to a class discussion about environmental and societal problems that might arise when producing the chemicals. Amy then gave each group of students ten viewpoints about chemical fire retardants (five benefits and five harms) retrieved from the Internet (Appendix 25). The groups were required to read the statements and discuss whether the authors of each were for or against using chemical fire retardants and why the students thought this. They also had to determine who might have written the statement (i.e., the stakeholder). Amy joined in the group discussions, clarifying some of the viewpoints for the students. Student groups declared their decisions to the class by attaching their cut out statements to the whiteboard under headings of for and against.

The class was asked if they had found anything challenging in this lesson. Responses included the three main parts of the exercise: identifying stakeholders ("It was challenging to say who the stakeholders were"); determining the side of the argument ("Trying to work out if it [the statement] was for or against"); and determining why the stakeholders are for or against ("Coming up with a reason why they said what they said"). Although they did find these things challenging, the students appeared to be engaged and Amy commented at the end of the lesson that she was pleased with how well they were working and discussing the issues. She was disappointed that a number of students had missed this lesson as it had "provided model arguments for the issue that they could have learned from"

(several students had been called away to rehearse for the school production).

5.3.2.7 Using a PMI framework to identify stakeholder benefits and harms

Class discussion and a PMI activity helped to strengthen and consolidate students' ability to identify consequences of stakeholders. Amy first identified (through raised hands) who in the class had come to a decision about using chemical fire retardants in furniture. She asked them to justify their decision. Some examples were:

No, because chemicals can cause people to get hurt – people could be allergic to the chemicals and people could still die from the fire anyway and furniture would be more expensive.

The chemicals make more smoke because it burns slower and the room fills up with smoke and that affects people. They only do one thing – slow fire down – but there are so many things that could go wrong with it, so no I don't agree with it.

Each group in the class was allocated one of six stakeholder groups Amy had prioritised as important (fire service, furniture manufacturers, consumers (buyers of furniture), scientists, environmentalists and government). The group had to come up with the benefits and harms from the perspective of the stakeholder they had been given. Amy stressed that it may be difficult to find both a negative and a positive thing. She asked for some examples as firefighters:

They would be for it because it would give them more time to get to fires and more time to put out fires and save lives and buildings.

A negative thing could be that they waste their time and money going to little fires when there might be more important fires to go to.

For some stakeholders, like this example of firefighters, there may be only one perspective that makes sense. Dredging up harms, when there is clearly an overwhelming benefit, might be unnecessary and even stretch credibility.

Students were required to rule up a PMI chart with columns for 'plus' and 'minus' (which Amy explained were "good things" and "bad things"), a box at the bottom for any questions or ideas they came up with, and the stakeholder group at the top. Students who had been exposed to various

viewpoints during the previous session were asked to help those who had been absent. Examples of student work are presented in Appendix 28 and show that students were able to write about positive and negative consequences for stakeholders.

During the initial discussion in groups, Amy realised students were still thinking and talking from their own point of view. She stopped the class and reiterated that “This is from the point of view of the stakeholder you have been given, that is from the firefighters’ point of view, or the scientists’, or whoever you were given”. She suggested that stakeholders question other stakeholders, for example, consumers may question furniture manufacturers as to why they should pay a lot more money for furniture. The students were also beginning to think about and form solutions to the problem as overheard in this discussion:

Student: We should make different types of chemical fire retardants so that if you’re allergic to one kind you could use another one that would be safe for you.

Student: What if there’s not another chemical - then you’d have a problem.

A number of the comments made in the PMI reflect the reading of the viewpoints handed out in the previous session which were still attached to the whiteboard. For example, one viewpoint claims “These toxic chemicals have been shown to cause cancer, reproductive problems, learning disabilities... in laboratory animals and house cats ... these chemicals are climbing the food chain ... and are found in fish ...”. This would explain the environmentalists’ concern about “chemicals spreading through the environment” and “giving people cancer” (though the viewpoint was referring to animals). Another viewpoint claims “they are potentially toxic chemicals which are bad for children...” which would explain the students’ claim “they are bad for children”. The idea from the firefighters that they would get more money (by helping to advertise chemical fire retardants) indicates students may be confused about what firefighters actually do – especially concerning their relationship as stakeholders in the issue of chemical fire retardants. The activity took longer than expected, possibly

because students were now present who had missed the previous lesson in which additional information had been introduced, and they were 'catching up'.

5.3.3 Formulating an argument through role-play

Having considered stakeholders and consequences to stakeholders, Amy used a debate (based on ideas shared by Lynda on Heathcoat's (2009) mantle of the expert strategy) to help students use their science knowledge and ethical perspectives to formulate arguments from others' viewpoints. The lesson began by discussing what a debate was. Amy summed up by saying, "It's not personal. Stay with the topic. Stay with the purpose of the debate." After referring the students back to the question: 'Should chemical fire retardants in furniture be a regulation in New Zealand?', Amy asked the students to justify their case to the 'prime minister' with three clear arguments. She told the students "you would be trying to persuade – to convince the prime minister whether or not to make chemical fire retardants in furniture a regulation. Have really good, detailed reasons saying why." Amy said the prime minister would take notes and make a decision at the end of the debate. Each group would have a turn to have their say. The researcher was designated the prime minister.

During preparation for the presentation some groups had trouble agreeing which three arguments they would use. This led to self-initiated votes to solve disagreements, although in actuality every group presented more than three ideas. Some students also had problems with arguments that they didn't personally believe. Amy explained this was not their personal view but was from the point of view of the given stakeholder. They also had difficulty deciding whether as a designated stakeholder they were 'for' or 'against' making chemical fire retardants in furniture a regulation. For example, scientists, consumers and the government could easily go either way (the class had discussed arguments both for and against). Furniture manufacturers decided to be 'for' but it may have been easier for them to go against (because there were more arguments against). Eventually Amy had to

designate some groups for and some against because five out of the six were wanting to go against. Amy asked two other groups to go 'for' "so that the prime minister won't be persuaded because she hears mostly 'against' arguments. It has to be fair." When the groups came to present, only two groups went 'for' and four 'against'.

The prime minister was invited to sit in a chair at the front of the groups of students. Amy selected groups randomly. Each group had a first speaker, then the others took a turn to present an argument and then the final speaker summed up what the group was saying. Appendix 29 lists the ideas that were presented in the order in which they were presented.

There were more reasons against having a regulation requiring the use of chemical fire retardants in furniture than for. Students in general seemed to have a good grasp of the reasons introduced in the articles they had read. In contrast, the students arguing in favour of a regulation (firefighters and furniture manufacturers) appeared to struggle with some of their ideas. For example, the firefighter group claimed that the firefighters would make more money promoting chemical fire retardant furniture. As pointed out in the previous section, this suggests that students might not understand the relationship between a firefighter's job and chemical fire retardants. Some of the arguments were also inherently contradictory. For example, one statement from the furniture manufacturers was that "you should be able to choose your furniture – it's your own risk". This did not justify their claim 'for' the regulation. The stakeholder appears confused, the students perhaps having difficulty separating personal ideas from the role they were taking. One group (Government) who was asked to go 'for' was 'against' chemical fire retardants in the final presentation of arguments. The difficulty may have been because of their awareness from the class readings that some chemical fire retardants are harmful.

The arguments 'for' were based on two main ideas – saving lives and property. One argument from a consumer offered an alternative solution – to use natural fire retardants such as wool: "especially good in New Zealand

where we have lots of wool”. The comment about the furniture being “ugly” was a fair comment in that it is a serious consideration for scientists³.

At the end of the debate, the prime minister was expected to make a decision. After thanking the ‘people’ for attending and reiterating some of their justifications, she said although the most important consideration was to save lives and then property, there had been many concerns about the chemicals that make furniture fire retardant. The prime minister said that due to this there would not be a regulation made in the near future. She also said she liked the idea of the natural fire retardant materials and would look into this further.

5.3.4 Student learning

Student learning was evident in presentations made during the debate (Table 5.4) and was supported by student comments in a survey administered two weeks after the end of the teaching sequence and comments from Amy in a later interview. These data suggest that, by participating in the classroom activities, students developed an understanding of consequentialism and the need to support a view with scientific evidence.

5.3.4.1 Presenting arguments through role-play

Students were able to identify with a stakeholder (i.e., express views for a particular stakeholder) and most students were able to justify their viewpoint to the prime minister. By comparison to an earlier lesson concerning the same issue (Appendix 27) in which students groups struggled to generate consequences for the stakeholder groups (Section 5.3.2.5), the students were able to articulate a greater number of justifications for

³ Fire engineers from the University in Canterbury report (Fleischmann, C., & Spearpoint, M., personal communication, August 27, 2009) that natural wool products used as fire retardants are not generally stylish and are not that comfortable. How things look and feel is very important for people and is one of their main considerations when producing fire retardant furniture.

particular viewpoints (Appendix 29) displaying broader student knowledge. For example, from the consumers' viewpoint in Appendix 27 one area of concern was recorded - health problems. In Appendix 29 seven different objections were recorded: furniture not really the issue, health, smell, alternative fire retardants available, cost, effectiveness, and appearance. This suggests the importance of providing multiple opportunities for students to practise to extend their ideas and understanding.

5.3.4.2 Student views of their learning

The students reported their learning in response to a class survey in which they were asked what they had enjoyed; whether they'd done anything new; what they'd learned, including learning about other people's views; if they'd thought about their own views; and if they thought they'd learned enough on the topic to make a decision about it (see Appendix 2). An interview with Amy supported students' views of their learning.

Conceptual learning

When asked in a survey about learning, more than half the students referred to ethics-related ideas (Table 5.4). Other comments related to science learning. At the onset of the exploration of ethics no student was observed discussing stakeholders, consequences or decision-making. When questioned by Amy none of the students could explain what fire retardants were, indicating that both ethics issues and science concepts were new for all students. The specific and repeated mention of consequences and stakeholders (Table 5.4) may have been due to the explicit way these terms were introduced and taught. Two students highlighted 'making decisions', which Amy had also stressed during the lessons. The others referred to concepts from the fire science unit. It could be that these students believed the survey questions referred to the whole fire unit rather than just the ethics exploration.

Table 5.4

Student responses to the survey question: “Tell me about some of the things you learned” (n=30)

Comments	Number of comments*
Ethics-related comments:	
Stakeholders	10
Consequentialism/consequences	4
Fire retardant issues	4
How to make decisions	1
How scientists make decisions	1
Science-related comments:	
Fire retardants	4
Fire retardant fabrics	4
Chemical reactions	1
Science-related comments from the fire science unit:	
Atoms	1
To start a fire you need oxygen	1
Flames have different colours	1
No air no flame	1
About flames	1

* Some students made more than one comment

When asked what was new in terms of how they learned, more than half the class (57%) said sharing, speaking, debating and expressing their view. 14% considered thinking processes as new - thinking about both sides of an argument and considering an issue. 13% referred to content (science concepts) rather than the nature of the learning and 16% recorded that they had done similar activities before and did not learn anything new. It may be that the students who reported that they had not learned anything new had not fully participated in the discussions and may not have understood the ethics process. Amy reported in the final interview that some students did not participate in discussions and were not always following what was going on. She identified these as being lower ability students who she felt struggled to keep up.

Considering multiple viewpoints

Question 5 in the survey asked if students learned about other people’s views on the issue. All students except two said others had different viewpoints to them. Some comments were: “Miss _[student teacher] was against me”; “Our big discussion was that the scientists and the firefighters

disagreed”; “People had different views but most agreed”; “In debating we did [have different viewpoints], even the teachers”.

When asked if students thought about their own views during the ethics in science learning, most students reported that they did think about their own views and why they believed them but they made no further comment. Five students said the ethics in science learning did not make them think about their own views and one student said yes and no but no further explanation was given. The lack of explanations and detail given could be because the survey was completed two weeks after the unit had finished (due to school commitments). The students may have forgotten details. It may also be that some students had difficulty relating to the issue and thinking deeply enough about it to remember details.

Confidence in decision-making

When the students were asked if they had enough information to make a decision only three said no – “because it was too hard”. Others were more positive, for example: “Yes - I think the debates and the sharing really helped me”; “Yes because of all the information I got”; “Yes - All the information that I had learned helped me”.

Again the lack of detail in the responses could have been due to the timing of the survey and that students had moved on to focus on something else. Regardless of the written responses, Amy was impressed with the learning, the discussions students had had and the decisions they had made. She said she thought that her “class won’t handle it” but they did and she realised “the importance for the students to consider all the various viewpoints to make informed decisions”.

Student learning is explored and expressed through activities. The next section explores written student responses and Amy’s comments about the activities.

5.3.4.3 Activities for learning

Part of the student survey asked the students about their learning in terms of learning experiences or the activities used to help them gain knowledge. Amy's lessons involved a lot of class discussion and small group work that most students may not have interpreted as activities, and only three 'activities' were identified by most of the students: the DVD, the debate, and fire experiments.

The activity the students reported enjoying the most (61%) was watching the DVD on the different rates of burning: "it was entertaining"; "interesting"; "fun"; "enjoyed seeing the walls burning/melting"; "seeing what can happen in a fire"; and "watching the speed of fire". Amy reported that the DVD acted effectively as a 'hook' to bring the class's attention back to fire three weeks after completing the science unit on fire. It was also used to open discussion on the science they needed to know – that materials have different rates of flammability. Amy felt "the DVD was exciting in terms of getting attention, and obviously memorable".

The second most popular activity reported by students was the debate (35%). Most respondents in this group said it was because it was interesting listening to other people's ideas and because you could say what you thought. Some students in this group also mentioned the thinking and decision making, for example: "making hard decisions because it made us think and listen" and "I enjoyed deciding whether the statements were right or wrong because you thought of reasons and shared them".

A few students (4%) mentioned the fire experiments saying they were memorable activities. However, most students appreciated these activities related to science content for fire chemistry (before the ethics in science was introduced). Three students enjoyed the socio-cultural aspects of discussion and decision-making: "I like working in groups"; "Discussing stakeholders"; "Deciding on stakeholders".

Amy thought it was particularly useful to aid students' learning by making notes on her whiteboard lesson by lesson. Key points and new learning remained on the whiteboard until the end of the unit. She said: "It was accessible to all the children all day so they could discuss the ideas amongst themselves to clarify ideas." She also found using small groups effective when reading and brainstorming as "each child felt more inclined to contribute". The activity she felt worked the best for student learning was the small group work using the scenarios to create consequences.

Student learning can be attributed to a large extent to teacher planning, organisation and pedagogy. The next section investigates how teacher development contributed to Amy teaching ethics in science.

5.3.5 The teacher development programme

When Amy first heard about ethics in science she thought "it sounded intimidating". Her thought was "my class won't handle it, but I want to do it". She appreciated the need for the intervention programme. Amy based her planning on the classroom ethics-in-science planner that was introduced and explored during the two development sessions. The following sections explore Amy's perceptions of the teacher development and how she used the classroom ethics-in-science planner.

5.3.5.1 *Teacher development*

Amy reported that the teacher development sessions were both helpful and necessary. Once she learned what ethics was about "it didn't feel so scary. She said it was good to have two sessions – "it meant I could go away from the first session and absorb it and consolidate ideas." She said the first one "gave me the ideas and left me curious". The second one gave her "the plan of attack of how I was going to teach it".

Amy found the planner itself the most helpful from the teacher development sessions in that it gave her a structure in which she could

develop her lessons. She liked the example planner, 'Should money and effort be spent understanding and saving the takahe' (Appendix 15), and used it as a guide to plan her ethics lesson. Amy enjoyed the power point presentation, which helped her to understand ethics in science – "it was helpful to understand what ethics actually is and that there are no finite answers to any questions that may come up".

Amy appreciated learning about ethics and thought it had been a worthwhile addition to include in the science unit on fire, particularly

... for the top kids because it extended their thinking. They started thinking more deeply. They had worked with the science they had learned and then they were forced to think even more deeply. The others struggled because chemical fire retardants are not really a big issue – but if it was something affecting them it would be more powerful and they would all be passionate and involved.

She would like to try teaching ethics outside of a science unit as a stand alone unit based on a science issue. She was also keen to use the ethics approaches to teach ethics in other curriculum areas. Amy's student teacher, who observed most of the ethics lessons on chemical fire retardants, used the consequences approach in her environmental unit based on the book 'The Lorax' by Dr Seuss which followed shortly after. Amy said the interesting part was that the students all knew about consequences, so time taken to teach about consequences was not necessary: "The children knew what she was talking about without having to discuss consequences, so other ethics issues would not require so many lessons. It would be quicker next time".

Following the teacher development Amy gave careful thought to the planning. She reported in the final interview that because teaching ethics in science was new to her and the learning new for the students, she needed to consider carefully how to teach it. In particular she felt she needed to break the learning into small chunks of learning both for her sake (to teach it) and for the students' learning "so they could understand and follow what was happening".

Initially Amy looked at the science – what students knew and what they needed to find out based on the ethics question which she introduced right at the beginning. She said she “started with just the facts, keeping opinion out of it so that it could be introduced later in the unit”. Amy introduced the ethics by discussing consequences before readdressing the question on regulating furniture. Stakeholders were introduced and defined. Key questions for Amy at this stage were “what are they?”, “who are they?”, “who are they in relation to our question?”, and “who had rights and responsibilities?” A consequentialist approach was then applied to the use of chemical fire retardants. The consequences were prioritised:

Can we make that decision? Does this consequence outweigh that one? Is ‘firefighters getting people out faster’ more important than ‘having harmful smoke that occurs when the chemicals burn’? This made the higher level children think more deeply. It showed which kids lacked empathy. Kids don’t think enough outside themselves, but this kind of teaching makes them think about their thinking. They have to think ‘why should my opinion be more important than others?’

The debate was held last because by then students were informed and had formed their own views. Amy said that:

In the end they realised there was not a right or wrong answer but they were weighing things up themselves to make a decision. They were learning to think like scientists. It’s important for children to consider all viewpoints and to consider others. This is the nature of science. This teaching reveals the nature of science to the students.

In summary, regarding teaching for student learning Amy stated:

For the children who are reflective in their own thinking and curious about the world around them it was interesting to see how engaged they were. For children who are lacking academically it was almost too far ahead of them and they needed to work in smaller groups with a lot of teacher scaffold. This was clear during our lessons where the more deeply thinking children became passionate about arguing for or against an issue and others chose to opt out of discussions as they may have felt slightly intimidated. With careful monitoring and more experience from the teacher’s perspective, I feel that all children would be able to be actively involved in lessons.

5.3.5.2 Use of the classroom ethics-in-science planner

Amy reported that when she had first seen the planner (Table 4.4) she felt “overwhelmed but once I got my head around it in the second session and

saw how it had been used for the takahe I realised I could do that.” It was the wording of the headings that confused her at first – “but that’s only because it was new and presented differently from what I’ve seen. It is actually self-explanatory”. She used the example planner on the conservation of the takahe (Appendix 15) and collaborated with Lynda to clarify the different components of the planner and how best to use them.

Amy referred often to her planning whilst teaching the lesson sequence, commenting: “I followed this more closely than the fire unit. I clung to it.” She appreciated the detail in the planner and having to break down the lessons:

That’s what got me through the lessons. I had to break it down in my head and as I was breaking it down in my head that was how the lesson planner unfolded. I was writing and thinking, ‘Oh, I get it’. I started juggling things around – realised what I needed to teach before I could do the debate. I would have floundered if it hadn’t been broken down.

The following discussion explores Amy’s use of the ethics-in-science planner as presented in Appendix 30. Amy’s response in each component in the planner is commented on.

Science context

Amy recorded her context as ‘Chemical fire retardants in furniture’. Since the ethics exploration was part of a science unit on fire, the context for the ethics should have been fire. The place of the ethics in the overall context may have been lost due to the heavy focus on ethics, including in the teacher development. Where ethics in science sits within science contexts will become more obvious as teachers become more familiar with teaching ethics.

Science curriculum links

Amy collaborated with Lynda to determine the science links in the curriculum. She also included the overarching science strand – the nature of science (MoE, 2007, Achievement Objective Level 3). This link became more evident and clear to her throughout the teaching. She eventually concluded:

The ethics approach is a teaching tool that can be used to reveal the nature of science ... Children see how science actually works - how decisions need to be made and that science is often not 100% established. It [ethics teaching] gives an insight into the nature of science explicitly, which is at times difficult when teaching through the strands.⁴

Ethics question

The ethics question was 'Should chemical fire retardants be regulation in production of furniture in New Zealand?' This sentence is confusing and when Amy was working with the class she changed it to 'Should chemical fire retardants in furniture be a regulation in New Zealand?'

Relevant science knowledge

Amy made curriculum links to both the material world and to the nature of science. She saw relevant science knowledge as being able to understand fire at a molecular level (the chemistry of fire), which included the science concepts and ideas from the broader fire unit. This was helpful when considering the interference of chemical fire retardants in the gas phase of the chemical reaction of fire. Perhaps an understanding of the chemicals themselves and how they work could have been included in this section. Instead Amy included the understanding of chemicals with the ethics focus questions in the planner.

Ethical approaches and questions

When Amy saw the ethics approaches and questions heading she said:

It sounded scary again. I wasn't sure what was expected, but I read what was in the takahe planner and could see what it meant. Talking about it with Lynda was helpful. Then I liked the ethics questions – it [the questions] kept bringing it [the lesson content] back to the ethics, otherwise I could have gone off on a tangent.

Ethics focus questions

The first two focus questions written by Amy were science-focused rather than ethics focused. This was how the lesson unfolded for Amy –

170_____

⁴ The achievement objectives in the science learning area of the New Zealand Curriculum (MoE, 2007) are presented in five strands: Nature of Science; Living World; Planet Earth and Beyond; Physical World and Material World.

beginning with the science questions first. During the interview Amy suggested having somewhere to put the science-focused questions:

Could there be focus questions to go with the relevant science knowledge section, maybe? It's not really needed – just a possible suggestion. I don't think you should change the ethics focus questions [title] to just focus questions. There needs to be an ethics focus.

Activities and strategies for intended learning

Amy's activities were participatory pedagogies designed to help the students explore the focus questions. Most of them involved class discussion. Some activities (pair-share, shared reading and debating) were from the suggested 'Activities and strategies for intended learning' provided as part of the planning document.

Planned interactions, resources and learning intentions were linked together with the activities driven by the ethics focus question. For example, the ethics focus question 'Who are the stakeholders?' was supported by a class discussion about stakeholders and their various viewpoints (referred to as scenario cards in the planner). The learning intention was for students to identify stakeholders (in the viewpoints) and discuss whether or not they were affected positively or negatively. A PMI analysis completed in groups helped students consider the harms and benefits of chemical fire retardants to stakeholders. This was not mentioned in the planning, rather it was an 'on-the-fly' activity that seemed to follow easily once students had identified stakeholders from their viewpoints.

Overall, Amy liked the layout of the planner and said she "would use this again. In fact I would adapt it to have other ethics debates in other areas. The children should be exposed to all these approaches".

5.3.6 Summary

Analysis of the data collected in Amy's room suggests that her students were able to engage in ethics learning. Although some students struggled, nearly all showed they understood the ethics question and were

able to justify a viewpoint. This was evidenced in the role play where the students made a statement to support the view their group took.

The learning was achieved through a classroom programme devised by Amy using the classroom ethics-in-science planner introduced as part of the teacher development programme. Collegial interactions were important for teachers' learning just as social interactions were important for student learning. Amy's lesson sequence included activities that helped to explore the science involved (brainstorm, DVD, research activities) and activities to explore consequentialism as an ethical approach (familiar scenarios for learning about consequences, class discussions, listing stakeholders, identifying ideas in given viewpoints and PMIs). Students were able to formulate an argument and justify views through the presentation (debate) to the 'Prime Minister'.

Amy reported needing the support of the teacher development programme to help her understand ethics, ethics approaches and strategies for teaching ethics in science. The ethics-in-science planner helped Amy to structure her programme in a way that scaffolded the necessary learning for ethical decision-making. It linked the ethics to the curriculum (including the nature of science) and helped Amy to determine relevant science knowledge, although additional science that was not recorded was needed (regarding what a fire retardant is and the working and nature of the chemicals used as fire retardants) before the ethics discussion could take place. Amy particularly felt that the ethics questions helped her retain specific foci for each lesson. She appreciated the design of the planner and was keen to use it to plan teaching programmes in other subject areas.

5.4 ANTON'S CLASSROOM PROGRAMME

Anton's class of 32 students comprised 16 Year 5 (9-10 year old) and 16 Year 6 (10-11 year old) students of mixed ability from a range of cultural backgrounds: New Zealand Pakeha (64%), New Zealand Māori (19%), Asian (14%), and Dutch (3%). The ethical issue centred on whether chemical fire

retardant furniture should be compulsory and was taught during three sessions within a week. Only one of these lessons was observed. Anton and some of his students were interviewed at the completion of the ethical exploration.

Anton used the ethics-in-science planner to plan his classroom programme. The teaching and learning activities and their purpose within the programme included:

- *Introductory video clip and brainstorm:* DVD showing three different fires and rates of burning (a christmas tree in a house, a lounge and an office). The class then discussed what a fire retardant is and whether chemical fire retardants should be compulsory in furniture. Brainstormed questions ‘What is a fire retardant?’ and ‘What is a chemical fire retardant and should they be compulsory in furniture?’
- *Pre-test/warm-up values continuum:* Students decide whether or not chemical fire retardants should be compulsory and line up in a values continuum.
- *Researching chemical fire retardants:* Students research and discuss articles ‘Slowing down the burning’ (Appendix 18) and ‘Controversy over fire-retardant chemicals’ (Appendix 31) and a collection of articles on flammability, fire retardants and some controversial issues related to chemical fire retardants (Appendix 32). Groups read different articles, which they later shared with the class.
- *Defining consequences:* Class discussion .
- *Identifying stakeholders:*. Class discussion.
- *Stakeholder analysis of harms and benefits.* PMI worksheets (Appendix 12) completed using a noisy round robin strategy (Appendix 13).
- *Understanding alternative views using role-play:* Anton assumed the role of ‘John Key’ (the Prime Minister of New Zealand) and called a meeting to discuss regulating the addition of chemical fire retardants to furniture. Students represented a range of interest groups and presented their views.

5.4.1 Links with the science learning

The DVD of three different fires was shown to 'hook' students back into thinking about fire because it had been a week since completing a science unit on the chemistry of fire. The DVD also served to stimulate thinking about different rates of burning for different fuels – a lead into the science was needed for discussing fire retardants. Anton wanted the class to form a continuum on the issue as a warm-up and pre-test. However, he first helped students understand some of the relevant science by explaining that chemical fire retardants are man-made chemicals that, when added to materials, such as foams and furniture coverings, make them fire retardant. He added that some of these chemicals were toxic and could be dangerous for small children who might suck on the furniture. The explanation was followed by a class brainstorm on 'What is a fire retardant?' and 'What is a chemical fire retardant and should they be compulsory in furniture?'. The class then lined up in a values continuum to express their initial views.

After the continuum line-up, the class used a reciprocal reading approach (having a leader, clarifier, predictor and questioner in each group) to read and discuss different research articles. Articles used were 'Slowing down the burning' (Appendix 18), 'Controversy over fire-retardant chemicals' (Appendix 31) and a collection of articles on flammability, fire retardants and some controversial issues related to chemical fire retardants (Appendix 32). Able students were spread among the groups by Anton so that they could help other students understand the articles. Student groups shared their learning with the class.

The articles were reintroduced in the next lesson and discussed as a class in order to consolidate learning. Anton asked the researcher, who was present, to clarify some aspects of the research. For example, to elaborate on the effects of chemical fire retardants the researcher recounted a story where she witnessed scientists burning two couches, one with chemical fire retardants and one without, and that the one with the retardants had burned

much more slowly. The class continued to explore ideas about how chemical fire retardants interfere with the burning process:

- Teacher: So what are chemical fire retardants?
- Student 1: Aren't fire retardants just nonflammable materials?
- Teacher: Yes, it can be but they also put chemicals in it [the materials] to make them fire retardant as well. Mmm, how is fire made up, what is needed for fire to happen?
- Student 2: You need oxygen, heat and fuel.
- Teacher: So what would a chemical fire retardant do to stop the triangle from working?
- Student 3: Do the chemicals take something away from the triangle?
- Student 4: They could take away the heat source.
- Student 2: Are they chemicals that keep the oxygen away?
- Teacher: When we did the fire work what did they use to put out fire?
- Student 3: Carbon dioxide. Maybe the chemicals are added to the fire to try to smother it.

Anton, with a little additional information from the researcher, explained that the chemicals interfere with the chemical reaction of fire when in the gas phase and that this slows the fire down but does not stop it. Anton asked the students to remember back to when they were bonded together as atoms to make molecules (in a role-play about chemical reactions) and then undid their bonds and changed with other atoms to become bonded into different molecules, explaining that this is when the chemical retardants would interfere with the reaction process. He also talked about some chemicals causing the burning to char the material creating a protective barrier from the fire. A student asked if the chemicals made smoke more toxic. Anton explained that in incomplete combustion (where not everything burns completely in the combustion process) the unburnt material is all toxic.

Students appeared to be very interested in understanding the science concepts, which was important for them to be able to carry out an informed investigation into whether they should be applied to furniture. Observations during the lesson also highlighted the importance of the teacher's understanding of the science concepts in order to lead the discussion and

provide scientifically accurate answers when appropriate. The next section discusses the ethical approach Anton used and how this was developed.

5.4.2 Exploring ethical perspectives

The ethical exploration in Anton's classroom focused on regulating the addition of chemical fire retardants to furniture in New Zealand and was approached largely through a consequentialist framework, as evidenced in a round robin activity. Students, however, included the rights and responsibilities approach in class discussions concerning people's right to buy furniture of choice – and the right not to buy expensive chemical fire retardant furniture that they possibly could not afford. There was also reference to autonomy. For example, one student asked “Whose responsibility is it? [to decide whether or not furniture should contain chemical fire retardants] Can I say no?” incorporating the autonomy approach.

Anton said he chose the consequentialist approach because “it was the easiest for me to understand and to assign activities for”. This was possibly because the consequentialist framework was used as an example in the teacher workshop, with handouts describing the round robin and PMI activities. He also said that this approach may have been “the easiest for the students to understand as well”.

5.4.2.1 Using a values continuum

Anton had initially intended to read the research articles before getting the students to make a decision and line up in a values continuum. He then modified this and decided to do the values continuum first because the students were “way too restless” to start with research. This highlights the need for teachers to be flexible.

In order to introduce decision-making, Anton asked the students to line up in a continuum from absolutely disagree to absolutely agree using

different statements, such as “all furniture should be flame retardant”, “all planes should have flame retardant seating”, and “fire retardants should be compulsory in New Zealand”. For the latter statement, he also asked students at different ends of the scale to try and convince the others of their point of view using reasons. He reflected afterwards that the continuum showed student thinking early in the exploration, acting “like a pre-test to see if after the ethics discussions they change their minds”. Later Anton said the activity he enjoyed the most was the continuum – “where the children could say, ‘This is what I believe’”. Anton then introduced the class to the idea of consequences.

5.4.2.2 Using class discussion to identify consequences

When Anton asked the class “What is a consequence?” the response was “it meant you were in trouble”. Anton asked them to discuss the consequence of doing something good (for example, helping with the housework at home) to shift their thinking. The students needed to understand consequences to be able to determine harms and benefits to stakeholders in an issue. The following sections identify stakeholders and consequences for them in the ethics issue.

5.4.2.3 Using class discussion to identify and list stakeholders

In order to identify stakeholders Anton (after reviewing the research articles) told the class to imagine that there was a law coming to New Zealand – “that chemical fire retardants should be compulsory in all furniture including furniture in transport”. He asked the class who it would affect and the students volunteered possible stakeholders that he made into a class list (Appendix 26) on the whiteboard.

At the end of the discussion Anton refined some of these. For example, he added ‘children’ to ‘babies’, changed ‘everyone’ into ‘adults’ (because they buy the furniture), said he would prefer to say ‘politicians’ than ‘the

government' and suggested they call 'people who make fire extinguishers and smoke alarms', 'scientists'.

One student made the issue more relevant when she asked, "If it's made compulsory, will all classes at school need to have chemical fire retardants in furniture? Who would pay for that?" Anton replied that "the school would have to have the furniture if it was compulsory". Another student commented that schools would probably have to pay for it themselves. When Anton asked who would enforce such a law, the students replied that police would. Anton possibly steered the conversation in this direction because he had already anticipated the police as a stakeholder (he had headed up a PMI sheet with 'Police').

5.4.2.4 Using a noisy round robin activity to identify benefits and harms to stakeholders

A noisy round robin activity helped the class identify harms and benefits to stakeholders. Anton used ten different PMI worksheets, one for each of ten different stakeholders (from the list generated and modified in the earlier session). Students groups were required to write positive and negative consequences for each of the stakeholder groups and to add any other comments. On a given signal, student groups moved to the next PMI and added something that was not already there. Student responses are presented in Appendix 33. Some thoughtful comments were made for those most affected, for example, firefighters who are confronted with fires causing death were seen to have more time to get to fires and save lives. The firefighters were also less likely to be injured in smaller fires. Another stakeholder group identified by the students were people involved with making/selling furniture. Students envisaged that regulating furniture to contain chemical fire retardants would have financial benefits for them (presuming people had to replace their furniture).

The issue of health was raised for consumers (adults/children/babies). Students identified negative (harmful) aspects as

being toxic fumes of chemicals, allergies and reactions to the chemicals. An interesting 'other' point was raised when a student queried "whether the chemicals would react with anything" – [i.e., what else might they react to that would be dangerous for people]. The environmentalists' concern was the effect of chemicals in the environment and on people. Students recognised that scientists get caught up with political and social issues as seen in the comment "people will get angry with them".

A positive effect for politicians was that they were seen to be involved in debate – keeping them in jobs. Commuters and transport agencies were added by Anton because part of the discussion statement included chemical fire retardant furniture being included in public transport. This was mainly viewed as a safety versus cost issue, including more indirect implications, for example, "People might have to pay more because of increased costs [of transport] – so less people might use [public] transport".

The students seemed to struggle with harms and benefits for police and farmers. Neither of these stakeholder groups were on the original list given by the students, but were added by Anton. It seems the students had not envisaged the police as enforcers of the 'new' regulation (as Anton said he thought they would), but rather in relation to attending possible fires. The farmers (selected by Anton as owners of furniture, both in vehicles and buildings) may not have been identified by the students as key stakeholders. Having identified stakeholders and possible harms and benefits to each, the students formulated viewpoints and presented them through role-play as described in the next section.

5.4.3 Formulating an argument through role-play

In the final activity, a role-play was used to help students formulate their arguments from others' viewpoints. The lesson sequence required students to adopt the role of one of the stakeholders (from the noisy round robin activity) and present an argument either in support of chemical fire retardants in furniture being compulsory, or against. This role-play activity

was devised, in part, through discussion with Lynda, who had based her role-play on Heathcoat's (2009) mantle of the expert (see Section 5.2.3.1). Anton, however, had not participated in the *Mantle of the expert* workshop earlier in the year and was not really familiar with it. He was more familiar with the idea of teacher-in-role where the teacher takes on a role in the classroom to facilitate learning. In this activity, Anton took on the role of New Zealand Prime Minister, John Key, seeking to determine whether or not to introduce legislation making chemical fire retardant furniture compulsory. He called a meeting of stakeholders to get their views.

The students identified themselves with name tags (of stakeholders). They had to say whether or not they agreed with the new law and give reasons to support their view. The students divided into stakeholder groups and discussed their views as a group before reconvening to present their case. Anton said they never finished the meeting. The bell interrupted them and unfortunately they never got a chance to get back to it. He had also intended that the students would write to 'Mr Key' to present their arguments, although this also did not happen due to time constraints (a student teacher needed to complete a different unit before the end of the term).

Although the pre-test continuum was not repeated some students were mindful of their initial decision and changes they made during the teaching – "I was in the middle at first on the continuum... and I learned from other people [during the role-play with John Key] and decided they [chemical fire retardants] shouldn't be compulsory".

5.4.4 Student learning

Student learning was evident in the collation of comments from the PMIs (Appendix 33) and was supported by recorded conversations between students, as well as interviews with a student group and with Anton. These data suggest that, by participating in the classroom activities, students

developed an understanding of consequentialism and the need to support a view with scientific evidence.

Due to time constraints, students did not have time for the prepared class survey given to the other case study classes. Instead, the researcher took a group of five early finishers (of usual classroom work) into another room and interviewed them as a group. This group were able students (evidenced by being early finishers and confirmed as such by Anton at a later date). The interview was based on the same survey (Appendix 2) the other two classes of students filled in. Anton had said earlier that the lessons were not as in-depth as he would have liked and he had been unable to complete everything he had wanted to do due to time constraints. However, the discussion with these five students suggested that they had a good understanding of the ethical and some of the relevant science. The students were lively and appeared to enjoy contributing in a thoughtful and in-depth way to the discussion.

5.4.4.1 Student views of their learning

The students who were interviewed were able to articulate some of their learning in a group discussion. During the conversation the students were asked about their science learning. Although it was difficult to separate out the science learning because it was intermingled with the ethics concepts, they did, at times, stress aspects of the science. This is discussed below followed by the students' thoughts about their own and others' views on the ethical issue that was explored.

Conceptual learning

Although intertwined with ethics, evidence of science understanding was manifested during conversation. Initially the students considered what chemicals were and related them to previous knowledge. For example, David stated, "Drugs like painkillers have chemicals in them". The students then used their prior knowledge to talk about what 'chemicals' are (drugs, medicine) and how they affect people ("some chemicals are good for you and

some are bad”). They talked about what they had heard about scientists experimenting to see how rats responded to certain chemicals (“baby rats are born with no limbs”) and concluded chemicals can be dangerous. Later in the conversation the students discussed that more research was needed to determine how toxic chemical fire retardants are and whether or not they make smoke more toxic than smoke produced in their absence. Some of the students talked about setting up an experiment. David suggested they could “burn two identical things, but one has chemical fire retardants in it. Then take samples of smoke from both fires and test them to see what is in them and to see if the one with the chemical fire retardants is more poisonous.” The conversation demonstrated an understanding of science – driven by a need for human safety, testing should be carried out, a control should be used, there should be only one difference between the two items.

The students appeared to value opportunities to explore the science ideas and being able to understand current research. They said it was “good that we can take scientific ideas and simplify them so that we understand them” and one student commented that the learning helped him “change from having childish ideas to having more scientific ideas”.

The group were keen to discuss what they had learned, but because they were a group rather than just individuals reporting (as with a survey) they discussed and debated among themselves, talking about the chemicals in relation to the issues as they perceived them rather than reporting about what had been new science learning (such as how the chemicals worked as fire retardants). Some of the comments showed they were still grappling with the ideas. The discussion began as follows:

James⁵: The chemicals slow the fire, so you have more time to get out of the fire, but they release toxic fumes and some people think they’re good and some people think they’re bad.

David: Most of us said we thought they were good because it slows the process down to let you get away from the fire.

⁵ Students’ names are pseudonyms.

- Crystal: But the bad thing is that more people die from toxic smoke than from fire so the chemicals are not as useful.
- Anna: They're quite good because if you knew they were chemical fire retardants you would know to get down low away from the toxic smoke and because the fire is slow you will have time to get out. But there are pros and cons so it's quite hard really.
- David: Either way the house would burn down anyway but if it's slower at least you have time to get out.
- James: What you don't see is the poisonous gas so you don't get down. It's poisonous and it poisons our planet.
- Crystal: It also would cost a lot of money for furniture makers. And fire-fighters might not get a lot of business because there's [sic] no fires and they would lose money.
- David: No, firefighters would have more time to get to the fire.

The students also talked about the possible effects on furniture makers: the costs of manufacturing going up because of increased costs to make the chemical fire retardant furniture, and follow-on effects for consumers. Crystal pointed out issues of inequity: "So that's the problem with poor families because they might have to sleep on the floor because they can't afford the beds". As can be seen, a number of the arguments for and against chemical fire retardants came out in this short discussion. The students were quite forthright in giving their opinion, but they also listened to each other. They were able to express a viewpoint. David concluded that "If we can't figure out if chemical fire retardants are good or bad, why don't we do what they did with the anti-smacking law and have a vote?" His comment indicates an understanding of the political arena around issues that affect the country as a whole.

The students all agreed that their learning enhanced their understanding and unanimously stated that chemical fire retardants in furniture should not be compulsory but should be available if people choose to have them, and that people should be able to learn more about it so that they could make an informed decision.

Considering multiple viewpoints

When the students were asked if others had different views to themselves, Crystal replied “Definitely. Some were yes, some were no and some were unsure – they didn’t know. They liked the idea of slowing down the fire but didn’t like the toxic smoke.” The others agreed with this response. The students were then asked if hearing others’ views made them think about their own. Some of these responses were:

I was in the middle at first – on the continuum – and didn’t know which one to choose. Then we had a spokesperson for each group [in the meeting with Mr Key] and I learned from other people and decided they [chemical fire retardant furniture] shouldn’t be compulsory

Yes, because that is their view and I wondered about why they thought that but it’s probably because they have a different brain structure from me so they have different ideas. It was very interesting learning off other people.

Yes, but people must be protected. As long as it protects people. That’s the bottom line. You wouldn’t want the earth without people.

A discussion then developed about protecting the earth. The students talked about how on one hand people destroy the earth, but on the other were trying to save it. They concluded by saying we need to look after the environment for our own survival.

Crystal’s comment shows her ability to think ahead and apply ethical thinking to a future context, as well as appreciate multiple viewpoints:

I’m just wondering – it’s not just the government’s decision – it’s everyone’s decision. All the families should be able to have a say or take a vote. It’s good we are learning about this because when we grow up and become adults we will know how to debate things like this and we will be able to have a say.

Confidence in decision-making

The students were asked to consider whether they felt they knew enough about the topic to make an informed decision. Their conversation suggests a sense of maturity in terms of understanding their role in decision-making, and appreciating the difference between their role in the classroom context and that of ‘real life’ where, as adults, they would probably need more information.

- Crystal: Yes and no, because, for one thing we are not real scientists and neither is Mr _ [teacher]. We have enough information for us, for our minds - we don't need more and more and more like real scientists. We only need enough information to make a debate for Room _[3] kids.
- David: As kids we probably don't have all the information we really need, but we'll have more information in the future.
- James: We're not the ones to decide for everyone. We had enough information to make a decision for us, for this debate, at the moment.
- Crystal: It's not all about just your decision. It's about everyone's decision - making a decision all together. It's global.
- Anna: I made a decision. I don't know if I'll stick with it in the future, but it's fine for now. I thought we shouldn't have to have chemical fire retardants but we should have an option.
- David: I would have liked to see more research about why they say it should be compulsory - I can't make a definite decision.
- Suzie: I think we should see what more people think and why.

The students' comments were thoughtful and perceptive. They appeared to appreciate the difference between themselves and 'real' scientists. They were confident they knew enough to be able to conduct a debate (in the meeting) that was good enough for "Room 9 kids". They also appeared to appreciate the importance of "global" decision-making, realising some issues affect large numbers of people and the decision has to be made together with consideration of all views. Anna realised that her view might change in the future but was confident to make a decision for now. These comments show thinking beyond the self.

5.4.4.2 Activities for learning

Although Anton said the class had not done a lot of activities on this topic, the students that were interviewed said they had "done heaps - maybe 4 or 5 lessons [they did 3], and learned about the good and bad sides of the debate". When asked if they had done anything new in terms of activities, the students talked about new ways of learning and even applied a learning style (debate) to the playground:

Having interesting conversations with friends – like debates with friends in the playground that we didn't do before, like yesterday we were debating about whether we could get paid to come to school.

The continuum. I hadn't done that before and it was interesting how spread out the class was. There were only 2 or 3 right in the middle.

The students all agreed that discussing and debating, where you have your own opinion and can present it to others makes learning interesting and fun:

The debates were cool

It's good saying what you think

You're learning things all the time

I enjoyed this discussion [the interview] the most

This kind of learning shouldn't end until you die.

5.4.5 The teacher development programme

Anton initially struggled with the idea of teaching ethics (“It was new to me – hard to grasp”), and valued the teacher development programme. The next two sections explore, consecutively, Anton's perception of the development programme and how he used the ethics-in-science planner to which he had been introduced.

5.4.5.1 *Teacher development*

Although appreciating the need for the teacher development sessions Anton felt they were “full on” and that it was

... all new and took about three quarters of the way through before the penny began to drop. Then I thought, ok, cool, I see how it works. We probably missed a lot of what you talked about but I think I got the gist of it.

Anton believed the teacher development sessions were “absolutely necessary” and felt he:

... definitely needed two. In the first one I got my head in the game and in the second one I started to get it. It was good to have the break in between to mull it over and then for it to consolidate.

Anton also found it helpful to have the sessions apart, even from a practical point of view. He said it would have been too many meetings in one week if they'd been together, or too much information if it had been all at once.

Anton's first impressions left him concerned that learning about ethics in science didn't involve enough hands-on science, "but the more we went into it the more I realised it made the hands-on things we'd done meaningful." Anton also expressed some concern about the need for a meaningful context in terms of relevance for his age group. He felt that chemical fire retardants may not have been such a good choice as a topic saying that:

While fire retardants was good, it would be better to have one that wasn't made up, but one that involved the children doing real research and could then be used by the children. An issue that is an actual issue – like they could see the affects of it. Like the takahe is real and you can see the effects of saving it here [in New Zealand]. It's real here. Chemical fire retardants are not a reality here – they are in the States but nothing is happening here.

This comment expresses Anton's own views that chemical fire retardants are not really relevant in New Zealand because it is not something the government is considering. Anton alluded to the benefits of having a relevant issue that can lead to action involving the children.

Anton reported that, in retrospect, he did not feel that he really needed to include an ethics aspect to his science unit on fire. He said the fire was really exciting but he felt "the students went down as they did the ethics part". However, he recognised that his top-achieving students "benefited from the critical thinking developed in the discussions. They could think outside themselves and consider others' viewpoints" but that the time available for the lessons was too short for the lower ability students, who "didn't know what was going on. They needed more time to understand the science and to develop their ability to think using an ethics approach". He said he could see himself teaching ethics in science as stand alone sessions (not necessarily part of a science unit) – maybe from a news article or event – and he could definitely see himself teaching ethics in other curriculum areas.

5.4.5.2 Use of the classroom ethics-in-science planner

Anton said that a discussion with Lynda helped him to plan his lesson sequence, and that she gave him some additional ideas for activities, for example, using a continuum to determine students' values.

Initially Anton was overwhelmed by the planner, saying "there were a lot of boxes to fill in and lots of big questions" and he wondered "what do I actually do?" Anton left a number of the boxes blank, including relevant science knowledge and learning intentions, commenting that he "did not know what was required" and "it did not seem essential to my planning and lesson sequence".

During the interview, when asked about needing support for new areas of learning, Anton said it is good to have the information available, but not necessarily on the planner (he added later, however, that people probably wouldn't consider it if it wasn't incorporated into the planner). He said he would prefer to have the planner more "streamlined, with less boxes and information just relating to the lesson sequence". Anton found the planner "a bit too broken down. It was a bit too theoretical for my liking – but it was well done. I loved the drop downs."

To improve the planner, Anton suggested having:

...some sentence starters, especially since it was new and unknown. Maybe there could be some drop downs in this part as well, either that or bits where you could just highlight what you want - always looking for the easiest option available. I'm a teacher, time is of the essence.

It appears from Anton's comments that on one hand he felt there were too many boxes and headings, but on the other he was looking for support, such as having some sentence starters. He suggested that it might have been useful to work on the planner during the teacher development sessions where he could get support. The planner had been discussed (box by box) twice during the teacher development session and examples were given. However, the planner and many terms were new to Anton and it was another four weeks before he completed his own planning (Appendix 34) and taught the ethics

component to his class. Anton suggested having example planners with different science contexts so that teachers could see how they had been used and modify them to suit their needs.

Science context

Unsure of the expectation, Anton did not fill in the science/technology box in his planner. It seemed that the phrasing that was used had been problematic, since he knew the context, having just completed a fire in science unit and having chosen to do ethics as part of that (the decision made in the teacher development programme). The size of the box also made him think he was expected to write a lot, although this was actually just a reflection on the size of the adjacent box for classroom and teacher details.

Science curriculum links

Anton also left this box blank because, he said, he did not understand what was required or see it as essential to his planning. In subsequent conversation Anton realised what was being asked.

Ethics question

Anton used the ethics question “Should we make the use of [chemical] fire retardants compulsory for New Zealand furniture?” Although the word chemical does not appear on the planner, Anton explained in the interview that that was his intended meaning. This was made clear in the introductory lesson as the class explored fire retardants and then chemical fire retardants.

Relevant science knowledge

Relevant science knowledge was recorded as “how fire works”. This science knowledge had been covered in the preceding science unit on fire. Anton shared later that he had “not really known what to put there”. During the lessons Anton discussed with the students what chemical fire retardants are and how they worked, suggesting that as he moved through the lesson sequence he had an understanding of what the students needed to know. Anton also gave the students an article ‘Slowing down the burning’, which discussed what the chemicals are and do, and there was a brief discussion

about the chemicals interfering in the gas phase of the chemical reaction of fire and the effects of some chemicals causing the charring of materials.

Ethical approaches and questions

On one hand Anton appreciated the link with the ethical approaches and example questions. The area of ethical reasoning was new to him and he said it was helpful to have it detailed in the planner, but on the other hand he found the extra information “too much to deal with” suggesting “the new ideas and learning should just be brought out in the teacher development sessions”. Anton did not appear to fully appreciate the use of well-known ethics approaches to frame ethics teaching and learning.

Ethics focus questions

Anton said that he appreciated space to detail the ethics focus questions. He felt that generally teachers don't need planners to help develop logical sequences for teaching because “teachers are logical. They think step by step without a planner, however, the ethics focus questions were new – you don't usually have them on a planner – they make you focus.”

Anton's first question under the heading ‘Ethics focus questions’ related to his main ethics question: Should it be compulsory for there to be [chemical] flame retardants? Anton used the question as an introduction to the lesson sequence in order to “get the students thinking about the big question from the outset”. Subsequent questions all related to the consequentialist approach, seeking to identify who might be affected, the benefits and harms for these stakeholders, and prioritising stakeholders. Again, Anton was guided by the amount of space provided in the planner and felt there were too many boxes for ethics focus questions; he thought he had to have a question in each box.

Activities and strategies for intended learning

The activities, planned interactions and resources corresponded with the ethics focus questions, for example, the initial question used to introduce the idea of chemical fire retardants being compulsory was linked to a

“conviction continuum”, where Anton wanted the students to make an initial ‘stand’ on the issue for comparison to later informed decision-making (though this was not written into the document). His planned interactions included watching a DVD showing various fires to set the scene and to discuss what retardants are (for student understanding) before participating in the continuum. Other activities, including reciprocal reading (structured reading for understanding), noisy round robin (using PMI sheets) and role-play were listed in the example list of activities and were used to answer the ethics focus questions. The last three activities (a letter to John Key, a worksheet, and mantle of the expert drama) Anton said he did not have time to do.

Anton did not insert any written learning intentions. He explained that, as with other boxes on the planner, he was unsure of what was expected. In discussion later, while reviewing the document, Anton said he was “seeing it with fresh eyes and it’s making more sense now. I was tired at the time – middle of term and all that”. With time and further discussion, it seemed that the planner began to make more sense to Anton and he was able to understand and appreciate why the planner included each of the boxes.

5.4.6 Summary

Classroom observations and interviews with some of Anton’s students suggested that they were able to engage in ethics learning (being able to reason critically and justify a viewpoint), even though only three lessons were taught.

The learning was achieved through a classroom programme devised by Anton using the classroom science-in-ethics planner and drawing on concepts introduced in the teacher development programme. His classroom programme included activities that helped to explore the science involved (research and discussion) and activities to explore consequentialism as an ethics approach (class discussion and the noisy round robin using PMIs). Students appeared engaged when exploring the science (see Section 5.4.1)

and the ethics (considering harms and benefits in Appendix 33) and, according to Anton, were able to formulate an argument and justify views through role-play where he became the prime minister and groups of students presented their argument in their role as stakeholders.

Anton reported needing the support of the teacher development to help him understand ethics, ethics approaches and teaching ethics in science. Although the classroom ethics-in-science planner guided Anton to structure his programme to some extent, an interview with Anton and analysis of his plan suggest he needed further support to understand the ethics frameworks and for planning strategies to develop students' ethical thinking skills. Anton linked ethics focus questions to planned activities and reported that these questions helped him to focus the discussion and activities on the ethics. Although Anton may not have been so clear regarding aspects of the planner, his lessons meant that the students who were interviewed were able to display in-depth thinking and justify their views. Anton indicated that he had greater understanding of the value of different aspects of the planner at a later date, when it began to make more sense to him, highlighting the need for repeated exposure to ethical concepts for teachers.

5.5 CROSS-CASE ANALYSIS

The three case studies presented in the previous sections demonstrate that ethics teaching and learning can occur within primary science classrooms. Each contributed a particular perspective to the overall study. Lynda's case study highlights the range of pedagogies that can be successfully used, whereas Amy's case study shows the importance of planning and Anton's case study highlights student learning and analysis. Together they show that ethics thinking can be embedded within existing science classroom programmes, strengthening and supporting the science and reducing the need for new, stand alone programmes focusing solely on ethics. Teachers can do this through thoughtful planning that includes a range of engaging activities designed to develop critical thinking. This is discussed in Section 5.5.1 along with ethical perspectives selected and used by teachers. In

Section 5.5.2 student learning is explored across the three classrooms, demonstrating progression in ethical thinking and learning of science concepts as well as those related to the nature of science. Finally, the importance of teacher development and the use of the subject-specific classroom planner as a contribution to successful ethics teaching are demonstrated in Section 5.5.3. Section 5.5.4 summarises the chapter.

5.5.1 Exploring ethical perspectives in science

The ethics in science exploration across the classroom programmes relates to the way the teachers structured their learning for ethical inquiry. This includes how they worked (e.g., by incorporating ethics into the existing programme and through collaboration) and what they did (e.g., ethical approaches and activities and strategies used).

5.5.1.1 Incorporating ethics into an existing programme

The teachers incorporated the ethics learning within their current science programme (exploring the chemistry of fire). They felt it enhanced the science being taught. Lynda saw the ethics as “a wonderful addition to the science unit – adding a richness, a depth and a high level of thinking” (Section 5.2.4.2). She also added, “It’s so much richer having come at the end of the science unit. We already had a passion going, so it added depth” (Section 5.2.6). Amy appreciated that “the ethics aspect extended their [students] thinking. They started thinking more deeply. They had worked with the science they had learned and then they were forced to think even more deeply” (Section 5.3.5.1). Anton appreciated that the inclusion of ethics in the science extended his top students who “benefited from the critical thinking developed in discussions”.

The teachers decided to incorporate the ethics into their current science programme during the development programme. It seemed easier to them in that most of the science learning had already been established making it easier for the teachers to focus mostly on the ethics teaching and

learning. This helped to make the ethics lessons more straightforward and shorter than it would if having to teach all the science as well (as with an ethics exploration not incorporated into an existing programme). The teachers appreciated that if science ideas and concepts could be well taught before introducing the ethics, the students would have a good basis for justifying decisions. For example, Lynda made the comment that “without the science knowledge we couldn’t discuss the issues”.

5.5.1.2 *Linking with the science context*

The teachers commented that investigating the chemistry of fire before the ethics exploration engaged the students with ‘fire’ and gave them a good knowledge base to build on. However, they realised further science learning was necessary to be able to explore the ethics issue. All classes engaged in further research concerning the science around chemical fire retardants – what they are and how they work. The teachers shared research found on the Internet with each other. Scientific content was mostly found on websites.

Initially there was some confusion amongst the teachers concerning differences between *natural* fire retardants and *chemical* fire retardants. All the teachers initially referred to *chemical fire retardants* as *fire retardants* (as seen in Lynda and Anton’s planners – Sections 5.2.5.2 and 5.4.5.2). Although Amy used the term *chemical* in her planner (Section 5.3.5.3) she used the term *fire retardants* when she spoke to the students (but was meaning chemical fire retardants). As the teachers began to teach they realised that some materials were naturally fire retardant and that the ‘chemicals’ (in the term chemical fire retardants) referred specifically to manufactured substances added to materials to slow combustibility. The more they learned, the more specific they became in their teaching. Consequently student learning became more explicit, for example, students in Lynda’s class realised the difference between natural fire retardants (naturally occurring materials that burn more slowly than others) and chemical fire retardants (materials that have special chemicals added to slow the burning). They chose to vote

for seating in the movie theatre by having two separate votes – one where the seating used natural fire retardants and one where the seating used chemical fire retardants (Table 5.1).

The teachers realised students need to have science knowledge to be able to discuss ethics in science. Amy linked the science to previous learning and explored burning times of different materials, concluding some materials are fire retardant and that the addition of chemicals changes the combustibility of fabrics. However, she realised during teaching she had not gone far enough in researching the chemicals themselves. Several lessons later, when students were struggling to understand the issues and consider consequences for stakeholders (Appendix 27; groups 5, 6, 7 and 8), Amy realised the students needed to know more about chemical fire retardants, how they worked, what they did and the issues surrounding them. Researching these ideas (at that point) appeared to provide significant support and students had many more ideas for consequences (benefits and harms) to stakeholders following this (Appendix 28).

Lynda and Anton both linked previous science learning to the ethics exploration. Lynda extended earlier learning to incorporate flammability rates of various fabrics (Section 5.2.1). The learning then investigated manufactured chemical fire retardants, which Lynda said was crucial. Anton also discussed rates of burning for different fuels with his class before explaining what chemical fire retardants are. The class then researched chemical fire retardants to find out how they worked and what the possible issues are (Section 5.4.1). At one stage Anton had thought that the ethics aspect of the science didn't involve enough "hands-on science, but the more we went into it the more I realised it made the hands-on things we'd done meaningful" (Section 5.4.5.1).

The case studies demonstrate the importance of teachers' understanding of the science involved. For instance, the students in Anton's class were exploring chemical fire retardants (Section 5.4.1) and were trying to understand how they worked by relating to previous work. They thought

about “what makes fire happen” and “what would a chemical fire retardant do to stop the triangle from working?” The thinking was logical but needed further knowledge and input from the teacher to lead them to understanding the role chemicals played in slowing down the fire. Amy’s students also discussed aspects of combustion and how fire increases and speeds up - “things burn more because they have a bigger surface area like the flour in the exploding flour experiment”⁶ (Section 5.3.1). The students suggested chemical fire retardants could stop this from happening but because the science was also new to Amy, she was unable to lead the students further into an understanding of how chemical fire retardants might work. In both classes this was resolved with further research, but if the teachers had had a clear understanding at the time the science learning may have happened more quickly.

5.5.1.3 Collaboration

The teachers were all part of the same syndicate within the school. They were used to collaborating with each other. They all used similar ethics issues because teaching ethics in science was a new area and they could support one another in their planning. Amy and Anton discussed the issue from a regulation point of view – Should New Zealand have a regulation that furniture has chemical fire retardants added? Lynda’s class discussed the issue of whether or not chemical fire retardants should be added to furniture. A number of different fire issues were raised during teacher development sessions (for example, should farmers be able to burn off their own land? Should people be allowed to incinerate their own rubbish? Should there be restrictions on what may be burned in household fires, for example, should people be allowed to burn nappies?). However, in discussion the teachers agreed they would be more supportive of each other if they essentially did the same topic.

196_____

⁶ An experiment carried out as part of the science unit that looked at surface area in relation to fire spreading and increasing in speed. An attempt to ignite compact flour was compared to lighting flour when blown on (aerated) in a cylinder.

The teachers collaborated concerning science concepts. During the teacher development sessions there were some in-depth discussions concerning fire concepts. For example, Amy, unsure what smoke was, asked for clarification of her ideas. The resultant discussion about insufficient combustion and unburnt particles helped clarify science ideas for all the teachers.

The teachers collaborated to some extent concerning their classroom programmes. A number of the activities and strategies were similar across the programmes. Lynda as a more experienced teacher had sound pedagogical knowledge, particularly concerning activities that would not only engage students but also help to develop their critical thinking and cause them to consider multiple viewpoints. Anton used activities that had been suggested to him by Lynda, for example the continuum to determine student values (Section 5.4.5.2). However, most of the activities used by the teachers came from the examples presented in the planner (Appendix 11), for example, debates, PMI sheets, noisy round robin, role-play, values continuum and mantle of the expert. Mantle of the expert was Lynda's idea and it was added to the example list in the planner. Lynda had previously attended a workshop using mantle of the expert (Section 5.2.3.1) as a learning strategy for developing authentic learning and critical thought and shared this with the other teachers as an ideal strategy for an ethics exploration. Amy and Anton adapted the idea into role-play activities for their classes (Sections 5.3.3 and 5.4.3).

The teachers used a similar pattern in their classroom programmes (Sections 5.2, 5.3, and 5.4) where:

- A controversial issue was presented
- Students gathered information (some of the science having been explored in the previous chemistry of fire unit – see Appendix 19)
- Students analysed information
- Students weighed up and evaluated the issue
- Students made a decision
- Students formulated an argument with justification.

The argument was presented in some form (writing, discussion or debate). The teachers in this research reported being supported by the subject-specific ethics-in-science planner in structuring and scaffolding the lessons (Sections 5.2.5.2, 5.3.5.3, and 5.4.5.2). The takahe example discussed in the teacher development may have helped to develop such a model.

The teachers also found collaboration important to clarify components of ethics-in-science planner. Amy commented “talking about it with Lynda was helpful” referring particularly to ethical approaches and questions (Section 5.3.5.3) while Lynda mentioned discussing components of the planner over the phone with Amy to clarify requirements of science curriculum links (Section 5.2.5.2). Anton said a discussion with Lynda helped him plan his lesson sequence (Section 5.4.5.2).

The teachers therefore felt that collaboration was an important part of learning to teach ethics. This is consistent with a sociocultural view of learning, where the teachers participate as learners in a social, authentic setting.

5.5.1.4 Ethical approaches

The teachers primarily planned for and used consequentialism as an ethical approach. They said they thought it was the easiest to use for both themselves and students (Sections 5.2.2, 5.3.2 and 5.4.2), but Amy and Anton also acknowledged their choice might have been influenced by the example of the takahe (explored through consequentialism and used as an example during teacher development). Lynda also felt “it was better to do one [approach] well”, particularly while the teachers were still learning about the approaches themselves.

During the course of teaching all teachers found approaches of autonomy and rights and responsibilities were at least touched on by students, particularly when discussing stakeholders and who had more rights than others to make decisions. Anton’s students raised issues around

consumer choice (Section 5.4.2) and one of Lynda's students asked, "Whose right is it to be able to choose? Is it ours or the government's?" (Section 5.2.2). Lynda commented that although she would like to have developed ideas about the rights of individuals she felt she did not have the time, choosing instead to focus on consequentialism.

Amy made more of a conscious choice to discuss rights and responsibilities, evidenced by her inclusion of a question on rights in her planning "Who has rights in regard to our big ethics question?" (Section 5.3.5.3). She found that the rights and responsibility approach "unfolded, particularly when we started to discuss stakeholders and who had more rights than others to have an opinion" (Section 5.3.2). After discussing who the stakeholders were Amy asked the students who had greater rights than others to have views on the issue and then led the students to realise that some people might have more rights because they might be more affected (e.g., babies have a right to be protected from harm so parents have a responsibility to make sure furniture is safe for their children) (Section 5.3.2.5). It was when discussing rights that Amy realised responsibilities are involved: "We discussed who had rights as a stakeholder and, if they had rights, whose responsibility was it to see they were carried out" (Section 5.3.2).

All teachers found they had to define consequences with the classes before ethics discussion could take place (Sections 5.2.2, 5.3.2.1 and 5.4.2.2). Students in all classes expressed an understanding that consequences were a negative outcome to an event (for example, being punished for bad behaviour). Lynda used a 40-minute drama strategy (space-jump) to demonstrate consequences could be positive or negative (Section 5.2.2.1). Amy (using two 40-minute sessions over two days) engaged in class discussion followed by students identifying consequences (positive and negative) to familiar scenarios on charts (Sections 5.3.2.1 and 5.3.2.2). Anton used a 10-minute class discussion asking students to identify positive consequences for various situations (Section 5.4.2.2). While the students from Lynda's room reported really enjoying the space jump, Anton's students

seemed to have grasped the concept of consequences as much as students from all other rooms. It appears that primary students need help to understand consequences as a concept, but once explained students were shown to grasp it fairly quickly.

The findings suggest it is important that time is spent establishing concepts and terminology related to ethics. If this is done well in initial ethics explorations it may not need to be addressed in such detail again. Amy used one lesson to cover the meaning of a stakeholder (Section 5.3.2.3) and two lessons to cover consequentialism (Sections 5.3.2.1 and 5.3.2.2). During the stakeholder lesson Amy used an example of builders in a school removing a window from the students' classroom to relate the idea to the students by comparing it to their world. Amy asked the students who this would affect. It was at this point that the students appeared to understand the concept with exclamations of "I get it now"; "I didn't know what you meant by stakeholders before"; "So, it's all the people that have something to do with it". Amy reported after the ethics exploration was over, her student teacher took a lesson on the environment using "The Lorax" by Dr Suess (Section 5.3.5.1). The student teacher found the students were able to discuss the consequences to situations/stakeholders in the book immediately without needing to have the word consequences defined as this had been done well in the earlier ethics exploration. When students were asked what learning was new, the repeated mention by students in Amy's room about stakeholders, consequentialism and consequences may reflect the explicit way these terms were introduced and taught (Section 5.3.4.2).

After learning about ethics and ethical approaches all classes were able to identify stakeholders and possible harms and benefits for each (Appendices 20, 21, 27, 28 and 29). The students formulated viewpoints and could express them in various ways through values continuum, role-play, discussion, worksheets and writing.

5.5.1.5 Activities and strategies

The teachers used similar activities and strategies to accomplish the ethics exploration. This is not surprising considering they attended the same teacher development sessions where a number of the activities and strategies were modelled, they used the same ethics-in-science planner, (which included examples of the activities) and they collaborated together sharing pedagogical knowledge.

The teachers found that while class discussion is an imperative part of ethics discussions they should be kept short to keep students focused. Amy used more class discussion than the other teachers, possibly because she was still trying to clarify the concepts for herself. There were some behaviour issues from time to time with some students in her class. Amy concluded that short bursts of class discussion interspersed with interactive activity and participatory pedagogies may be more engaging for primary students than “long discussions where only about a third of the class are involved”.

The teachers all used a PMI format to collate benefits and harms to stakeholders (Sections 5.2.2.3, 5.3.2.7 and 5.4.2.4). Both Lynda and Anton used the noisy round robin strategy (Sections 5.2.2.2 and 5.4.2.4) to generate these ideas and Lynda reported that it was very effective in determining benefits and harms within the consequences approach because it “focused the children and they came up with ideas quickly” (Section 5.2.2.2). Think-pair-share and small group discussions were also used to generate ideas. Values continua were activities where, Anton said, “students could easily express an opinion without feeling stressed – a great way for children to say ‘this is what I believe’”. These activities appeared to focus students and keep them involved through participation. All the teachers used role-play activities to help students formulate an argument (Sections 5.2.3, 5.3.3 and 5.4.3). The role-play put students in role and made them think from the perspective of the person they became. This was an effective strategy for encouraging authenticity and helping students ‘see’ from various viewpoints. Lynda

commented, “It was a superb way to bring their learning together and allow authentic voice. The children spoke and justified their views.”

Other activities, such as the ‘What do you think?’ worksheet (Section 5.2.3.2) and transactional writing (Section 5.2.3.3) used by Lynda, were used to strengthen student views and understanding and gave them opportunities to demonstrate their learning. The responses to questions in the worksheets and the transactional writing were more in-depth than comments made in PMIs.

Although there was reliance on the activities provided in the teacher development sessions, teachers were also able to develop additional activities. Lynda’s suggestion to use mantle of the expert (Section 5.2.3.1) worked well for focusing learning and developing discussion. Amy downloaded ten different viewpoints of various stakeholders from the Internet and used those to stimulate discussion in terms of determining stakeholders, consequences and justifying decision-making (Section 5.3.2.6).

The students expressed enjoyment in participation of collaborative learning strategies: “I like working in groups” “I enjoyed discussing stakeholders” (Amy’s students, Section 5.3.4.3); “having interesting conversations with friends”; “the debates were cool” (Anton’s students 5.4.4.2); “learning about and making a [class] continuum” (Lynda’s student, Section 5.2.4.3). Amy reported small groups effective for reading research articles and brainstorming ideas as “each child felt more inclined to contribute” (Section 5.3.4.3). Anton spread the more able students among the small group (Section 5.4.1). He said they helped other students understand articles. These groups then shared their learning with the class.

Engagement

All students were engaged to a greater or lesser extent during the exploration. Students found themselves interacting and contributing even though “I don’t normally say anything in the class”(Section 5.2.4.3). Role-play debates and continuum activities helped students’ to discuss and justify.

Lynda's students were particularly captivated with mantle of the expert and Space-jump (Section 5.2.4.3). Her class discussion was short and engaging. Students were not just listening or reading unless it was for a purpose (for example, researching to share a view in a role-play). The activities and strategies (such as the noisy round robin) were used to generate discussion about stakeholders to do with chemical fire retardants, the consequences for them, prioritisation of stakeholder views of the ethics issue, decision-making about the issue and teacher-recorded summaries of discussions (whole class and small group). Results from these discussions were recorded on large charts or PMI's (A3 size) that were visually available to all students. Amy also summarised her students' learning on the board and left it there (accumulating) for all students to view and refer to over the weeks they explored the ethics. She commented that for the reflective students in particular "it was interesting to see how engaged they were" (Section 5.3.5.1). Both Amy and Anton reported using the DVD (on different rates of burning) as an initial hook to engage students causing them to think about fire in preparation for the ethics exploration.

Teachers were able to engage students by being flexible in their teaching. This related to their pedagogical knowledge of the class, content matter and teaching approaches. For example, Anton began his teaching with a brief introduction to the issue and what it was about and then moved onto a class values continuum (Section 5.4.2.1). This was because his class was "way too restless" and he wanted to do a hands-on activity. He said the continuum was a good warm-up and served as a pre-test, which the students could use at the end of the exploration to compare their own learning and possible changes in thinking. Anton introduced the research aspects of the learning when his class was more settled.

Benefiting all students

The issue appealed to and engaged many students. High ability students were able to extend and challenge themselves while the teachers stated that, although lower ability students may have struggled to some extent, most were engaged and able to give opinions and make decisions.

This depended on the teacher's approach and as teachers became more familiar with ethics they also became more aware of how they could structure lessons to include slower learners. For example, Lynda worked with a group she identified as needing support (Section 5.2.1) so that she could help focus them and reiterate research to them. Classroom activities were particularly engaging for these students (space-jump and mantle of the expert shown to be the most popular in Section 5.2.4.3). In the mantle of the expert role-play Lynda designated roles that would keep these students engaged (teenagers, reporters) and concerning the learning she recounted:

Even the students that usually need a lot of support gained a lot at their level... they had to make choices and that to do that they needed to learn about both sides of the argument. The students surprised me all the time with the depth of thinking this teaching produced (Section 5.2.4.2).

Anton suggested his struggling students “needed more time to understand the science and to develop their ability to think using an ethics approach”. All teachers used mixed ability grouping where appropriate so that lower ability students could learn from more able students (Section 5.2.2.2; 5.3.1; 5.4.1). Amy also felt that teacher scaffolding (for example, Amy's use of focus questions in the research articles – Section 5.3.1) is important in terms of support for lower ability students, stating:

For children who are lacking academically... they needed to work in smaller groups with a lot of teacher scaffold. This was clear during our lessons where the more deeply thinking children became passionate about arguing for or against an issue and others chose to opt out of discussions as they may have felt slightly intimidated. With careful monitoring and more experience from the teacher's perspective, I feel that all children would be able to be actively involved in lessons (Section 5.3.5.1).

Besides the possibility of benefiting lower ability students, ethics in science explorations can extend top achievers as well. Amy said it was great “for the top kids because it extended their thinking. They started thinking more deeply. They had worked with the science they had learned and then they were forced to think even more deeply” (Section 5.3.5.1). Lynda felt the benefits extended to the whole class stating that:

The ethics was a wonderful addition to the science unit – adding a richness, a depth and high level of thinking.... the whole class knew they had to make choices and that to do so they needed to learn about both sides of the argument”(Section 5.2.4.2).

Authenticity

The learning in each of the rooms was authentic. Chemical fire retardants are a real issue. Scientists in New Zealand are exploring adding them to furniture and are aware of the issues involved, particularly concerning cost⁷. The students may not have been aware of the chemicals or the issues surrounding them before the exploration, but they quickly learned how chemical fire retardants added to furniture may affect them and other stakeholders should it become compulsory as it has in the United Kingdom. To strengthen the authenticity of the learning for the students, all three teachers used role-play where the students took on authentic roles of stakeholders. This helped them think from the stakeholder perspective, particularly when asked questions that made them think from the stakeholder’s perspective. This worked particularly well in Lynda’s room where the students were required to become ‘experts’ in their field (role) and to share this knowledge with the class. The expectation of being the ‘expert’ caused them to delve into the research to gain some knowledge. Having the ‘press’ present, recording events and asking questions, added to the authenticity (Section 5.2.3.1). The students were thinking, interpreting, negotiating and behaving in much the same way as a community of stakeholders would. One of Lynda’s students made the comment “it wasn’t really me [talking] it was a scientist”(Section 5.2.4.3).

Amy added strength to authenticity by encouraging her students to question others in role. For example, a ‘consumer’ was encouraged to ask ‘furniture manufacturers’ as to why they should pay a lot more money for chemical fire retardant furniture. The ‘furniture manufacturers’ had to justify their view that they would “get more money for their furniture” (Section 5.3.2.7).

205_____

⁷ Science Learning Hub (<http://www.sciencelearn.org.nz/Contexts/Fire/Looking-Closer/Chemical-fire-retardants>)

Anton challenged the relevance of the topic in terms of authenticity. He commented:

While fire retardants [as a topic] was good, it would be better to have one ...that involved the children doing real research and could then be used by the children. An issue that is an actual issue – like they could see the effects of it. Like the takahe is real and you can see the effects of saving it here [in New Zealand]. It's real here. Chemical fire retardants are not a reality here – they are in the States but nothing is happening here (Section 5.4.5.1).

Anton suggested preference for a topic more immediately relevant (than the chemical fire retardants) to New Zealand students and that could possibly lead the students to some action: “maybe they could get involved and do something about it”. Amy also referred to this when she said some of her students “struggled because chemical fire retardants are not really a big issue – but if it was something affecting them it would be more powerful and they would all be passionate and involved” (Section 5.3.5.1). The teachers chose to do their exploration within the fire context because fire had been their last science unit. They also agreed to do the chemical fire retardant topic because the resources were easily available. In addition, the teachers agreed that because the ethics learning was new (to them and their students) they wanted to do the same topic (collaboratively) and thought it would be easier to do one that already had some resources.

Students, however, do respond to relevant issues and this was made pertinent when one student in Anton's room related the topic back to her and her situation at school: “If it's made compulsory, will all classes at school need to have chemical fire retardants in furniture? Who would pay for that?” (Section 5.4.2.3). Even though Anton, not the students, had identified the school as a possible stakeholder in the issue, the students could generate benefits and harms for the school because they could relate to the possibility of furniture at school having chemical fire retardants (Section 5.4.2.4).

Authentic learning is meaningful and real to students and may result in a development of skills that can be used in other areas. An example of this could be seen in a comment made by a student in Anton's room when, in reference to learning to explore issues and have debates, she commented that

she was enjoying “having interesting conversations with friends – like debates with friends in the play ground that we didn’t have before, like yesterday we were debating about whether we could get paid to come to school”(Section 5.4.4.1).

Argumentation

Classroom discussion and activities that required discourse among the students were a key feature of the ethics exploration in each classroom. A number of the students expressed an appreciation that they could express their view. 57% of Amy’s class reported that discussion in the form of sharing, speaking, debating and expressing their view was new to them (Section 5.3.4.2) and 30% of Lynda’s class said debating (or arguing) was a new learning activity for them (Section 5.2.4.3). One student said, “We haven’t done that much in debating and it made me think differently”. Another said, “I listened to others’ views and thought about my view and it made me question my judgement”.

Students of Amy’s said that they enjoyed being able to say what they thought. They enjoyed “making hard decisions because it made us think and listen” and “I enjoyed deciding whether the statements were right or wrong because you thought of reasons and shared them” (Section 5.3.4.3). They learnt they could “have a different view and still be friends”. One student said, “It was great to be able to argue, because at home I’m not allowed to talk back to my parents”. Others in Lynda’s room were not used to speaking in class and appreciated being able to participate commenting, for example, “I’d never let myself go before” (Section 5.2.4.3).

Discussion helped the students clarify their ideas and formulate their views and arguments. Ethics exploration in each classroom ended with a debate scenario so that almost all the students had a say at some point. Nearly all students were engaged and participated in formulating an argument.

Scaffolding

Scaffolding as a teaching strategy was very important. It seems that the more the lessons and activities were scaffolded the better the learning outcomes. As an example, Lynda carefully scaffolded the transactional writing, explicitly stepping the students through transactional writing itself and then through each paragraph needed for their arguments. Most of the students successfully achieved what was required - an introduction stating their view and defining chemical fire retardants, two paragraphs containing their arguments, and a conclusion (Sections 5.2.3.3 and 5.2.4.1).

The teachers scaffolded their lessons carefully so that one built onto another. Amy in particular built slowly from one lesson to another. Each lesson started with a recap from the previous one and recorded on the board so that it was “accessible to all the children all day so they could discuss the ideas amongst themselves to clarify ideas” (Section 5.3.4.3). Sometimes work was repeated or moved through slowly if Amy thought some students needed more time or clarification (for example, learning about consequences in Sections 5.3.2.1 and 5.3.2.2). Amy made sure students understood what stakeholders meant (Section 5.3.2.3) before identifying them (Section 5.3.2.4). After identifying the stakeholders, the students prioritised them according to their rights (Section 5.3.2.5). Students then generated a list of consequences for stakeholders (Appendix 27). Due to some disappointing results (some groups struggling to generate consequences) Amy then introduced some more articles concerning the ethics issue from the Internet as examples for students (Section 5.3.2.6). Students were given very specific tasks (e.g., state whether the author is for or against the issue; write why you think this; write who you think might have written this article). The students used a PMI framework to again identify stakeholders’ benefits and harms. The results for this (Appendix 28) are more extensive than the first attempt at consequences (Appendix 27) and then the results from the role-play (Appendix 29) demonstrate more concise and in-depth thinking showing Amy’s careful monitoring of student understanding and scaffolding of activities to meet their need. This also suggests the importance of multiple opportunities for students to practise and build on or extend their ideas. Amy

commented that lower ability students particularly “...needed a lot of teacher scaffold” (Section 5.3.5.2).

Teacher direction

The teacher has an important role in keeping the students focussed. For example, during the debate in Lynda’s room the students diverted to discussing the needs of the disabled during a fire on two occasions and Lynda needed to refocus the discussion back to the ethics question (Section 5.2.3.1). Amy streamlined a research article causing the students to focus on key points (identifying stakeholders and benefits and harms) by asking specific questions before the reading and then having the students answer them at the end of the reading (Section 5.3.2.6). She also encouraged students to challenge statements made by their peers rather than just accept what was being said. At one point in a lesson on consequentialism (Section 5.3.2.1) a student responded that a consequence was a punishment. Amy redirected the thinking here by asking the class if anyone wanted to challenge that statement and by leading students to realise that not all consequences are negative.

5.5.1.6 Critical thinking and multiple perspectives

Argumentation gives opportunity to develop critical thought. The teachers reported that the ethics exploration (with its ethical approaches and questions) made their students think critically. Students were required to form and defend a view. This needed some analysis and a weighing up or evaluating of benefits and harms for various stakeholders. Anton said, “My top students benefited from the critical thinking developed in discussions. They could think outside themselves and consider others’ viewpoints” (Section 5.4.5.1). The result of this consideration is that students were able to make decisions, even changing their minds. One student, reflecting on where she stood in the initial values continuum, said “I was in the middle at first on the continuum...and I learned from other people and decided they [chemical fire retardants] shouldn’t be compulsory” (Section 5.4.3). Amy stated students “started thinking more deeply. They had worked with the science

they had learned and then they were forced to think even more deeply” At another time she said “Kids don’t think enough outside themselves, but this kind of teaching makes them think about their thinking. They have to think ‘why should my opinion be more important than others?’” (Section 5.3.5.1). Lynda felt “This unit worked really well in terms of developing critical thinking - I don’t know how you would get a richer discussion” (Section 5.2.6).

Students from all classes said they learned about views other than their own. They were encouraged to think from the perspective of various stakeholders and then to think about both harms and benefits for the stakeholders. In giving an opinion on chemical fire retardants from the point of view of accident and emergency workers, one student in Lynda’s room (Appendix 21) claimed, “it’s both plus and minus. It gives us time to get out [of a burning building] but [the smoke] is toxic”. This shows that the student could see both sides of the argument. A student in Lynda’s room demonstrated she could write about both sides of an argument before giving her personal view, for example Julie raised and refuted the issue of the toxicity of chemical fire retardants (“all smoke is toxic isn’t it?” and “firefighters have chemical fire retardant clothing”). She also mentioned people’s concern about health risks during the production of chemicals and issues about chemicals getting into the environment. Her view however, was supported by science (different ways the chemical fire retardants interfere with the burning) showing that chemical fire retardant materials “slow down the combustion process therefore allowing you more time to get out of a fire”. Julie wrote in her assessment that she “was able to see two different sides of the story. Before I could only see one. I changed my opinion because of the information we got.”

From analysing the issue from the stakeholders view, students were also able to realise possible effects on others. After considering possible raised costs of compulsory chemical fire retardant furniture another student from Anton’s room was able to relate the effects to lower income families stating that they “may have to sleep on the floor”(Section 5.4.4.1). Not all

students were easily able to reflect others' perspectives however. Amy reported some of her students struggled with taking a viewpoint that was not their own. While preparing for the role-play where students were assigned stakeholder roles students had difficulty being 'for' chemical fire retardants when their personal view was 'against'. Some became confused in their arguments, reverting to their own view while ostensibly arguing on behalf of someone else, for example, stating, "you should be able to choose your own furniture – it's your own risk" when they were arguing for chemical fire retardants as a furniture manufacturer (Section 5.3.3).

The students reported that learning from others and viewing from others' points of view made them think about their thinking and learning (reflect critically). Some students became aware of how they were learning. Students from Lynda's class commented, "You can learn off other people in the class"; "I learned to listen and thought about others' views; I thought about my view and why I believed it," "I actually changed as a person by realising changing views is ok", "I thought about things differently" (Section 5.2.4.2).

5.5.1.7 Summary

In summary this research has shown that ethics in science can be incorporated into an existing science programme strengthening and supporting the science. Students within the classes were engaged, not only by the ethics issue but also with the science learning. Learning for teachers and students was collaborative. A number of ethical approaches were used but consequentialism was the dominant approach. The teachers used a range of activities and strategies designed to develop critical thinking. These activities and strategies engaged students and were shown to benefit (to some degree) all students including those of lower and higher abilities. The ethics learning was authentic where students deliberated over real issues in a similar manner to what stakeholders might do. Students learned to use scientific evidence to support their arguments. Teacher scaffolding and direction were

seen as important strategies that, carefully thought through, contributed to positive learning outcomes.

Students were encouraged to consider multiple views, which led them to appreciate others' views, to be aware of possible consequences for others and to think about their own view and how and why they thought that – developing critical thought.

5.5.2 Student learning

Student learning was demonstrated throughout the ethics in science exploration. Most significantly, students developed an awareness they thought differently about the issue - “we all had different viewpoints, even the teachers” (Section 5.3.4.2) and could identify their view and compare it to others. One of Lynda's students said thinking about her view in the light of others made her realise that her view “had a bad side to it”. Another stated it made him “question my judgment” while others commented, “It made me think and then change”; “I listened to other people's views and I learned about both sides”, and “First I thought chemical fire retardants were bad but when I learned more I realised it [sic] was a good thing” (Section 5.2.4.2).

Crystal from Anton's room said learning about others' views helped her make up her mind:

I was in the middle at first – on the continuum – and didn't know which one to choose. Then we had a spokesperson for each group and I learned from other people and decided they [chemical fire retardant furniture] shouldn't be compulsory (Section 5.4.4.1).

One of Anton's students demonstrated the ability to think ahead and to appreciate the importance of multiple views. When considering the issue of regulating furniture to contain chemical fire retardants she felt that it wasn't “just the government's decision – it's everyone's decision. All families should be able to have a say or take a vote. It's good that we are learning about this because when we grow up and become adults we will know how to debate things like this and we will be able to have a say” (Section 5.4.4.1).

5.5.2.1 Progression in ethical thinking

Ethics in science teaching can help students' progress from a personal perspective to thinking about others on a global level. As demonstrated in Section 5.5.1.6 a number of students progressed from one (personal) view to an understanding of others' views within this exploration. Students also learned to become more discerning when thinking about ethical issues, making less emotive statements and using more scientific evidence to support viewpoints. These statements will be explored further after establishing that some students are egocentric and others make emotive statements when exploring ethics in science at this level.

Egocentrism was seen in an early lesson on consequences when Amy asked the students to identify consequences to familiar scenarios. The consequences some students wrote about referred to consequences specifically related to them, for example, in response to "Choosing to drop rubbish from your eating lunch onto the ground" Amy's students wrote "You feel guilty" "You might have to pick up rubbish all around the school all lunchtime" "You might have to say sorry..." rather than writing about consequences relating to the greater good of the whole school (i.e., the effects on the environment) (Section 5.3.2.2).

Some students were emotive when presenting their view. One of Lynda's students, for example, was strong and emotive in his view when he stated, "Do you want chemicals that may be toxic in your chairs? An unnatural substance that could either kill or harm your child? I think not!... it may kill a small unsuspecting child." And later added, "It harms the workers that are forced to make it to support their family. Are early deaths from workers and the people who buy it really worth maybe saving a family or two - who may die from the fumes [of the chemicals] anyway? Is it really worth it?" (James' transactional writing, Section 5.2.4.1).

Other students in Lynda's room read statements in articles off the Internet such as 'chemical fire retardants cause brain damage' and 'new born

babies would really suffer' (Section 5.2.2.2) and used them to justify why they would not use chemical fire retardants. Amy's students recorded statements (Appendix 28) such as "chemicals are bad for children" and "it might give people cancer" after reading an article (Appendix 25) that suggested fire retardant chemicals have been shown to cause cancer, reproductive problems and learning disabilities in laboratory animals. Another claimed "they are potentially toxic chemicals which are bad for children." Although the students used some of these statements in early identifications of harms of chemical fire retardants (Appendix 20 and Appendix 21), they were not mentioned as much in the mantle of expert discussion (Section 5.2.3.1), the 'What do you think?' worksheet (Section 5.2.3.2) and the transactional writing (Section 5.2.4.1). Towards the end of the learning students showed more discernment, making statements such as "I think we should see what more people think and why" and "I would have liked to see more research..." (Anton's students, Section 5.4.4.1). Ethics in science teaching helps students to see others' views, making them less dogmatic and/or emotive. Researching robust science helps students to be more discerning.

At the end of the exploration some students were able to discern the reason for learning about ethics in science, stating, for example: "When we... become adults we will know how to debate things like this and we will be able to have a say" (Section 5.4.4.1). A student from Anton's room commented, "This kind of learning shouldn't end until you die" (Section 5.4.4.2), supporting the curriculum notion of developing lifelong learning. It is with a developed sense of maturity and realism that one student said, "For one thing we are not real scientists and neither is Mr __ [teacher]. We have enough information for us, for our minds – we don't need more and more and more like real scientists. We only need enough information to make a debate for Room [3] kids." And as a concluding statement that shows a progression in ethical thinking that has moved from a personal to global view "It's not all about just your decision. It's about everyone's decision – making a decision all together. It's global".

5.5.2.2 Science learning

The teachers began their teaching by building on prior learning of the students. Sections 5.2.1, 5.3.1 and 5.4.1 show that the teachers began by linking new science learning to the science learning in the fire unit. For example, Amy's students (5.3.1) were able to use the idea (previously learned) that combustion occurs more easily when there are many small items because of the larger surface area and appreciated that chemical fire retardants may stop fire spreading onto other surfaces. In the teacher interview discussion with some of Anton's students, they began by drawing on prior knowledge when discussing chemicals. They talked about what they knew about chemicals before learning about chemical fire retardants. The conversation included drugs, medicine and experimental effects of chemicals on animals. They were also able to use previous science knowledge to devise an experiment to test for toxicity in smoke from chemical fire retardants (Section 5.4.4.1).

Incorporating ethics in science provides opportunities for understanding of science concepts to be reinforced and expanded, as each of the case studies demonstrated. For example, students from Lynda's room reported learning "about chemical fire retardants and how they slow down burning" (Section 5.2.4.2). Amy's students added they learned about atoms, flames and what fire needs to burn (Section 5.2.4.2). A GATE student from Lynda's class expressed that he "learned everything to do with chemical fire retardants – I didn't know anything before" (Section 5.2.4.2). One student in Anton's class appreciated gaining more scientific knowledge, saying that the learning helped him "change from having childish ideas to having more scientific ideas" (Section 5.4.4.1).

Besides learning about chemical fire retardants, a group of Anton's students discussed (in the interview) the need to design an experiment that would determine how toxic the smoke of furniture with chemical fire retardants added is, compared to furniture without the chemicals. The experiment design demonstrated an understanding of science – that (in this

case) it was driven by human need, testing should be carried out, a control should be used, and there should only be one difference between the two test items (Section 5.4.4.1). It appeared that these students worked this out in discussion rather than because of any previous experience in experiments (the class had not done science experiments in this fashion before).

Science learning is imperative for ethics explorations in science because as Lynda said “without this science knowledge we couldn’t discuss the issues” (Section 5.2.1). It is what students use to make a decision and to justify their views. This was exemplified in the transactional writing examples in Section 5.2.4.1 and some scientific learning can be seen supporting views of stakeholders in Appendices 29 and 33.

5.5.2.3 *Nature of science*

Ethics explorations in each classroom demonstrated student learning about the nature of science. Links were made between scientific knowledge and decisions and possible actions. Students were exposed to the dilemma of scientists and to how chemical fire retardants relate to society (that there are benefits and harms for various stakeholders). One student from Lynda’s room commented “scientists make us aware of harms and benefits so we can think about them and make choices about things.” Students learned to use science knowledge to support their reasoning when making their decisions from particular viewpoints.

Aspects of the nature of science were implicit in the ethics learning, for example, in the prime minister’s summing up of Amy’s class presentation of ideas (Section 5.3.3) it was stated that although lives and property were the top priority, there had been many concerns about the chemicals. Because of this a regulation would not be made just yet. The prime minister also commented that natural fire retardants sounded like a good alternative that would be worth further investigation. This summary of the students’ presentations highlights that science is an ongoing endeavour and that things change as new discoveries come to light.

Students from all classes discussed the need to find out about chemical fire retardants in terms of human safety. This shows an understanding that science can be driven by human need as seen in the example in Anton's class where students discussed the need for science testing to determine whether smoke from chemical fire retardants is more toxic than smoke without the addition of chemical fire retardants (Section 5.4.4.1).

Amy noted, "this teaching reveals the nature of science to the students" (Section 5.3.5.1). When discussing links with the curriculum she stated:

The ethics approach is a teaching tool that can be used to reveal the nature of science... Children see how science actually works - how decisions need to be made and that science is often not 100% established. It [ethics teaching] gives an insight into the nature of science explicitly, which is at times difficult when teaching through the strands.⁸ (Section 5.3.5.2)

Both Lynda and Amy were able to incorporate a nature of science component into their ethics-in-science planners (Appendices 23 and 30).

A discussion in Anton's class led the students to conclude that the issue (whether or not to use chemical fire retardants), as with any issue, is fundamentally about protecting people and the earth. Students became aware that as scientists tried to solve problems for people other problems arose that were detrimental for the earth. They concluded, "We need to look after the environment for our own survival". This assumption underpins many ethics discussions.

5.5.2.4 Teaching time

Teaching time may relate to student learning in ethics in science explorations. The teachers' ethics explorations differed in teaching time. Amy taught 10 lessons (approximately 40 minutes each) spanning four weeks.

217_____

⁸ The achievement objectives in the science learning area of the New Zealand Curriculum (MoE, 2007) are presented in five strands: Nature of Science; Living World; Planet Earth and Beyond; Physical World and Material World.

Lynda taught five one hour lessons within a week and Anton taught three lessons of about an hour each within a week. Although lesson times varied and the length of the ethics exploration varied, most students appeared to have an understanding of ethics at the end of the teaching programme and were able to make decisions and justify them. However, students in Lynda's room showed increasingly deeper thinking the more they worked through the various activities the science involved indicating ethics thinking takes time and needs developing to be done properly. This is evidenced by comparing the results of positive and negative consequences of stakeholders in Appendix 20 with Appendix 21 where students become more specific with benefits and harms and similarly considering some interesting ideas, to the 'What do you think?' worksheet where students comments become less emotive (Section 5.2.3.2) to the transactional writing. Students' writing included acknowledging two sides of an argument, being able to counter argue, using science to support views and less emotive writing. Tim's writing, for example (Section 5.2.4.1), presented counter arguments for the use of chemical fire retardants in furniture: that the chemicals are toxic and increase the cost of furniture, demonstrating a consideration of other viewpoints but he then used science knowledge to argue that every gas is toxic – depending on the amount of it – and concluded that the extra cost of the furniture is worth saving your life.

The teachers also took varying times to work through different parts of the programme. Although none of the students appeared to understand consequences at the onset of the lessons (see Sections 5.1.4, 5.2.4 and 5.3.4.2) by the end of the teaching students from all three rooms reported consequences were the result of an action that could be positive or negative (this is explained further in Section 5.5.1.4 *Ethical Approaches*). It seems the students were no worse off for having had a short lesson (10 minutes) in Anton's room (compared to two lots of 40 minutes in Amy's room). In fact a small number of students in Amy's room appeared distracted and had difficulty staying on task. This may have been for any number of reasons, but the lengthy lessons with that particular focus may have contributed. Conversely however, Amy's student teacher found she was saved the time of

teaching consequentialism when teaching an environmental unit at a later time because the students already understood it.

The time taken to teach ethics in science would be dependent on many variables such as the science and ethics being taught, the students and the teacher (their experience and pedagogical content knowledge). Lynda's students all appeared engaged, responded well in class discussions, transactional writing, surveys and informal discussion with the researcher. The group of students who reported their learning from Anton's room displayed high levels of engagement and thinking. However, Anton reported that some of the other students "really struggled" and "didn't seem to get it". He also said that "ones who didn't know what was going on...needed more time to understand the science and to develop their ability to think using an ethics approach". This could be because the total time spent on the ethics was too short, the work was not reinforced with additional activities (e.g., Lynda used a writing activity) and they did not adequately complete the debate. Amy, on the other hand, may have had more lessons than she needed. She also reported that some of her students struggled and two or three of them were distracted at times. In this case, shorter, less repetitive lessons may have helped.

Lynda is a more experienced teacher and this may account for her activity choice and timing of lessons (PCK), resulting in all students being engaged and contributing to class discussion. All three teachers, however, reported being unsure about teaching ethics (Sections 5.2.5.1, 5.3.5.1 and 5.4.5.1) highlighting the need for teacher development for PCK in teaching ethics in science.

School disruptions may interfere with student learning by shortening teaching time or causing students to miss crucial teaching. About half Amy's students were called away for a dress rehearsal for a production in one lesson and missed a vital part of the learning. The students were confused and Amy needed to spend extra time catching those students up (Section 5.3.2.6) resulting in an extra lesson and the unit becoming longer than Amy

had anticipated. Anton said his lessons were not as in-depth as he would have liked but he had been unable to finish everything because of time constraints (Section 5.4.4). His class never finished the role-play because the bell went. After that they had run out of time because his student teacher needed some class time for his lessons (it was the week before the holidays). It also meant the writing (of letters to 'Mr Key') and the intended continuum never happened (Section 5.4.3). Concluding with these activities may have helped consolidate learning for Anton's struggling students.

5.5.2.5 Summary

In summary the student learning supported the teaching of ethics in science. At the conclusion of the exploration students reported an awareness of multiple views. They were also able to identify their view and compare it to others. Consideration of different views led students to think differently, considering consequences for people other than themselves. This shows a progression in ethical thinking; a maturing in moral development. Related to this was an increasing ability to support decisions or statements with scientific evidence thus becoming less emotive and or dogmatic to what they demonstrated at the outset of the exploration. Students generally demonstrated a more mature outlook at the conclusion of the exploration acknowledging the importance of ethical discussions; realising that it would make them more informed as adults and better able to make important decisions.

Within the context of the ethics question, students also demonstrated new science learning. They showed an interest and desire to understand the science as a necessary step for discussing the issues, helping to support the notion that science concepts and ideas are imperative for ethics in science discussions.

Student learning was also apparent concerning the nature of science. Students were helped to make links between scientific knowledge and decisions and possible actions. They reported that science is not so black and

white and scientists are constantly weighing up issues and making decisions, and that science changes as new discoveries come to light.

Teaching time was seen to have some affect on learning – time is needed for students to understand ethics and ethics approaches, particularly when ethics in science is new to students and teachers. Multiple activities appeared to help consolidate learning.

Student learning does not happen however, without teacher input. The next section describes the teacher’s thoughts on development in planning the ethics exploration and looks at how helpful they found the ethics-in-science planner.

5.5.3 Teacher development including the ethics-in-science planner

The teachers acknowledged that the teacher development sessions and the ethics-in-science planner were needed to be able to adequately teach ethics in science. The sessions increased their understanding of ethics, sensitivity to ethical issues, and approaches to ethical reasoning and justification. As a result they felt more confident about teaching ethics in science.

5.5.3.1 Teacher development sessions

Teacher development sessions were crucial in supporting teachers to teach ethics in science. In the final interview teachers reported knowing very little, if anything, about ethical thinking before the sessions. They expressed that they found the teacher development sessions valuable and identified a significant change in their learning about ethical frameworks and ethical decision-making. They also recognised the sessions were vital for their teaching of ethics in science.

The initial difficulty teachers expressed in understanding ethics and ethical approaches and how to use an ethical approach to teach a science issue was probably due to the newness of the subject matter. Lynda stated:

When I first heard about ethics in science I had no idea what it was about, but I was keen to learn. The first teacher development meeting we had on ethics was mindboggling – a lot to take in. It felt foreign.

Amy also said “It sounded intimidating” and Anton said, “it was new to me and hard to grasp”.

All agreed the two sessions, power point explanations of ethics and ethical approaches, the example planner (Appendix 15) and example teaching ideas were “absolutely necessary” (Anton, Section 5.4.5.1). Amy (Section 5.3.5.1) reported that once she had teacher development, teaching ethics in science “didn’t seem so scary” and having the two sessions “meant I could go away from the first session and absorb it and consolidate ideas.” The second session “gave me the plan of attack of how I was going to teach it”. Lynda confirmed that two sessions were necessary saying “I couldn’t have picked it up any other way” and she also felt it “was good to come back to [in session two], to go over again and help consolidate learning”(Section 5.2.5.2). Anton commented:

I definitely needed two. In the first one I got my head in the game and in the second one I started to get it. It was good to have the break in between to mull it over and then for it to consolidate.

Lynda and Amy reported the importance of understanding what ethics in science actually was and Lynda said she “looked back at the notes a lot” while Amy commented that the power point helped her to “understand what ethics actually is”. Both Lynda and Amy said that while they were planning and teaching they adhered to the example planner ‘Should money and effort be spent understanding and saving the takahe’ (presented at the teacher development) as a guide (Sections 4.4.1; 5.2.5.1 and 5.3.5.1).

In reflection the teachers expressed being pleased with their learning through teacher development and commented that they would teach ethics again – extending it to other curriculum areas and teaching it within stand-

alone science issues (not necessarily as part of a science teaching unit). They saw ethics teaching as adding “a depth” and “richness” to the learning. Both Lynda and Anton reported science in ethics worked “particularly well in terms of developing critical thinking” (Sections 5.4.5.1 and 5.6.2) and Amy confirmed, “it extended their thinking - they started thinking more deeply” (Section 5.3.5.1).

5.5.3.2 *Teacher knowledge*

Teacher development is important for developing teacher knowledge – without which student learning may be affected. All of the teachers initially struggled with the ethics in science concepts. Lynda reported learning along with the students (Section 5.2.6). Initially she thought the learning would be “too high” for the students but she quickly changed her mind when she saw how “quickly they grasped the ideas” (Section 5.2.4.2). Amy responded by breaking the learning down into “small chunks of learning, so they could understand and follow what was happening” (Section 5.3.5.1). She acknowledged the breaking down into chunks was as much about her learning and pace of understanding as the students. Anton felt his class needed more time to develop thinking in an ethics approach, but he also acknowledged he found the “concepts were hard to grasp” (Section 5.4.5).

Amy acknowledged initial confusion in understanding stakeholders and consequences and this could be why she took more time than the others to teach them. The teachers all acknowledged difficulty in understanding ethics and ethical approaches.

Restricted teacher knowledge may affect learning, which highlights the need for further ethics-in-science teacher development and on-going teaching practice in ethics in science. This could increase pedagogical content knowledge for the teachers in this area and increase student learning.

The teachers were introduced to the Ethics-in-science planner in the teacher development sessions and they used this document for their ethics

planning. The teachers were expected to complete the planner in their own time, rather than use the material they had discussed during their collaboration in the teacher development session. The researcher wanted to give the teachers enough support so that they could plan and teach ethics in science, but not so much that they used the examples given, without much thought to planning. Also, not completing the planner during the session meant the teachers might have the freedom to change to a different ethics issue if they wished to at a later date.

5.5.3.3 The ethics-in-science planner

The teachers found the ethics-in-science planner useful for planning their ethics in science explorations. Because teaching ethics in science was so new it became a document to “cling to”. However, initially Anton and Amy felt “overwhelmed” and they expressed needing time “to get my head around it” (Sections 5.4.5.2 and 5.3.5.2). All teachers emphasised the importance of having the example planner, which they followed closely while using the ethics-in-science planner to plan their own ethics teaching.

The planner was new to the teachers in terms of format and terminology relating to the ethics. The teachers collaborated after teacher development and used the example planner to work through it. Once they understood the format and terms the teachers appreciated how it was able to “step me through the lesson sequence”; “had a structure in which I could develop my lessons” and “it had a nice, logical flow to it”. The teachers emphasised they liked the visual layout of the planner, the logical sequence, the hyperlinks (for ethical approaches and activities and strategies) and examples given with the planner (Sections 5.2.5.2, 5.3.5.2 and 5.4.5.2).

Some of the difficulty Anton initially had with the planner was in seeing some of the requirements (science curriculum links and learning intentions) as extra work – “it did not seem essential to my planning and lesson sequence”. Anton acknowledged in the interview that he didn’t really understand the requirement at the time of writing. Although he “found the

lesson planner too broken down [into boxes]” and wanted “just a lesson sequence” he also admitted needing the support and eventually suggested adding more to the planner such as example “sentence starters” to help with the terminology. He said time was a problem for him so the planner had to be easy to understand and write up. He suggested writing up the planner during the teacher development time would have been more helpful to him and put that forward as an idea for future development sessions with teachers (Section 5.4.5.2).

Difficulty teachers had with the planner related to the newness of the subject, which highlights the importance of a subject-specific planner to help them focus and structure their teaching. The initial support in terms of teacher development helped teachers become familiar with ethics understanding, ethical approaches, terminology and how to present the science issue within these approaches. Collaboration helped the teachers with their planning and it appeared to be a practical solution for ongoing support within the school. Once the teachers gained a good understanding they helped one another with how to plan and teach ethics in science.

The teachers appreciated having the ethical approaches and the related questions within the planner (hyperlinked) to refer to, particularly because it was new learning that the teachers had not come across before. They all said they would use the approaches again in science and in other areas. They also appreciated the activity and strategy ideas along with some practical examples (noisy round robin, PMI format and ‘what do you think?’ worksheet) – which they used. The activities and strategies offered have been used by other teachers teaching ethics and lend themselves to generating the discussion, deliberation and critical thinking needed in exploring ethics issues. The teachers enjoyed seeing their chosen activities (in their plans) play out in the classroom and felt the activities were a good fit for an ethics discussion in that they drew out ideas and caused students to think, analyse and discuss.

Both Amy and Lynda used the 'ethics focus questions' box for some initial science questions as they structured their lesson to flow from the science learning. Both teachers suggested a possible change on the planner. Amy suggested another box for 'science questions' while Lynda suggested changing the present title to 'focus questions' to incorporate both the ethics and science questions.

A planner is often a guide and once teachers are in action they may teach a little differently from their plan depending on the situation in the classroom. Although there were some differences between written plans and actual teaching the teachers taught quite closely to their planners. Amy said, "I followed this more closely than I did the fire unit. I clung to it. It's what got me through the lessons". As a new subject area the plan needed to be one that was well thought out and "as I was breaking it down in my head that was how the lesson planner unfolded. It made me realise what I needed to teach." The planner needed to help the teachers think through classroom interactions and to plan for explicit learning.

5.5.3.4 Summary

Teachers described teacher development sessions as crucial for teaching ethics in science. The sessions helped to develop teacher knowledge of ethics, ethical approaches and ethics issues in science. The teachers, however, still acknowledged difficulty in understanding ethics and ethical approaches during the teaching indicating the need for ongoing ethics in science teacher development and continued teaching practice in this area.

Although the teachers had some initial difficulty understanding the ethics-in-science planner, it became a document that they "clung" to, necessary for planning their ethics in science exploration. The teachers appreciated that it presented common ethical approaches and questions, gave a selection of activities and strategies to choose from and helped them link an ethical issue with science concepts and ideas. The teachers also

appreciated that the planner was formatted to help step them through classroom interactions needed for explicit learning.

5.6 CHAPTER SUMMARY

This chapter reported on the three case-studies involved in the research and presented the findings in a cross-case analysis. Each case-study was written up individually and then the cross-case analysis explored the relationships and patterns from the individual cases. The three themes that emerged from the cross-case analysis were:

- Exploring ethical perspectives in science.
- Student learning.
- Teacher development – including their use of the ethics-in-science planner.

Exploring ethical perspectives in science related to teachers' pedagogy for ethical inquiry and included how the teachers worked; for example, by incorporating the ethics into an existing science programme, using the same ethics issue, in collaboration and their choice of ethical approaches, activities and strategies.

The ethics in science programmes were embedded in science teaching units on fire and focused on examples that students could relate to. The teachers in the three case studies did this by collaborating together to teach the same ethics component – whether furniture should have chemical fire retardants applied. They linked the science learning to the ethics through ethical approaches – predominantly consequentialism. All teachers followed a common ethics teaching model where the students researched, weighed up and evaluated the issue and then made a decision by formulating an argument with justification. The teachers used a range of similar engaging activities designed to develop and enhance critical thinking.

The teachers reported students developed critical thinking. The students did this by forming and defending a view. This required weighing up

or evaluating benefits and harms for various stakeholders. The process resulted in students becoming aware of multiple perspectives on the issue, which in turn caused the students to become metacognitive - considering their own view and why they had that view.

Student learning was demonstrated by students' discussions of ethical issues within these programmes. A progression of ethical thinking was shown in both written work and discussions, where students reported an awareness of multiple views and a consideration of consequences for people other than themselves. They also demonstrated an increasing ability to support their view with scientific evidence becoming more objective and less emotive.

Students demonstrated new science learning and learning about the nature of science. They became aware that there are issues in science and that science ideas and concepts are changing as new knowledge comes to light. Teaching time was seen to have an effect on learning; time is needed to understand ethics, ethical approaches and ethical issues in science. Multiple activities helped to consolidate this learning.

The teachers acknowledged the need for teacher development for understanding ethics and ethical approaches, for ideas to teach ethics in science and to learn about the ethics-in-science planner. The use of the subject-specific planner proved an integral part of the teaching. The teachers used the planner most specifically to structure the lessons, for ethical approaches and questions, to get activity and strategy ideas and to plan classroom interactions for successful ethics teaching.

The final chapter discusses these findings and interprets them in the context of the literature research.

Chapter 6

Discussion, conclusions and recommendations

6.1 INTRODUCTION

This thesis investigated the teaching and learning of ethics in Year 5/6 primary science classrooms. Specifically, the work sought to understand whether 9-11 year old students can engage in ethical discussions in science. It also explored the support needed by primary teachers and whether it was helpful for teachers to use a subject-specific planner for teaching ethics in science.

The thesis adopts a sociocultural view of learning, that is, learning is understood to occur as learners interact with people, objects (tools), and events in the environment (Vygotsky, 1986), and the practices in which the learners participate constitute what they learn. This chapter discusses the findings from the three classroom studies, and interprets them in the context of the research literature. First, the contribution of a sociocultural view to the

current work is discussed followed by an exploration of ethical perspectives at the primary level, showing that 9-11 year olds are capable of understanding ethical approaches and language, and engaging in ethical discussions. Engagement, authenticity and argumentation were all demonstrated as enhancing learning. Teacher knowledge and development is also an important requirement for effective teaching and learning of ethics in primary science classrooms. The role of teacher support is discussed in terms of developing teacher pedagogical content knowledge (PCK), including ethical and scientific knowledge, and the ability to structure lessons appropriately and meaningfully integrate narrative strategies. The use of a subject-specific planner seemed a useful scaffold in this process. The chapter concludes with implications for teaching and learning and some recommendations for future research.

6.2 DISCUSSION OF THE FINDINGS

6.2.1 Sociocultural perspectives of teaching and learning ethics in science

A sociocultural view of learning (Vygotsky, 1986; Wertsch, 1985; 1991) is increasingly being used in education research, and seemed an appropriate lens through which to view learning in the current study. For example, Dawson (1999, 2001) notes that the literature concerning the teaching of ethics in science follows a common model that is social and collaborative. Similarly, in this research project, a collaborative approach seemed to underpin the ethics in science programmes. This collaboration occurred at multiple levels – teachers planning together, students working with students, and teachers working with students. The teachers collaborated to understand the meaning of ethics and ethical approaches, and relevant pedagogies. They also chose the same ethical issue and could support one another while learning a new subject area. Bell and Gilbert (1994) show that teachers are empowered when they initiate development themselves, working together to implement a new subject area. The students listened to others' views and made decisions based on what they had collectively researched and discussed. Also, the teachers reported that critical

thinking emerged from the ethical discussions which, according to Miri et al. (2007) and Tharp and Gallimore (1988), is a key feature of the thinking that develops out of social interaction.

Osborne and Freyberg (1985) highlight that effective teaching also needs to take into account students' prior knowledge in order to facilitate conceptual change. In this study the teachers drew on student prior knowledge, building on what the students knew about fire and flammability from the science context they had been working on prior to the ethical exploration. Some of the students explored what they knew about chemicals as they grappled with the new concept of chemical fire retardants. The question of whether or not to use chemical fire retardants was decided by the teachers as an intentional pursuit of understanding which, according to Vosniadou (2002), greatly promotes conceptual change due to the deliberate focus or nature of the learning. The problem-solving nature of the learning gave rise to metacognition and critical thinking, empowering students to think and reason (Glaser, 1993).

Also consistent with a sociocultural approach was that the learning was embedded in a real issue (the use of chemical fire retardants in furniture is being explored by scientists) and students worked in real ways to solve the problems. As Amy said, "In the end they realised there was not a right or wrong answer but they were weighing things up themselves to make a decision. They were learning to think like scientists" (Section 5.3.5.1). The use of role-play (particularly the mantle of the expert, where students put themselves into the role of the expert) added to the authenticity of the context (Lave & Wenger, 1991). The problem was thus real, relevant and embedded in a specific context (Brown et al., 1989; Hennessy et al., 1993; Lave, 1991). Some students discussed the ethics issue at home with their parents and caregivers, engaging in conversations of 'everyday science' concerning the furniture in the home and how fire-safe it was. They then reported the home views back to the class (see Section 5.2.4.4). This suggests students valued authentic learning, sharing funds of knowledge (Moll et al., 2001) from their homes and communities.

Anton and Amy suggested that future ethics issues taught to students could be of more personal relevance than the issue in this research. They also would like to explore issues that not only engage students and cause in-depth discussion, but where the students could make *real* decisions that result in action competence (e.g., they become involved in projects such as gully restoration or pest eradication) (Mogensen, 1997; Teaching and Learning Research Initiative, 2010). This could be the next step for these teachers. Learning resulting in participating and contributing within a community is one of the five key competencies in the curriculum (MoE, 2007).

6.2.2 Exploring ethical perspectives in science

The teachers incorporated the ethics exploration into an existing science programme. Levinson and Reiss (2003) and Lundmark (2002) recommend this as a way to incorporate the teaching of ethics in science in an already crowded curriculum. It also means the science can be explored in-depth, giving a solid foundation for the ethics discussion (Slingsby, 2008). The specific science learning concerning how fire retardant chemicals work was focused and engaging for students because of the motivation to understand it before a case could be argued for or against using the chemicals (Dawson, 1999, 2006; Levinson, 2003).

Consequentialism was used as the dominant approach in each classroom in this study. Similarly, Rao (1986) and Reiss (2003) concur that it is the simplest approach for deciding right or wrong and that many people use consequentialism as a single framework for approaching ethical questions. For example, Reiss (2008) found in a sample of reports written by senior secondary students that most students used consequentialism to address ethical issues. The teachers in this study said they considered consequentialism to be the easiest approach to use, but they may also have been influenced by the example of the *takahe* used in the teacher development sessions, which focused on consequentialism.

Some topics are also likely to lend themselves to a particular framework (e.g., the issue of animals being used for research might lend itself more to a 'rights and responsibilities' approach than to other approaches), and the teachers found their classes began to discuss rights and responsibilities as they considered the rights of stakeholders. Amy said she realised that if some stakeholders had rights then some must have a "responsibility to see they were carried out" (Section 5.3.2). Amy's class, in particular, explored this approach to some extent in addition to consequentialism. Reiss (2007) points out that the use of multiple approaches adds rigour to an ethical debate, which is enhanced by the particular strengths of the various approaches. Reiss (2010) also suspects that the increasing use of more than one approach could be an indicator of progression in ethical thinking.

The teachers found that initially the students did not have the language or skills needed for ethical discussion, so time was devoted to teaching concepts such as consequences and stakeholders. Slingsby (2008) and Lundmark (2002) note that (secondary) students are often led to debate ethical issues but lack not only the necessary science, but also the skills, tools and strategies necessary for ethical discussion. It seems significant that the teachers in this research found that, once explained, the concepts were easily grasped and the 9-11 year olds were able to use specific terminology such as stakeholders, consequences, harms and benefits, etc. The amount of time spent on the teaching of the concepts did not seem to make a lot of difference to the learning. Anton's students (who spent the least amount of time on 'consequences') appeared to grasp the concept as easily as the students who spent more time learning about it (see Section 5.5.2.4). It was noted, though, that time spent on ethics concepts saved time in later ethical discussions. For example, Amy's students, well-versed in consequences, were able to use their understanding to discuss an environmental issue at a later date with another teacher (see Section 5.5.1.4).

The teachers used similar activities and strategies in their ethical explorations. Most of these activities and strategies were provided as

examples during the teacher development sessions because they were engaging pedagogies known to enhance critical thinking and discussion skills and to generate ideas about an issue. For example, the teachers used the well-known PMI to collate harms and benefits of stakeholders and interesting ideas. This was used as the recording sheet during the noisy round robin strategy by two of the teachers. Both teachers were impressed with the easy generation of ideas during this activity. Frangenheim (2005) touts this activity as one of the most effective strategies for cooperative learning. This and other activities that were used, such as 'think-pair-share' based on Bloom's (1956) taxonomy, are designed to help students analyse, evaluate and create new ideas.

Heathcote's (2009) mantle of the expert was introduced as an idea by Lynda and was an effective role-play where students became 'expert' stakeholders. This was developed within a scenario that required students to research, analyse and consider others' views, and make a decision. Amy also introduced a new activity, which required the students to read others' views (collated by her from the Internet) and analyse them, determining who the stakeholder might be and why they had made their statement. This is consistent with Bell and Gilbert's (1994) finding that teacher development works best when teachers become empowered to initiate their own pedagogical development.

Small group and whole class discussions, values continua, worksheets, transactional writing, role-play and debating used by the teachers are also common activities that have been used by secondary students when exploring ethical issues (Conner, 2010; Dawson, 2010; Saunders, 2010). Commonly, secondary students are also presented with a case study that they need to analyse (Levinson, 2006). The primary teachers in this study did not do this; rather, they offered the ethics question only and then explained what chemical fire retardants were and guided students to research the issues. This was probably because the ethics discussion was part of a bigger science unit on fire. Teacher thinking was also likely to have been shaped by the teacher development. It could be that, as these teachers go on to plan further

ethical issues, they may offer an initial scenario or case study either within a science context or as a stand-alone exploration.

6.2.3 Enhancing student learning

The New Zealand science curriculum (MoE, 2007) makes explicit the nature of science as an overarching strand. Students are expected to engage in the exploration of science issues and make decisions about possible actions. The curriculum also requires students to (inter alia): “explore, with empathy, the values of others; critically analyse values and actions based on them; discuss disagreements that arise from differences in values and negotiate solutions; [and] make ethical decisions and act on them” (p. 10). This research was able to put into practise these objectives, at least to some degree, and found that primary students are able to participate in ethical deliberation and that such practises help them to understand the nature of science (Osborne et al., 2001). For example, by participating in argumentation they were engaging in the same processes and practises as scientists and became aware of how decisions can be made, and also that science is evolving and ideas can change (Bell, 2004). As one student commented, “We don’t have all the information we really need, but we’ll have more information in the future” (Section 5.4.4.1). Amy similarly reflected, “Children see how science actually works – how decisions need to be made and that science is often not 100% established. It [ethics teaching] gives an insight into the nature of science explicitly...” (Section 5.3.5.2).

The students also became aware that different people have different views. They learned not to trust one article or piece of research, *per se*, realising that different articles adopt different views. For example, one student commented, “I would like to see more research about why they say it [chemical fire retardant furniture] should be compulsory – I can’t make a definite decision” (Section 5.4.4.1). Students also became aware that they needed to understand science – becoming science literate (Black, 1993; Lehr, 2007; Zeidler & Keefer, 2003) and informed citizens (Frazer & Kornhauser, 1986; Reiss, 1999). This is because it would be important for them as people

to make decisions that involved science: “It’s good we’re learning about this because when we grow up and become adults we will know how to debate things like this and we will be able to have a say”, and “It’s about everyone’s decision – making a decision all together. It’s global” (Section 5.4.4.1).

A number of aspects that contribute to effective student learning appeared important in the work reported here. They included authentic learning, argumentation, critical thinking, metacognition and considering multiple perspectives. The teachers reported that this type of learning engaged the students. This is encouraging for the primary sector, where little science is currently taught (Crooks, 2008; Milne, 2008; NEMP, 2008). It seems significant that Macer et al. (1996) found that secondary teachers sought to teach ethics in science *because* it engaged the students with science learning. Amy commented that it was “interesting to see how engaged they were” (Section 5.3.5.2). This engagement led to learning new science concepts (how fire works and how chemical fire retardants interfere with this). Examples of student learning in science were evident in class discussion, student interviews and transactional writing (see Sections 5.2.4, 5.3.4 and 5.4.4).

As well as engaging students in science learning, the ethics in science components built on students’ argumentation experiences in that various views were presented and evaluated. Researchers such as Driver et al. (2000) and Tippett (2009) concur that argumentation is critical to learning, and to science learning in particular. Kovalainen and Kumpulainen (2005) and Mercer et al. (2004) demonstrate the power and importance of argument in the primary community. The Year 5/6 students in this exploration engaged in and enjoyed open-ended dialogue as well as being responsible for their own learning and decision-making (see Section 5.4.4.2). Students searched for information, motivated by the need to present views in discussion. The most popular activities cited by the students centred on discussion and argumentation (mantle of the expert or debating in role).

Bereiter (1992), Glaser (1993) and Hennessy (1993) suggest critical thinking emerges from a sharing of problem-centred knowledge with others in an authentic way, that is, through argumentation. The teachers in this research support the view that argumentation can result in critical thought, reporting that their students “benefited from the critical thinking developed in the discussions” (Section 5.4.5.1), “started thinking more deeply... were forced to think even more deeply” (Section 5.3.5.1), and that “this unit worked particularly well in terms of developing critical thinking” (Section 5.2.6). One student from Lynda’s class commented “the deep thinking that was included in all the activities was amazing and it made it fun to learn” (Section 5.2.4.3).

Argumentation can also lead students to become aware of, and able to express, various views (Dawson, 2006; Levinson & Reiss, 2003). The students in this study learned about their own views and the need to substantiate them. They also became aware of others’ views (Section 5.3.4.2) and experienced role-playing people with views different from their own. Students acknowledged learning about others’ views made them “question my own judgement” and a number of students changed their view after having learned about alternative views (Section 5.5.2.6). The awareness of their own and others’ views led to metacognition, where students considered why they thought what they thought. As one student commented, “I learned to listen and thought about others’ views. I thought about my view and why I believed it” (Section 5.2.4.2) and Amy said, “...this kind of teaching makes them [students] think about their thinking. They have to think ‘why should my opinion be more important than others?’” (Section 5.3.5.1). The understanding of others’ views is an important step in becoming more tolerant of others, which Zeidler et al. (2005) claim is a key to cultural understanding. Importantly, some students expressed delight in being able to have an opinion of their own while retaining friendships with those of different views. If young students can develop this capacity at the primary level, tolerance and understanding may become a part of their value system.

Ethics in science learning may also result in a progression of ethical thinking and moral development (Kohlberg, 1980; Rich & De Vitis, 1985; Turiel, 1996). In addition, students who are educated within the sphere of sociocultural issues (SSI) can have their morality developed to achieve a 'functional' level of scientific literacy (Zeidler & Keefer, 2003; Zeidler et al., 2005). Such programmes teach students to consider both sides of an argument and to use scientific facts to support their statements. The students involved in this project showed a progression of thinking that reflected Reiss's (2010) indicators of progression in ethical reasoning. For example, some of Amy's students demonstrated a shift from egocentric thinking (how will this affect me?) to thinking about how others will be affected. One student confessed that initially she could only "see one side of the story", but after the exploration she could see other sides and "changed my opinion because of the information we got" (Section 5.2.4.1). Other students demonstrated a shift from emotional persuasion and the use of emotive language to using scientific evidence by drawing on scientific knowledge they had been taught or had researched themselves (Section 5.5.2.1). Two classes also moved from using one ethical approach (talking about consequences) to considering multiple frameworks – mostly rights and responsibilities, but also aspects of autonomy.

6.2.4 Teacher knowledge and development

To teach any new curriculum area, teachers need teacher development (Bell & Gilbert, 1994; Bell & Baker, 1997; Jones & Compton, 1998) and teacher development can help them develop PCK in the new area (Jones & Moreland, 2006; Moreland, Cowie, Jones, & Otrell-Cass, 2008). The teachers in this study acknowledged being dependent on teacher development to learn about ethics, ethical approaches and teaching ethics in a science context. This is consistent with others (e.g., Conner, 2000; Jones et al., 2007; Lundmark, 2002; Saunders, 2009; Slingsby, 2008) who have shown that teachers specifically need teacher development to understand ethics and ethical approaches and to explore teaching strategies and pedagogies for teaching ethics in science. Forbes and Davis (2008) found that when pre-

service elementary (primary) teachers were given teacher development in the area of SSI, they were able to develop subject-specific knowledge for teaching (PCK). They improved their own subject-matter knowledge and reasoning skills about ethics in science while becoming skilled at adapting issues-based science curriculum materials for student learning. Similarly, the teachers in this research also improved their subject-specific knowledge for teaching ethics in science; they were able to understand the nature of science objectives in the curriculum, and adapt materials, activities and strategies for teaching.

Initially the teachers found the new area of ethics in science “intimidating” (Section 5.3.5) and “hard to grasp” (Section 5.4.5). Teacher development was considered “absolutely necessary” (Section 5.5.3.1) by the teachers to understand ethics and how to teach it. Lynda emphasised, “I couldn’t have picked it up any other way” (Section 5.2.5.2). The teachers also felt they needed the two teacher development sessions with time between them, allowing them to think about and consolidate ideas. This is consistent with Bell and Baker’s (1997) report that it takes time for teachers to grasp new ideas and make them classroom practice.

Some of the important aspects of PCK involved subject-specific knowledge (Magnusson, Krajcik, & Borko, 1999) of science and ethics, opportunities for scaffolding, and the use of narrative strategies. The teachers initially learned about ethics and ethical approaches through videos (see Section 4.1.4), but the ethics learning they mostly talked about was the example of the takahe unit. For example, both Lynda and Amy said they adhered to the takahe planner as a guide for their own planning and teaching (see Sections 5.2.5.1; 5.3.5.1). Teachers, like students, need scaffolding with use of examples (Atwill, 2004) until the subject matter becomes internalised, at which point support ‘fades’ (Hennessy, 1993).

The importance of the science knowledge became more apparent to the teachers once the teaching began. All the teachers had taught about fire and they were confident students had a reasonable knowledge concerning

the chemistry of fire. However, it quickly became clear that students needed to understand the chemical processes used by chemical fire retardants, and the teachers realised they needed to understand this themselves in order to be able to teach it. The teachers said they were learning as they went. Wine et al. (2005) found that lack of science knowledge in primary teachers meant that they struggled with PCK during the teaching. However, Moreland, Cowie, Jones and Otrell-Cass (2008) show primary teachers can reflect on their practise to consider and improve PCK. The commitment and initiative of the teachers in this study was reflected in their students' learning outcomes.

Researchers agree that students need multiple forms of support for learning (Roth et al., 1999; Tabak, 2004; Wine et al., 2005). How the teachers provide support (scaffolding) relates to their PCK (Wine et al., 2005). Asoko (2002) and Wine et al. stress that the teachers' role is crucial because they choose the context, questions and activities to stimulate thinking and discussion, and they provide the scaffolds for learning. During the teacher development sessions, the teachers' role was identified as including choosing activities suitable for exploring ethics in science, managing the possible sensitivities of discussions, asking open-ended questions and constructing appropriate scaffolding. It appeared that the more the ethics in science lessons were scaffolded, the better the outcomes for the students. For example, Lynda provided nine different experiences including class, group and pair discussion, mantle of the expert role-play, worksheets, and transactional writing (Section 5.2). These activities built on each other and required discussion, thinking, analysing, evaluating and decision-making. The students were also able to express their ideas in written form, which formed a useful summative assessment activity. Lynda chose activities that would stimulate critical thinking and give rise to argumentation, encouraging the learners to learn for themselves (Hennessy, 1993). The different activities also gave students opportunities to consolidate their learning in a number of ways. As a result, student learning improved from lesson to lesson (see Sections 5.2, 5.3, 5.4 and 5.5.2). Amy and Anton also scaffolded their lessons based on the teacher development and used activities conducive to ethical discussion. A number of these activities were narrative based.

Barker (2001), de Luca (2010), Girod et al. (2003), Hipkins (2004), Levinson (2008), Pellegrino (1999) and Solomon (2002) all consider narrative pedagogy a powerful tool for drawing students into meaningful ethics in science learning. Splitter and Sharp (1995) go further, placing narrative at the heart of inquiry for students. This is firstly because students enjoy narratives and are motivated to think, especially if the stories focus on issues that are contestable while remaining connected to the students' own experiences. Secondly, narratives become the vehicle students can use for discussion and inquiry. Students identify with the characters in the story who may be scientists and/or stakeholders involved with an issue and they may role-play these characters in a 'meeting', learning how to think critically, analyse, evaluate and make a decision using the same thinking processes that the adults in the real world would use. Examples in this study included the mantle of the expert activity, where students in Lynda's classroom became experts who met to decide whether the new movie theatre should have fire retardant seating, and the stakeholder meeting with the 'Prime Minister' in Amy's and Anton's rooms where students in role discussed introducing a regulation controlling whether chemical fire retardants should be used in furniture. Through these narratives, teachers were able to teach students how decisions might be made.

Other aspects of teacher PCK included developing and managing a framework for teaching ethics in science, incorporating open-ended questions to stimulate thinking and discussion, and managing activities to facilitate argumentation and meet the needs of the students. The teachers in this research followed an example framework (the takahe unit) for their ethics exploration in a general sense. Specific management of classroom discussions and other activities were not addressed in detail. It takes time to cover all the teacher learning needed for teaching ethics in science, and Bell and Gilbert (1994) and Tippet (2009) suggest that management of frameworks be achieved through ongoing teacher development and experience. Primary teachers are often skilled in pedagogical knowledge generally (Cowie, Moreland, et al., 2008) and can transfer this knowledge to teaching ethics in science. For example, Lynda demonstrated her extensive

classroom experience through her choice of activities and her timing of discussions to reflect the needs and abilities of her students. Questioning techniques and creating a community of inquiry can be learned (Sharp, 1987; Splitter & Sharp, 1995) and could be incorporated in future teacher development (see Section 6.4).

In summary, the teacher development resulted in: enhanced teacher knowledge about ethics in science including the nature of science, specific ethics knowledge, new pedagogical approaches, enhanced teacher-student interactions, improved teacher confidence, and enhanced student learning. Teachers were able to talk about ethics, ethical approaches and, by the end of the exploration, could explain some of the science involved in fire retardants and the use of specific chemicals as fire retardants. Through teacher development, collaboration and by drawing on general pedagogical knowledge, the teachers were able to provide appropriate scaffolding for student learning. One significant aspect of this was the adoption of narrative strategies that stimulated students to think, analyse, evaluate and become involved in discussion. The teachers also considered the ethics-in-science planner to be a helpful tool for teaching ethics in science, and one that enhanced their classroom practice.

6.2.5 The ethics-in-science planner

The teachers found the ethics-in-science planner not only helpful, but “crucial” for implementing the teaching of ethics in science. All three said they would use it again to teach ethics in science, and in other curriculum areas.

Forbes and Davis (2008) indicate that materials for exploring SSI, particularly in the primary classroom, are limited. The current research specifically developed and trialled such a resource, demonstrating the usefulness of a subject-specific planner for planning and implementing ethics in a primary science classroom. Roth et al. (1999) defines a planning tool as a resource for individual or collaborative reflection, analysis, and interaction. It

enables teachers to focus on analysing their own and their students' understandings, as demonstrated in this thesis. Specifically, teachers need planning frameworks to help them change content knowledge into a form that is learnable for students. Moreland, Cowie and Jones (2008) indicated that such frameworks impact greatly on science and technology teaching, especially in the primary school where teachers are not so familiar with these subjects (Jones & Compton, 1998; Wine et al., 2005). The ethics-in-science planner is based on INSiTE project planners (Moreland, Cowie, Jones, & Otrrel-Cass, 2008), which were shown to be effective at enhancing PCK by forcing teachers to focus on classroom interactions (see Section 2.5.6). Similarly, in this research, Amy reported the ethics questions helped her retain specific foci for each lesson. The planner also encouraged teachers to unpick the lessons so that they became aware of every step they needed to teach, and the interconnectedness of each task. For example, Amy realised that "as I was breaking it down in my head that was how the lesson planner unfolded. It made me realise what I needed to teach...I started juggling things around and realised what I needed to teach before I could do the debate. I would have floundered if it hadn't been broken down". Lynda commented that the planner helped her understand what she was going to teach and added, "it had a nice logical flow to it".

The headings in the ethic-in-science planner helped the teachers keep categories clear and coherent, while seeing their interconnectedness (Moreland, Cowie, Jones, & Otrrel-Cass, 2008). The 'science curriculum' link gave the teachers the opportunity to include the nature of science emphasis. Both Lynda and Amy did this and both referred explicitly to the nature of science in their teaching, such as "Now you're thinking like scientists; this is the nature of science" (referring to the use of scientific evidence to support an ethical argument). The 'ethics question' is important because the students (and teacher) need a clear understanding of what is being asked. This proved to be somewhat confusing at first for the teachers as they struggled to understand fire retardants (e.g., chemical versus natural). This is consistent with Wine et al.'s (2005) finding that primary teachers may struggle with science concepts. Including the 'relevant science knowledge' helped teachers

realise what would need to be researched and explored by the students. The teachers appreciated having the 'ethical approaches and questions' "up front" (accessed through a hyperlink), particularly since it was new and unfamiliar. It was also important to the teachers to have a range of 'activities and strategies' provided as examples. Some of them tried activities and strategies new to them and were impressed with the way an activity or strategy could generate ideas from students quickly and easily. Importantly, the teachers were not limited by the suggestions and some added ideas of their own.

In summary, the ethics-in-science planner developed in this project appears to have the potential to help teachers structure the teaching of ethics in science. Specifically, using the planner provided support for teachers' own learning and PCK development, leading to meaningful classroom interactions and enhanced student learning of ethics in science. For ease of use the teachers appreciated that it is an electronic tool.

6.3 RESEARCH CONCLUSIONS

This project sought to answer two questions: whether Year 5/6 students can engage in explorations of ethics in science and whether a subject specific planner can help primary teachers teach ethics in science. Firstly, the research found that Year 5/6 students can engage in ethics in science, and that they can do so willingly and enthusiastically. However, for primary students to engage successfully in ethics in science, teachers are likely to need support in planning and teaching. For example, the teachers in this study reported not knowing what ethics in science was about before the teacher development programme. They had little or no knowledge about ethics and ethical approaches, and during the teaching they also struggled with science concepts.

The teachers acknowledged they needed support. This was provided through two teacher development sessions where teachers were introduced to concepts in ethics and ethical approaches. They looked at and discussed ethics in science examples. A tangible teaching example (the takahe unit) was

used to introduce teachers step-by-step to a possible programme for teaching ethics in science. Teachers were introduced to activities and strategies that could be employed, and explored how these could be used to stimulate critical thinking and discussion. Finally, the teachers were introduced to the subject-specific planner.

The ethics-in-science planner was pivotal to the teaching. The teachers collaborated together and used the example planner to write their own plans. Two of the teachers reported being dependent on the plan to be able to teach ethics in science. The other teacher reported experiencing some difficulty in writing the plan, but later said he needed it to understand the ethical approaches and to access examples of ethics questions. Specifically, the planner helped the teachers focus on what they needed to teach. They came to realise the interconnectedness of the defined areas in the plan. They became aware of necessary interactions, and the steps they needed to take for critical thinking to take place. The planner also provided helpful suggestions for activities and strategies and stimulated teachers to think of others.

The planner includes many of the components teachers need to consider when teaching ethics in science: science curriculum links, the ethics question, and relevant science knowledge. Examples of ethical approaches are provided, with some questions appropriate to those approaches. Examples of activities and strategies are offered. The planner is designed to enable teachers to work out a step-by-step approach for activities and planned interactions along with resources and learning intentions.

The teachers reported that, because teaching ethics in science was so new and the planning format different from what they had seen before, they still needed the example planner, notes from the teacher development sessions, and collaboration to help them interpret and write up their plan using the ethics-in-science planner. With time teachers will develop the subject-specific knowledge they need to be able to scaffold their own ethics in science explorations.

Enhanced PCK was demonstrated through increased teacher knowledge of ethics in science, including the nature of science; specific ethics knowledge; new pedagogical approaches; teacher-student interactions; improved teacher confidence, and effective student learning. It is difficult to discern how much the ethics-in-science planner specifically contributed to teacher's PCK development, but this research supports findings from the InSiTE project (Cowie, Moreland, et al., 2008) that a subject-specific planning tool is an effective means for developing teachers' PCK. For example, the teachers reported that the ethics-in-science planner helped them break down the lessons into steps and to focus on specific concepts in their teaching. Through this process, teachers became more aware of the ethics issue, what relevant science needed to be taught, and what classroom interactions were necessary for discussions and critical thinking to progress.

Finally, it seems that the teaching of ethics in science can engage teachers and consequently students in science learning. Here, teaching engaged both teachers and students, strengthening the actual teaching and learning of science. This is consonant with Levinson's (2003) argument that science engagement is enhanced when it occurs within an ethical context. During the course of the lessons, the teachers realised the need to understand the relevant science and appreciated the importance of the science to the ethics question in their planner. The students were also keen to research and understand how chemical fire retardants interfered with fire so that they could form and substantiate their arguments.

6.4 IMPLICATIONS FOR TEACHING AND LEARNING

The inclusion of ethics into science classroom programmes has potential, as shown in this thesis, to enhance teachers' and students' ethical awareness; science engagement; science literacy; and critical thinking, argumentation and decision-making skills for all areas of learning, and the sheer joy of learning. However, this requires students to develop argumentation skills, the ability to differentiate between science and non-scientific issues, and to recognise reliable evidence and data (Tippet, 2009;

Zeidler & Sadler, 2008). Consequently, there is a need for effective planning by teachers. The ethics-in-science planner, proved to be useful to the teachers in the study, demonstrating that such a planner can be used to provide a supportive pathway for teachers and help them develop PCK for teaching ethics in science. However, teachers should not be limited by activity suggestions in the planner, but actively seek out the types of strategies and activities such as those described in Section 2.7.3. Many of the strategies and activities in the ethics-in-science planner are narrative based. Most of these strategies are designed to generate creative ideas and develop higher-level thinking. Levinson (2008) believes the use of personal narrative in ethics in science is indispensable. It helps students see others' perspectives. (Stories help students select, create and engage with science so that they understand the nature of the science *and* science content (Barker, 2001)).

Assessment of ethics in science has not been focused on in this work, but teachers should be aware that with ethics in science teaching there is not necessarily a 'right' or 'wrong' response (Reiss, 2007); the emphasis should rather be on students learning the skills of engaging in argumentation and making informed decisions. The curriculum includes ethics in science to give students the opportunity to develop skills in argumentation, critical thinking, and informed decision-making, therefore the focus of assessment should be on whether students can demonstrate these skills (Conner, 2004). It could be that assessment is considered formatively and/or summatively by, for example, evaluating argumentation skills using supporting evidence (Slingsby, 2008), or examining issues from multiple perspectives rather than teachers providing questions with fixed answers. Conner also favours open-ended questions that "allow students opportunities to demonstrate analysis, synthesis, evaluation and critical awareness of the ambiguous and contextual nature of the issues" (p. 45). Teachers in Conner's study also found peer-assessment and peer-feedback very useful. Lynda, in this research, used self-assessment along with transactional writing to summatively evaluate her students (see Section 5.2.3.3).

The project also has implications for providers of teacher development. For ethics in science to be successfully introduced into primary classrooms there needs to be on-going teacher development, where teachers are introduced to the language of ethical thinking and ethics in science teaching, and where teachers' PCK is developed to the point of enculturation (Atwill, 2004; Ball & McDiarmid, 1990; Tishman, Jay & Perkins, 1992). Teacher development therefore needs to go beyond specific development sessions. Teachers need support and encouragement over a period of time while they learn how to teach ethics in science in a number of different science contexts. Teacher development works best when teachers can collaborate and take responsibility for their own learning (Bell & Gilbert, 1994), so it would seem to be beneficial to include groups of teachers in development sessions, including some within the same school. One of the teachers in this project specifically expressed a desire for planning together during teacher development sessions (see Section 5.5.3.3) and it may be helpful for teachers to plan an ethics in science exploration in a development session, particularly when teachers are initially introduced to teaching ethics in science. The project also provided evidence that the teachers were under considerable demands concerning their time. For change to occur, teacher development needs to provide adequate time, support and resources.

Providers of teacher development could explore effective tools for teaching. The ethics-in-science planner could be used by a larger sample of teachers, examined for effectiveness and refined. Other models or planners could be used and new ones developed specifically for primary teachers. More examples (or exemplars) (Atwill, 2004) of ethics in science lessons in primary schools could be recorded to broaden the scope for teachers of what can be taught to primary students and how they are achieved.

Finally, the project has implications for the Ministry of Education in New Zealand. The Ministry of Education is committed to scientific literacy by virtue of the aims given for studying science in the science curriculum (MoE, 2007), which includes the aim that 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 sustainability of the environment” (p. 28), and by the inclusion of the overarching, unifying strand of the nature of science, where ethics in science is made explicit. There needs to be consideration as to how the Ministry might implement this – it may be teacher development on a large scale that would include primary teachers. Such a project would necessitate adequate time and support, teacher development, resources and funding, as discussed above.

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

There is a paucity of research into the teaching of ethics in science in primary schools (Buntting & Ryan, 2010). This research adds insights into young students’ willingness to engage in ethical discussion, and ways that teachers might be supported to pursue this, including through detailed programme planning. However, the limited number of participating primary teachers suggests findings cannot be too specific or conclusive (Shulman, 1997). Rather, they should be included in the general body of research (concerning ethics in science in primary teaching) and viewed comparatively. In addition, the study was not experimental in nature and teachers were not selected randomly. Instead it was exploratory and descriptive, seeking to uncover learners’ (both students and teachers) experiences and to contextualise the findings in the particular setting in which it was conducted.

More research is therefore needed to support a greater number of teachers as they include ethics in their science classroom programmes. This includes research into students’ learning and progression, for example, an analysis of students’ argumentation skills (including analysing, evaluating, and providing evidence), as well as their decision-making skills and openness to others’ views as a result of ethics learning. Research is also needed that considers effective pedagogies in the teaching of ethics in science in the primary classroom. Models, tools, planners, strategies, activities, questioning techniques and classroom management for teaching ethics in science could all be taken into account.

A particular aspect of pedagogy that should be explored concerns the facilitation of classroom discussions in teaching ethics in the primary science classroom. A large part of an ethics programme incorporates discussion and the teacher is needed to keep students focused and to maintain the direction of the discussion. In addition, teachers need assistance with teaching students explicit skills for engaging in scientific argument (Tippet, 2009). For this, notions of trust, care and respect need to be explored (Sharp, 1985), as do the teachers' views of their own role. Some researchers (e.g., Levinson & Reiss, 2003) suggest teachers remain impartial, while others (e.g., Wellington, 1986; 2004) suggest such teachers should be free to share their views or play the devil's advocate. Some of these issues need exploring in the primary context to help give teachers direction for fostering effective communities of learning in the exploration of ethics in science.

Teachers also need to help students develop skills in research (including finding reputable sources of information), creating communities of inquiry (Sharp, 1987). In addition, Tippet (2009) and Zeidler and Sadler (2008) believe it is imperative that science teachers and educators establish learning environments conducive to the safe expression and exploration of ideas. Classroom environments should be created that not only value scientific inquiry but also genuinely value critical discussion associated with ethical issues in science. Effective teacher development, and particularly ways to enhance teacher PCK, should therefore be considered in future research.

6.6 FINAL COMMENTS

Finally, this work supports the notion that young students can engage in ethical discussions in science. It concludes that primary teachers need support for teaching ethics in science, and that structured, subject-specific tools such as the ethics-in-science planner are helpful. It is intended that the planner will be published on the Science Learning Hub (www.sciencelearn.org.nz) and/or the Biotechnology Learning Hub (www.biotechlearn.org.nz), where existing content offers opportunities to

explore ethical issues. The planner can then be supported with other resources, such as ideas for facilitating classroom discussions and teaching ethics, already published on the sites. The work is therefore ongoing.

Social and ethical issues are essential for the epistemological development of young students, who need to engage in ethical thinking where science concepts can be connected to students' values, sense of ethics and moral reasoning. This paves the way for developing informed, scientifically literate citizens, conversant with ethical issues in science. It is imperative teachers are supported to achieve this end.

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Science unit: Takahe: An endangered species
Lesson planner for Teaching and Learning

Teacher: Barbara Ryan

Macro Task: To research and describe how the takahe has become endangered				
Meso Task: To understand what it means to be endangered				
	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
<p>Micro Task 1: Role-play how creatures become endangered. Small groups could be briefed quickly before hand of their task – with minimal input as to what is actually happening.</p>	<p>Headbands or labels to define the creatures. Have a defined space for the gozoos 'Food' - blocks, books and objects for the gozoos to 'eat'.</p>	<p>Make several children "gozoos", (imaginary animals). Put labels or head bands on them and send them into a specific place in the room; it becomes their 'environment'. They 'eat' blocks, books etc (supply them every so often so that the gozoos needs and the supply are balanced). Make a list of criteria for them to live on the board with the rest of the class (particular food and environment or place in the room e.g. under desks) Introduce some 'heppers'. They also eat blocks etc and move into the 'gozoos' living space (blocks are depleted at a faster rate). Then introduce some other creatures e.g., 'cootts' – that eat gozoos. What happens to the food supply when the 'heppers' are introduced? How are the gozoos faring with the introduction of the cootts? What happens to the gozoos when all the food is gone? Children act out scenario, teacher stopping ('freeze') every now and then to ask questions.</p>	<p>Children will be able to understand and discuss how a species can be gradually killed off by the introduction of other species.</p>	<p>Worthwhile introduction. Children enjoyed drama and interesting discussions followed leading to the meaning of endangered.</p>

Meso Task: To understand that the takahe is an endangered species				
	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
Micro Task 3: Uncovering the jigsaw	Poster of the takahe that is covered over with jigsaw pieces of blank paper. Use blutac to attach to poster.	Ask the children to guess what is under the paper. Take one piece of the puzzle off at a time and discuss what is under it (e.g., an orange beak, does it look hard? Strong? What might it be used for?). Work through the puzzle until the takahe is revealed. Why might I have put this bird up here?	That the children will have a good slow look at the takahe while trying to guess what it is. They will understand that this bird is an endangered species.	Created excellent discussions. Many students were able to work out the bird based on its habitat and a series of questions (mine), logic and prior knowledge (students').
Extra Tasks: Book work Title page Mind map of endangered birds in NZ.	Work books	<ol style="list-style-type: none"> 1. Make a title page in books "The Takahe" 2. Make a mind map with endangered in the middle. Write down the names of as many endangered NZ birds from it that you can think of. (could be finished off as a homework task) 	<p>Beginning of an organised record of research done.</p> <p>Children will understand that the takahe is one of many birds of concern in this country.</p>	

Meso Task: To make observations and to research how the takahe became endangered				
	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
<p>Micro Task 4: Taking a scientific look at the takahe: What does it look like and what does it do?</p>	<p>Book: Nature kids: Takahe by Jenny Jones</p> <p>Pictures/photocopies/posters of the takahe</p> <p>Drawing paper and recording books, sketching pencils</p> <p>CD of Bird Calls of NZ</p> <p>Tussock grasses and tillers</p> <p>Recording books A3 paper and pastels for a vocabulary list of new words.</p>	<p>Read Takahe – Jenny Jones</p> <p>1. Who, what, where? How do you think it became flightless?</p> <p>2. Takahe Facts – short spelling game to learn scientific name.</p> <p>3. Good Looks – children then look at other takahe pictures, including photocopies that they can study close up. Discuss beak and detail on the beak, thick and heavy legs, stubby tail, soft, fluffy feathers on the wings, eyes etc In books children make a pencil drawing (or several) of the takahe. One of their drawings should be labelled in a scientific manner. (*this activity could lead into paintings and /or collage work on the takahe)</p> <p>4. Sounds – play the takahe sound from CD “Bird Calls of NZ”</p> <p>5. Dinnertime – show the chn some tussock grass and the tiller part of it. Head up Food in books Draw and label all the food a takahe might eat.</p> <p>6. Behaviours</p> <p>7. Breeding</p> <p>8. Eggs</p> <p>9. Hatching</p> <p>10. Young Ones In books draw the nest. Describe why they choose a nest like this.</p>	<p>Children will understand from discussion that in the early days the takahe had almost no enemies and the ones that they did have (gulls, falcons) they could hide from in tussock on the ground; hence the adaptation to a rail and a flightless bird. Children will observe soft, fluffy wings (as opposed to strong flight feathers of other birds). Children will be able to use the takahe’s scientific name, <i>Porphyrio</i>. (<i>Porphyrio mantelli</i> for the North Island and <i>Porphyrio hochstetteri</i> for the South Island). Children will learn about observation in scientific drawings while drawing and labelling the takahe. Through drawing they will become familiar with the features of the takahe and be able to link those to its habitat and way of life. Children will be introduced to the call of the takahe</p>	<p>Stressed the idea of scientific drawing as opposed to art.</p> <p>Discussed labelling.</p> <p>While some students wrote just the words I had suggested, some wrote more as they came across them and a few students wrote up detailed meanings beside the words.</p>

		As the story is being read and discussed write up and keep adding on A3 paper new words e.g., purple swamp hen, habitat, grasslands, porphyrio (practise the pronunciation), rails , Walter Mantelli, von Hochstetter, pukeko, diurnal , tussock grasses, tillers, clutch, incubation, imprinting , egg tooth. Children could record these words in their books (Spend more time on bold words- keep referring back to make them familiar – homework might be to learn these words and be able to use them in a sentence.	Children will know what the takahe eat. Children will appreciate how and where the takahe nest and why their environment is important for this (in that it suits their physical features).	
Micro Task 5: Exploring the history of the takahe.	<p>Person to play Dr Orbell</p> <p>Book: Nature kids 'Takahe' by Jenny Jones Takahe Fact Sheet (not including time line) for each person from http://www.kcc.org.nz/birds/takahe.asp Map of NZ showing Murchison area and Lake Orbell</p> <p>A large copy of takahe time line until early 1970's – rewritten to be viewed by whole class.</p>	<p>Have one of the children (or someone else) knock on the door dressed as Dr Orbell might have been. In role-play he introduces himself to the class and talks about his incredible find. Discuss the issues with him so that the class is clear about who he is and what he did.</p> <p>Read Takahe 1.Takahe: Lost and Found Give out 'The Takahe' fact sheet from Kiwi Conservation club Reciprocal reading with whole class for page 1. Show the Murchison mountains on a map of NZ. Add Dr Geoffrey Orbell to the new word list Glue in first two and half pages. Children can independently read 'Stuff about the takahe' and 'What does a takahe do all day'</p> <p>Put up time line and read through together as a class to early 1970's. Why might the</p>	<p>Children will learn about Dr Orbell and how he rediscovered the takahe (1948) after everyone thought it to be extinct.</p> <p>Children will know the area and type of terrain in NZ where the takahe had been surviving.</p> <p>Reinforcing the learning about takahe.</p> <p>Children will be able to sequence the events of the decline of the takahe.</p> <p>Children will understand the impact of the introduction of the red deer.</p>	<p>Drama aspect successful. Students often referred to it later. Most students remembered Dr Orbell, but forgot other people referred to.</p> <p>A lot of reading for some students.</p> <p>Probably would break it up more with other activities or have questions for them to answer from the reading to give them a particular focus.</p>

	Handout: Takahe – Oh Deer.	red deer be mentioned here? Hand out: Takahe – Oh Deer! Children can silent read independently or those who would like to can do reciprocal		
	Headband labels for people and animals – Maori, settlers (releasing exotic animals), takahe, deer, rats, stoats, ferrets	reading as a group. Class discussion at the end – discussing the answers to the questions. Children look for the answers to the questions. (Oral discussion) Glue into books. Role-play quickly with small group to the class as an audience how the takahe became extinct according to this time line. (will need stoats, weka, ferrets, rats, deer etc) line into their books.	Children will be able to link the introduction of exotic animals to the near extinction of the takahe	Made this more of a ‘photograph’ or still to avoid rowdy behaviour. Students were placed in the ‘photo’ as we discussed what was happening.

Meso Task: To research and find out what is being done to re-establish the takahe in NZ.

	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections
Micro Task 6: Exploring the early steps to save the takahe.	Book: Nature kids: Takahe by Jenny Jones Map of NZ	Read from the book ; Takahe Saving the takahe Why did Elwyn use hand puppets to feed the chicks? Discuss imprinting Show Mt Bruce on the map – compare to where the birds came from! (Murchison)	Children will be introduced to Elwyn Welch and his work on the farm at Mt Bruce.	Students enjoyed the bantam in the boxes story. They learned the science ideas about imprinting through the stories about raising takahe chicks.
Micro Task 7: Exploring what is happening now to save the takahe.	Wild South video: Project Takahe (Teacher background readings - NZ Birds Takahe by Jenny Jones and rest of the	Watch video (30mins) Have written up on paper 1.Murchison mountains and surrounding area (see Takahe map - kcc) 2. Mt Bruce wildlife centre 3. Te Anau wildlife centre	Children will have an appreciation of what scientists and concerned people are doing to save the takahe today.	Video an excellent reflection/consolidation on work covered. Students interested in

	<p>time line from website reference). Map of NZ. Takahe map from Kiwi Conservation Club Refer to Jenny Jones book (Nature kids Takahe) page 21 for Mt Bruce and page 24 for</p>	<p>4. Burwood Bush Captive Rearing Unit. (read together DOC's takahe breeding programme) 5. Off shore islands (read Takahe today p24) - Tiritiri Matangi - Maud - Mana - Kapiti Briefly discuss each one using resources and</p>	<p>Children will have an understanding of predator-free islands.</p>	<p>Tiritiri – general keenness to ask parents to take them.</p>
	<p>Takahe Today. DOC's takahe breeding programme – page 2 of Takahe – Oh Deer (already glued into books).</p> <p>Cut up copies of timeline for each child (in plastic bags) – including 2 x DOC numbers of birds.</p> <p>Tiritiri Matangi photos – on computer. Book 'Greg the Naughty Takahe' Tiritiri Matangi brochure. Red Beach website Tiritiri website</p>	<p>map.</p> <p>Each person is given cut up time lines. Children work in groups of about 4 discussing what dates would match what events. Children glue their own time line into their books.</p> <p>Included in the timeline bags is a handout of DOC numbers of takahe in 1999/2000 and 2004/2005. Glue into books at the end of the timeline.</p> <p>Compare and discuss as a class. Questions to be asked</p> <p>What do we need to know about the takahe to help it survive? How have people used their knowledge of it to help the takahe?</p> <p>Discuss the future of the takahe. What can we do? What is happening at Mangatautari?</p> <p>Talk about personal experiences on Tiritiri Matangi. Show photos (compare takahe with pukeko in photo). Read 'Greg, The Naughty Takahe' Share personal encounters with Greg. Encourage children to ask their families if they can visit Tiritiri Matangi in the holidays. Show brochure and island map.</p>	<p>Through discussion and previous learning children will show an understanding of the history of the takahe and of the programmes in place to help them. Children will appreciate we need to know about its food, habitat, behaviour, breeding habits, enemies etc Children will be able to link the needs of the takahe to helping it survive by providing environments to cater to these things – eliminating enemies and harmful effects (deer especially). A predator free environment. Children will link takahe to Mangatautari studies. Children will appreciate my enthusiasm and personal encounter with the birds.</p>	<p>Too complicated for most students in this age group. Concept great, but task too long with too many dates (12) and events to sequence. Dates and events were lost and some students were frustrated. Simplified task to 6 items for subsequent classes.</p>

<p>Micro Task 8: Consolidating and sharing the learning – presentations of learning in groups.</p>	<p>Variety of music CDs. Poster paper and poster paint/pens. Possible dress up items</p>	<p>Children work in groups of their choice to produce and present an item on saving the takahe. The item may take the form of a dance, drama, rap or poster. Children can use display books to help them.</p>	<p>Children will use the observations they have made and link ideas to show reasons for its becoming endangered and possible solutions for the saving of the takahe.</p>	<p>Most children chose posters. Children in plays covered all main points expressively. Dances interestingly portrayed using takahe movement and behaviour.</p>
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<p>Micro Task 9: Ethical thinking: Class discussion and Noisy Round Robin for PMI</p> <p>Debating the issues of saving the takahe. (whole class/groups)</p>	<p>Large sheet of paper and pens</p> <ul style="list-style-type: none"> - To make a list of who/what is involved. - To make a list of consequences for them (have a column for the harm or /& benefit) <p><u>Noisy Round Robin</u> A4 sheets headed up with who and what is involved in saving of takahe. Then have 2 columns one for benefits (plus) and one for harm (negative) (PMI)</p>	<p>Why are we saving the takahe? Making a list of consequences (class in sharing circle – large paper headed up in the middle)</p> <p>What are the consequences – to the birds? (gradually increasing in numbers) The deer? (they are being culled out of that area) Stoats and other animals that ate takahe eggs? (hunted and killed by people) Scientists? DOC? People? (jobs, new ideas, excitement/joy) The environment? (better care – development of the islands)</p> <p>What are the benefits (good things) about saving the takahe? (saving some of NZ’s uniqueness, brings tourists)</p> <p>What are the problems? (costs) Does it harm anyone? (exotic animals). This can be done through a noisy round robin using small groups to get ideas. As a class add these ideas to the master list.</p> <p>Do the takahe have a right to live? What about natural consequences? Have we interfered in the natural process?</p> <p>Does saving the takahe cause people to become better people? Why? In what way?</p>	<p>Children will appreciate that there are consequences for everyone/creature involved in the saving project. Consequences may benefit or harm others. Children should think about the rights of those involved. They should also think about whether the proposed course of action (saving the takahe) might cause people to become better people (more virtuous) (Michael Reiss ‘Principles of bioethics’).</p> <p>Survival of the fittest argument. But then we introduced animals after the takahe had adapted to</p>	<p>Children enjoyed discussion. Some clearer about issues involved than others. Children covered all ideas listed.</p> <p>Probably the noisy round robin wasn’t necessary. It was really covered previously and children were trying to come up with ‘more’ things that weren’t there or were not important. Some became confused.</p>
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		<p>After discussion divide children into about 6 groups. 3 groups work on the positive side of saving the takahe coming up with arguments for this.</p> <p>After the group discussion and note taking two opposing groups can debate their argument in front of the class. After each argument the class may be invited to share about the strength of the arguments.</p>	<p>NZ.</p> <p>People are helping, caring, thinking and developing science ideas, protecting and restoring.</p> <p>Learning to present an argument – communication skills, practise in public speaking. Some ideas could be –</p>	<p>Children enjoyed debating. For most it was their first experience at debating. Most of them only made one point, but that was</p>
			<p>Affirmative: gives employment, causes development of new ideas and technology, tourism, uniqueness for NZ, saving a national treasure.</p> <p>Negative: against nature 'survival of the fittest', cost of breeding programmes and of protection on the islands and mainland, could have a virtual takahe</p>	<p>good enough The leaders made good rebuttals to the opposition in concluding remarks.</p>

Micro Task 10: Assessment task	Takahe Quiz http://www.kcc.org.nz/quiz/takahe.asp Paper for the report.	Complete a quiz on the takahe. Children could do this online if facilities allow. Write a report on 'Takahe: An Endangered Species'.	Impressed with reports. If not quite accurate at times they were comprehensive, showing an excellent knowledge of the bird and most expressed why or why it shouldn't be saved.
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Extra for experts - independent activities if time allows

- Write a newspaper article on the discovery of the takahe imagining that you were the person who discovered it. Mention why you are interested in the takahe and what made you go to Fiordland looking for them.
- Read the information on how Dr Orbell rediscovered the takahe
 - Write a little story on how he organised an expedition to find some takahe to take back.. Who would he have gone to see to make people interested in his quest, to get finance, what skills would people need to make the expedition?
 - What implements would they have to take with them to be safe in such rugged country, to capture the birds and bring them back alive?
- Why are rings put around the legs of birds? You could contact someone from DOC or the zoo to find out.
- Explain why Tiritiri Matangi was chosen as a suitable habitat for the bird.

*Integrated curriculum links

- Art. Water colour and /or acrylic paintings of takahe
Collage pictures of takahe (from pre painted sheets of paper, cut or torn and glued)
- Language. Poetry describing the problem and suggesting solutions.
Factual reports on the plight of the takahe.
- Music. Rap or song on the plight of the takahe
- Dance/drama. Choreograph sequencing the history of the takahe to music

APPENDIX 2

Survey and interview questions for the students

Interview questions for the teachers

Survey /Interview Questions for Students

1. Which activity did you enjoy the most during these lessons? Why?
2. What were some of the other activities that you enjoyed in these lessons?
3. Did you do anything during these lessons that you hadn't done much of before? (Speaking and sharing ideas? Thinking about things differently?)
4. Tell me about some of the things you learned?
5. Did you learn about other people's views on this issue? Did that make you think about your views and why you believe them?
6. Do you think you knew enough about the topic to make a decision about it?

Summative Interview with the Teacher

1. What do you think/feel about teaching ethics in science?
2. Do you think the lessons 'worked' in terms of developing critical thinking? Examples?
3. What did you find particularly helpful from the earlier discussions (e.g., understanding ethics, ethical approaches, strategies for teaching, planning and planning format)?
4. What activities/strategies did you find useful?
5. How useful was the planner? (In what way was it useful? Not useful?)
6. Do you have any suggested changes for the planner now that you have used it?

APPENDIX 3

Power point presentation1: Teacher development session 1

Introducing ethical thinking into science/technology classroom programmes

Barbara Ryan



- To develop and trial a planning tool for introducing ethical thinking
- Fits with the new curriculum (particularly through nature of science)

What is ethical thinking?

Being able to make reasoned decisions about whether something is right or wrong

BIOETHICS – A study of the ethical, social, legal and philosophical issues arising from the biological sciences

Why teach ethics / controversial issues?

- Contextualises science/technology teaching and learning
- Makes science/technology more relevant and interesting
- Prepares students to be responsible citizens
- The Nature of Science / Nature of Technology strands in the new curriculum

- *The Nature of Science / Nature of Technology*

- All scientific and technological knowledge is formulated within a social context and carried out for a purpose (which is presumed to be good)
- Application of scientific and technological knowledge has consequences
- Scientific and technological knowledge has strengths and limits – tells us how to do something, not why/whether it is a good idea

Possible aims for teaching ethics

- Heighten ethical sensitivity – being able to identify the issues and different viewpoints
- Increase ethical knowledge – making choices; learning to argue and reason persuasively
- Improve ethical judgement – justifying choices; weighing different viewpoints

A possible framework?

1. Identify all possible courses of action
2. What is the science/technology that is involved? How feasible is each option?
3. Consequences - Who/what might be affected by each course of action. How?
4. Is each consequence harmful or beneficial?
5. Are any rights advanced/negated? Who has the duty to ensure these rights are achievable?
6. Is there freedom for individual choice? Do group benefits outweigh individual choice?
7. Does the proposed course of action make someone a 'better' person?

(Western) ethical frameworks

1. Consequences, harms and benefits – *consequentialism*
2. Rights and duties
3. Autonomy; the right to choose
4. Virtue ethics – kindness, honesty, thoughtfulness, etc.

- ▶ Common ethical frameworks
- ▶ Which ethical framework?

Common ethical frameworks

http://www.biotechlearn.org.nz/themes/bioethics/video_clips/common_ethical_frameworks_v0154

Which ethical framework?

http://www.biotechlearn.org.nz/themes/bioethics/video_clips/which_ethical_framework_v0155

Ethical agreement

http://www.biotechlearn.org.nz/themes/bioethics/video_clips/ethical_agreement_v0158

Introducing ethics in teaching

http://www.biotechlearn.org.nz/themes/bioethics/video_clips/introducing_ethics_in_teaching_v0156

Reaching ethical conclusions

http://www.biotechlearn.org.nz/themes/bioethics/video_clips/reaching_ethical_consensus_v0159

Identifying ethical issues

- Which ethical issues / controversial issues can you think of?
 - What 'themes' do these issues relate to?
- awareness of issues = ethical sensitivity

Complexity and multiple perspectives

- Bicultural and multicultural perspectives
 - How many cultures are presented in your class?
- Religious views

- ▶ Ethical agreement
- ▶ Introducing ethics in teaching
- ▶ Reaching ethical consensus

A range of teaching strategies

Brainstorming	Debates
Mind mapping	Transactional writing – argument/report
Small group discussion	Concept cartoons
Class discussion	Case studies
Reciprocal Teaching	'What if...' scenarios
Pair Share	Research
Teacher talk	Values continuum – people/cards/lines
Role Play	Recording ideas in tables
Guest speakers	Worksheets – 'What do you think?'
Round Robin	PMI sheets and discussions
Silent/noisy card shuffle	Presentation to class
Videos/film	

Including ethical thinking into classroom programmes

- To introduce a topic/unit
- To extend a topic
- Integrated throughout a topic
- As a stand-alone programme

BIOETHICS EDUCATION PLANNER

<p>CURRICULUM LINK The nature of science and/or technology: Understanding about science Investigating in science Communicating in science Participating and controlling Characteristics of technology Characteristics of technological systems</p> <p>STRANDS/ AQs Covered -</p>	<p>Ethical question or issue: _____</p> <p>LEVEL: 1 2 3 4</p> <p>YEAR: _____</p> <p>TEACHER: _____</p>	
<p>KEY COMPETENCIES:</p>		
<p>INTENDED LEARNING OUTCOMES: The student will: _____</p>		
<p>Science and/or technology knowledge</p>	<p>Ethical approaches and questions</p>	<p>Activities and strategies</p>
<p>MANAGEMENT/MATERIALS: Resource - Artefacts -</p>		
<p>ASSESSMENT: Assessment Activity</p>		

Planning for teaching and learning

Bioethics: Planning for Teaching and Learning Teacher: _____

Ethical issue or question: _____				
Teaching activity	Focal Artefacts	Planned Interactions	Intended Learning Outcomes	Reflections

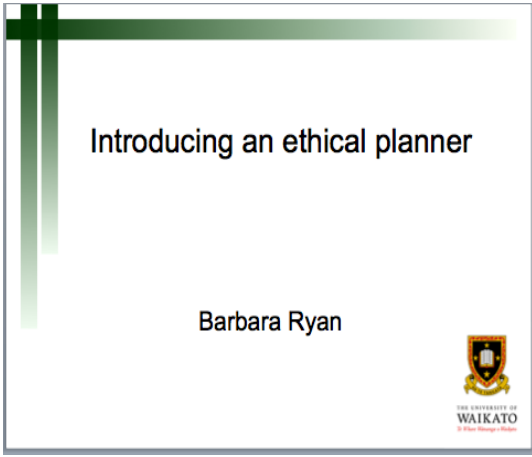
Classroom trials

- To see how ethical thinking can be introduced and managed in classrooms
- Is the supporting planner and, are other planning resources useful? How can they be improved?
- What activities / interactions work well?
- What are students capable of?

APPENDIX 4


Power point presentation 2: Teacher development session 2

This power point was used to support teachers in their understanding of ethics teaching, particularly in using the ethics-in-science planner. The teachers were shown an example ethics-in-science planner 'Conservation of the takahe' (reworked from the ethics section of the earlier 'Takahe: An endangered species' unit). They then worked through the plan themselves using an ethics example from the science unit they were already teaching.

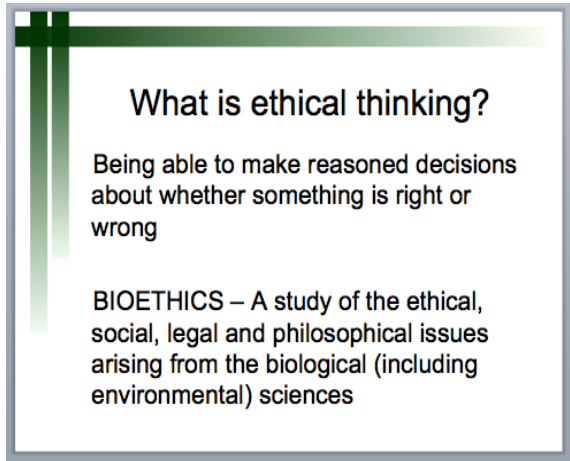


Introducing an ethical planner

Barbara Ryan



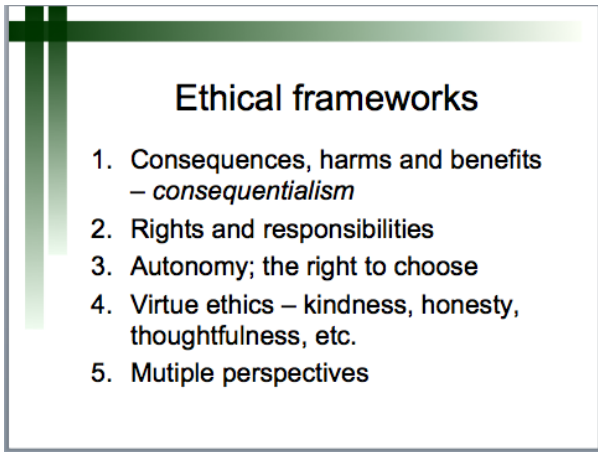
THE UNIVERSITY OF
WAIKATO
1832



What is ethical thinking?

Being able to make reasoned decisions about whether something is right or wrong

BIOETHICS – A study of the ethical, social, legal and philosophical issues arising from the biological (including environmental) sciences



Ethical frameworks

1. Consequences, harms and benefits – *consequentialism*
2. Rights and responsibilities
3. Autonomy; the right to choose
4. Virtue ethics – kindness, honesty, thoughtfulness, etc.
5. Multiple perspectives

ETHICS EDUCATION PLANNER		
Science/technology context:	Conservation of the takahe	Year: 5&6 Level: 3&4 Teacher: B. Ryar
Science curriculum links:	<p>Ecological interactions - Consider how the takahe is suited to its habitat and its response to environmental changes, both natural and human (showing both how it became endangered responses to efforts of conservation) (Living World, Level 3&4)</p> <p>Nature of science - By learning science, students learn to make links between scientific knowledge and everyday decisions and actions (NZC, page 28). In this unit, they learn about takahe, its features and habitat, and why it is endangered. They then consider conservation strategies, culminating in an exploration of whether money should be spent in this way. Under 'participating and contributing', students are expected to explore various aspects of an issue (takahe conservation) and make decisions about possible actions (level 3 & 4).</p>	
Ethics question:	Should money and effort be spent understanding and saving the takahe?	
Relevant science knowledge:	<p>Understand (from the science unit):</p> <ul style="list-style-type: none"> - What it means to be endangered - What it means to be a native species - That the takahe is an endangered, native bird - How the takahe became endangered (its adaptation to an environment with no predators then the impact of the introduction of pest species including predators and competitors the effects of changing the ecosystem) - The focus of conservation efforts and the potential advantages and disadvantages of each approach (setting aside conservation land, controlling deer numbers and predator fertilising tussock grass, specialised breeding facilities...) 	

Reasons for the planner

1. A new curriculum

A more detailed planner helps teachers to become familiar with its contents – particularly the science and nature of science objectives.

2. Focuses learning interactions

Research study ([InSITE](#)) shows that if planning and learning interactions were more focused and purposeful their students were more aware of what was to be learned.

3. Develops PCK

A subject – specific planner approach was pivotal in helping teachers develop pedagogical content knowledge (PCK) - extending ability to productively interact with students' ideas and interests.

Particularly important with an unfamiliar area like ethics.

4. Helps teachers make connections

The InSiTE planners help teachers to make explicit connections between ideas, tasks, and lessons. It will help teachers think about the links between the ethics and the science and the classroom interactions.

Conservation of the takahe example

- Context
- Curriculum links
- Ethics question
- Relevant science knowledge
- Ethical approaches
- Activities and Strategies for intended learning

Activities and strategies for intended learning

Brainstorming	Debates
Mind mapping	Transactional writing – argument/report
Small group discussion	Concept cartoons
Class discussion	Case studies
Reciprocal Teaching	'What if...'scenarios
Pair Share	Research
Teacher talk	Values continuum – people/cards/lines
Role Play – (consensus meetings)	Recording ideas in tables
Guest speakers	Worksheets – 'What do you think?'
Round Robin	PMI sheets and discussions
Silent/noisy card shuffle	Presentation to class
Videos/film	Media analysis
	Guest speakers

Activities and strategies for intended learning

Hyperlinks

- PMI worksheets
- Round Robin
- What do you think? (worksheet)
- URL to concept cartoons

Fire ethics questions

Teachers discussed various ethical issues related to fire.

Fire ethics questions

Should fire retardants be added to furniture?

Should farmers be able to burn off on their own land?

Two options considered and discussed by teachers.

Science curriculum links

- **Properties and Changes of matter**
Compare chemical and physical changes. Compare the effects of chemical retardants in materials when burning with those without (MW, L3&4)
- **Chemistry and society**
Relate the above to its uses in society (MW, L3&4)
- **Nature of Science**
Participating and Contributing – explore aspects of this issue (using chemical retardants) and make decisions about possible actions (L3&4).

Teachers identified curriculum links for the use of chemical fire retardants in furniture.

Relevant science knowledge

Relevant science knowledge

- Current problems with regards to structural fires.
- What chemical retardants are.
- Effects of chemical retardants on fires.
- Problems related to producing retardant chemicals.
- Potential problems with using these chemicals in furniture.

Teachers discussed what relevant science knowledge students might need for this issue.

Possible ethical approaches

Possible ethical approaches

- Consequentialism
- Rights and responsibilities
- Autonomy
- Multiple perspectives

Teachers discuss possible ethical approaches that could be used for ethical issue

APPENDIX 5

Informed consent letters and forms

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone: 07 838 4500 ext 6652
e-mail: ryanb@waikato.ac.nz



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. Strong links will be made between the teaching and learning and the new science curriculum, in particular the Nature of Science strand.

The work is part of my Masters project titled Bioethics in the Primary Classroom. Specifically, I would like to develop a resource in conjunction with a teacher that would support the teaching of ethics in science. I am planning that the resource may be useful to others. I have already met informally with _____ and they are willing to be involved, subject to your permission.

The project will include two after-school professional development discussions. I am then keen to see how the teacher incorporates the ideas explored during the discussions into their classroom teaching. With your permission, and that of the teachers and students, I may ask to: take photocopies of planning materials and teacher worksheets or other resources, observe and audiotape classroom lessons, interview the teachers whose classes are observed, take photocopies of 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 conformed consent from the teacher and the students' caregivers. Students will be asked informally. Participants also have the right to withdraw their participation at any stage. You can also choose to withdraw your school from the project at any time.

Data collected from your school will be used to complete my thesis and may be used to inform the ongoing development of resources to support bioethics education, 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) or the New Zealand Science Learning Hub (www.sciencelearn.org.nz) to help support other teachers using materials published on these sites. 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 my supervisor, Dr Cathy Buntting (e-mail buntting@waikato.ac.nz; Tel. 07 838 4466 ext 6047).

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
Barbara Ryan

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' parents and caregivers (and informally from the students themselves) 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 production of a Masters thesis. It may also be used for the purpose of informing resource development, and may be used in presentations or education articles. Some of the work may be published on the NZ Biotechnology Learning Hub (www.biotechlearn.org.nz) and/or the NZ Science Learning Hub (www.sciencelearn.org.nz) to support other teachers using materials on these sites.
6. I can direct any questions to Barbara Ryan, University of Waikato (e-mail: ryanb@waikato.ac.nz, Tel. 07 838 4500 ext 6652).
7. For any unresolved issues I can contact Barbara's supervisor, Dr Cathy Buntting (e-mail buntting@waikato.ac.nz, Tel. 07 838 4466 ext 6047).

I give consent for my school to be involved in the project under the conditions set out above.

Name: _____

Signed: _____

School: _____

Date: _____

May, 2009

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone: 07 838 4500 ex 6652
e-mail: ryanb@waikato.ac.nz



Dear ____ (Teacher)

I am writing to invite you to participate in the research and development study involved in my Masters project. The aim of the project is to support teachers to introduce and manage discussions about bioethics as part of their science classroom programmes.

Such discussions are intended to help students develop their reasoning abilities in order to justify their decisions about acceptable responses to science-related scenarios, such as should animals be used in research? Strong links will be made with the new science curriculum, in particular the Nature of Science strand.

I have already written to ____ (Principal), who has given permission for me to invite you to participate in this project.

The first part of your involvement will require two after-school sessions to explore the concept of 'bioethics' – what it is, and how it might be introduced within a classroom programme (looking particularly at how it could be incorporated into your upcoming science unit). There will also be discussion around producing a planner that might become a useful tool for teachers wanting to teach bioethics.

After the discussions I will refine the planner and will then be interested to see how useful it is to you in being able to form your lessons. I will also be interested in how you present your ethics lessons and whether or not some of the suggested strategies in our discussion 'worked'.

With your permission, this may involve: taking copies of your planning materials, worksheets or other resources, observing classroom lessons, interviewing you, taking copies of some of your students work and interviewing/surveying some of the students (Students' caregivers will also be approached for their consent).

You and your students have the right to withdraw from the project at any stage. Any data that are collected will be coded to protect your anonymity, as well as that of your students and your school. This means that your individual contributions will not be able to be acknowledged within a public forum.

The findings will be used to produce my Masters thesis and 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) or the New Zealand Science Learning Hub (www.Sciencelearn.org.nz) to help support other teachers as they use materials published on this site.

I am excited about this project and hope that you will be keen to be involved. If you need more details, please contact me at the above address. In the event of any issues arising from the research you can also contact my supervisor, Cathy Bunting (e-mail bunting@waikato.ac.nz; Tel. 07 838 4466 ext 6047).

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

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, the students in my class, and my school.
6. Data obtained during the research project will be used for the production of a Masters thesis. It may also be used for the purpose of informing resource development, and may be used in presentations or education articles. Some of the work may be published on the NZ Biotechnology Learning Hub (www.biotechlearn.org.nz) and/or the NZ Science Learning Hub (www.sciencelearn.org.nz) to support other teachers using materials on these sites.
7. I can direct any questions to Barbara Ryan, University of Waikato (e mail: ryanb@waikato.ac.nz, Tel. 07 838 4500 ext 6652).
8. For any unresolved issues I can contact the Masters supervisor, Dr Cathy Bunting Tel. 07 838 4466 ext 6047).

I am willing to be involved in this project under the conditions set out above.

Name: _____

Signed: _____

Date: _____

May, 2009

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Telephone: 07 838 4500 ext 6652
e-mail: ryanb@waikato.ac.nz



Dear Parent and/or Caregiver,

_____ is teaching a unit on _____. As part of this unit, students will explore some of the ethical issues associated with _____. 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.

_____ has developed this unit in conjunction with me as part of my Masters research and development project. She has agreed that I can come into her classroom to observe her 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, audiotape some conversations, take photocopies of some of your child's work, and ask your child some questions about his/her learning experiences.

In all cases, I will take care to get your child's permission. For example, I will ask your child whether he/she would mind talking to me for a while. Some of the discussions may be audio taped. Pseudonyms will be used in any reporting of the work to protect the anonymity of your child, and _____.

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.

We (researchers) 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 but I will not record any details for the purposes of my research.

In order to allow me 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 my project supervisor, Dr Cathy Bunting (e-mail; bunting@waikato.co.nz, Tel. 07 838 4466 ext 6047).

Yours sincerely,

Barbara Ryan

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.
4. Data obtained during the research project will be used for the production of a Masters thesis. It may also be used for the purpose of informing resource development, and may be used in presentations or education articles. Some of the work may be published on the NZ Biotechnology Learning Hub (www.biotechlearn.org.nz) and/or the NZ Science Learning Hub (www.sciencelearn.org.nz) to support other teachers using materials on these sites.
5. Any reports of the data will use pseudonyms, so that the identity of my child will be protected.
6. I can direct any questions to Barbara Ryan, University of Waikato
(e-mail: ryanb@waikato.ac.nz, Tel: 07 838 4500 ext 6652).
7. For any unresolved issues I can contact Dr Cathy Bunting, project director (e-mail bunting@waikato.ac.nz, Tel. 07 838 4466 ext 6047).

I am willing for my child to be involved in the project under the conditions set out above.

Name: _____

Child's name: _____

Signed: _____

Date: _____

May, 2009

Hi guys,

Some of you may remember me as a teacher at _____ School. I am now working at the University of Waikato. Those of you who know me know that I am interested in teaching science and in fact I have taught a number of you in science. I am now interested in finding out how you learn and discuss science and what some of the best ways of teaching it are because we want to make science an interesting and exciting subject to learn. I would like to write about this, but first I need to do some research to find out some more things about learning in science.

During your next science unit, I plan to come in for some of it and listen to some of your discussions and see what you are learning.

This letter is to ask your permission to photocopy some of your work to use for my work. I would also like to talk to some of you about what you are learning. I may also tape some of your conversations and write some notes about your lessons.

I will not use your names in my work. If I do need to use a name I will use a *pseudonym* (a made up name) but mostly I will just be writing about the sorts of things children do when discussing things concerning science.

I have sent a letter home for your parents and caregivers to tell them about my work and check that they are also happy for me to involve you in my research, but I would like your permission too.

It is OK if you don't want me to use your work and ideas. You will still need to participate in the lessons, but I won't photocopy any of your work or use any of your ideas.

Would you please sign this form if you agree to me using your work and ideas?

Thank you and I'm looking forward to being with you during some of your science lessons.

I am willing to be involved in Mrs Ryan's project

Name: _____

Signed: _____

Date: _____

APPENDIX 6

Plus, minus and interesting (PMI) format for use with ethics lesson in science unit Takahe: An endangered species

I am a _____. Saving the takahe means that I may face the following...	
Benefits (plus)	Harm (minus)
An interesting thought or idea	

APPENDIX 7

Noisy round robin strategy for ethics lesson in unit: Takahe: An endangered species

Adapted version of “noisy round robin”

This classroom management tool relates to the unit plan: Takahe: An endangered species.

Main Idea: To generate a great number of ideas in groups of 3-5. Divide the class into small groups (3-5). Depending on the number of groups, have large sheets of paper, each with a different group that may be affected (harmed or benefited) by the saving of the takahe. These could include:

What effect would the saving of the takahe have on the takahe themselves?

What effect would it have on the red deer?

What effect would it have on predators (stoats, rats, ferrets)?

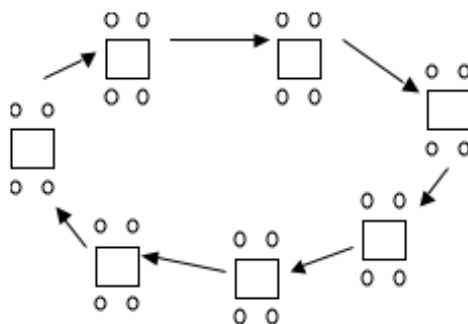
What effect would it have on DOC people?

What effect would it have on the community/me?

What effect would it have on scientists?

What effect would it have on the environment?

The groups are spread out around the room, each with a different piece of paper.



When the teacher says ‘takahe’ (or some other word that gives the signal to change and write), the students have 2-3 minutes to think of an idea or two (through discussion - hence noisy round robin). A writer for the group records the idea/s on the sheet.

When the teacher calls ‘takahe’ again, the groups move to the next piece of paper (i.e., the paper stays at each station). The students are timed again, and required to generate and write down their ideas. Because ideas cannot be repeated, students cannot write what is already there.

The students move on the teachers instructions around all the papers. The groups may then come together for a class to share and discuss their ideas.

Value could be added by each group taking their final sheet of paper and placing the consequences in order of most important to least important. The teacher can record the top 2-4 of each group’s list on the white board or another list.

A report could be a written document, a poster, an advertisement etc.

APPENDIX 8

Example chart of student responses: Consequences for saving the takahe - ethics lesson in science unit: Takahe: An endangered species

Saving the takahe		
What are the consequences		
Who/what	Consequence	Harm or benefit
DOC	increase takahe numbers, outdoor life, camping, paid	Get to save takahe Learn more Use lots of money Time spent saving takahe
Dr Orbell	Became famous	Nice to be famous
Scientists	Raising chicks, studying, doing something good, happy, exhausted, paid	Discover interesting ways to save takahe Help to save takahe Get paid Cost to government
Caring people	Donations, more aware of saving endangered species, learn more about takahe	Money to help save takahe People learn to be helpful People get more knowledgeable
Environment	Closed off – protected Improved tussock growth Improved environment Predator free People can see takahe	Nicer environment – richer soils for tussock predator free – takahe can survive Areas taken for takahe to live (harm to predators) Takahe may need to learn to eat different food in new environments More takahe able to breed Cost to government
Predators Ferrets, stoats, rats	Get killed/trapped	They die/Takahe live
Deer	Get shot	More food for takahe
Weka/hawk	Eat takahe eggs/baby takahe	Food for them/reduces takahe numbers
Wildlife centres	Takahe get help to survive – breeding programmes and putting takahe into protected areas	Takahe population goes up. Cost to centres

APPENDIX 9

**'What do you think?' worksheet used in ethics lesson from science unit:
Takahe: An endangered species**

WHAT DO YOU THINK?



Do you think money should be spent saving the takahe by creating predator-free areas?

YES NO

Give one reason: _____

Do you think it is OK to kill animals like rats, stoats and deer in order to save animals like the takahe?

YES NO

Give one reason: _____

Do you think money should be spent saving a threatened species of snail, called *Powelliphanta*, which like the takahe is found only in New Zealand?

YES NO

Give one reason: _____



APPENDIX 10

Ethical approaches and questions that could be used as a framework for teaching ethics in science (Jones et al., 2007)

ETHICAL APPROACHES AND QUESTIONS
<p>Consequentialism Consequentialism is to do with the consequences of actions. Using this ethical approach, we weigh the benefits and harms resulting from our actions.</p>
<ol style="list-style-type: none"> 1. Who/what is affected by this issue? 2. What are the benefits for those involved? 3. What are the harms for those involved? 4. Are some consequences greater or lesser than others? 5. If one is harmed and another benefits, how do you decide who or what matters most?
<p>Rights and responsibilities Rights and responsibilities are closely related: the rights of one imply the responsibilities (or duties) of another to ensure those rights.</p>
<ol style="list-style-type: none"> 1. Who/what is affected by this issue? 2. What groups have rights associated with this issue? What are their rights? 3. Do these same groups also have responsibilities? What are their responsibilities? 4. Do we value some rights more than others? Whose rights do we want to protect? 5. Do any codes, declarations and/or conventions relate to this issue?
<p>Autonomy Autonomy recognises the right to choose for yourself.</p>
<ol style="list-style-type: none"> 1. Who/what is affected by this issue? 2. What effects might my choice have on others? 3. Is there a public cost associated with my choice? 4. What effects might others' choices have on me? 5. Does everyone have to do the same thing? Will this cause problems? 6. Is informed consent important?
<p>Virtue ethics A virtue is something that the community accepts as being 'good', such as honesty, kindness and patience. Virtue ethics emphasise decisions that are in line with these characteristics.</p>
<ol style="list-style-type: none"> 1. Who/what is affected by this issue? 2. What qualities make someone a virtuous person? 3. What decisions/actions in relation to this issue would make you a better person? 4. What people would agree that these decisions/actions are 'good'? 5. What people would disagree that these decisions/actions are 'good'?
<p>Multiple perspectives Ethical decisions are viewed differently by different people. When considering an issue, it is important to explore a range of world views and respect diversity, for example cultural, socioeconomic, and spiritual or religious diversity.</p>
<ol style="list-style-type: none"> 1. Which groups have opinions about this issue? What are their opinions? 2. Why do groups of people think this way? have they always thought this way? 3. Which groups voice opinions about this issue? (Not all groups that have an opinion voice them in a public forum.) 4. Do the opinions of all groups have equal weighting? How do you decide? 5. Can all the groups agree, and do they need to?

APPENDIX 11

Activities and Strategies teachers could use for intended learning.

ACTIVITIES AND STRATEGIES FOR INTENDED LEARNING	
Brainstorming	
Case studies	Teacher tells a true story or presents a scenario and students discuss the ethics involved.
Class discussion	
Concept cartoons	Cartoons depict different concepts (including some deliberate misconceptions). Students discuss these concepts for scientific accuracy. See examples of concept cartoons made by students at http://www.conceptcartoons.com/science/news.htm
Debates	
Drama	
Guest speakers	
Mantle of the Expert	Inquiry-based role-play where a project is assigned to a student or students. Individuals are required to specialise in knowledge from a particular viewpoint, becoming an 'expert' in that area. They then use their knowledge to argue their case.
Media analysis	Read and discuss a media article related to the issue.
Mind mapping	
Think, pair, share	Teachers pose a problem or ask an open-ended question. Students are given time to think about it. Students face partners and work together, sharing ideas, discussing, clarifying and challenging. The pair then shares their ideas with another pair or with the class.
<u>PMI sheets</u> and discussions	PMI sheets can also be used in conjunction with noisy round robin.
Presentation to class	
Reciprocal reading	Reading an article together with new/difficult science concepts. Involves lots of discussion and clarification of ideas. Could be done in small groups or as a whole class.
Research	
Role play	Including consensus meetings – where students are given roles and have to meet in their role to reach a consensus on an issue.
<u>Noisy round robin</u>	A strategy for getting a number of class ideas in a short time.
Silent/noisy card shuffle	In small groups sort cards with or without discussion that depict concepts.
Small group discussion	
Teacher talk	
Transactional writing	Argument/report/position paper/writing frames.
Values continuum	Students' values related to an issue are prioritised. Students line up in a continuum from absolutely disagrees to absolutely agree. Alternatively, they may mark their thinking on a line or place their card on a line. This works well as a pre-test and then again as a post-test helping students to recognise possible shifts in their thinking and understand why they have made them.
Videos/film	
'What if...' scenarios	Similar to case studies, but they are imaginary examples of what the consequences might be in a particular situation.
Worksheets	Including ' <u>What do you think?</u> ' – students express thoughts on issues.

APPENDIX 12

Plus, minus and interesting (PMI) format for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?

PLUS, MINUS AND INTERESTING (PMI)	
I am a _____. Adding fire retardants to foam or material in furniture means I may face the following.	
Benefits (plus)	Harms (minus)
An interesting thought or idea	

APPENDIX 13

The noisy round robin strategy adapted for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant

ADAPTED VERSION OF "NOISY ROUND ROBIN"

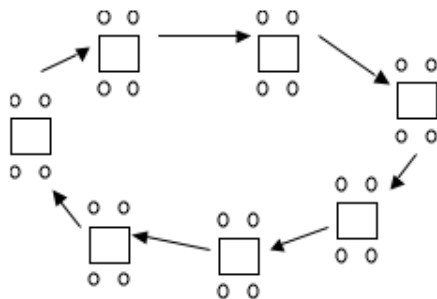
This classroom management tool relates to the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?

Main Idea: To generate a great number of ideas in groups of 3-5.

Divide the class into small groups (3-5). Depending on the number of groups, have large sheets of paper, each with a different group that may be affected (harmed or benefited) by my choice to (firstly) have or (secondly) not have fire retardants added to my furniture. These could include:

1. What effect might my choice to have/not have fire retardant furniture have on me?
2. What effect might my choice to have/not have fire retardant furniture have on people (my family and others)?
3. What effect might it have on the scientists?
4. What effect might it have on children?
5. What effect might it have furniture factory and store owners?
6. What effect might it have on workers at the factory where chemical retardants are made?
7. What effect might it have on the environment? (think about the production of retardants)
8. What effect might it have on fire fighters?
9. What effect might it have on homes and buildings in the event of a fire?

The groups are spread out around the room, each with a different piece of paper.



When the teacher says 'fire' (or some other word that gives the signal to change and write), the students have 2-3 minutes to think of an idea or two (through discussion - hence 'noisy' round robin). A writer for the group records the idea/s on the sheet. When the teacher calls 'fire' again, the groups move to the next piece of paper (i.e., the paper stays at each station). The students are timed again, and required to generate and write down their ideas. Because ideas cannot be repeated, students cannot write what is already there.

The students move on the teachers instructions around all the papers. The groups may then come together for a class to share and discuss their ideas.

Value could be added by each group taking their final sheet of paper and placing the consequences in order of most important to least important. The teacher can record the top 2-4 of each group's list on the white board or another list.

A report could be made as a written document, a poster, an advertisement etc.

APPENDIX 14

'What you think?' worksheet for the ethics-in-science planner: Should chemicals be added to furniture to make it fire retardant?

WHAT DO YOU THINK?



Most western countries in the world have a regulation that says that fire retardants must be added to the foams and fabrics in furniture. New Zealand does not. Do you think New Zealand should have such a regulation?

YES NO

Give two reasons _____

If there was such a regulation in New Zealand, should we manufacture the retardant chemicals needed to put into foams and fabrics for furniture?

YES NO

Give at least one reason _____

CLASSROOM PLANNER FOR TEACHING ETHICS IN SCIENCE

Science/technology context:	Conservation of the takahe	Year: 5&6 Level: 3&4 Teacher: B. Ryan
Science curriculum links:	<p>Ecological interactions - Consider how the takahe is suited to its habitat and its response to environmental changes, both natural and human (showing both how it became endangered and responses to efforts of conservation) (Living World, Level 3&4, NZC, page)</p> <p>Nature of science - By learning science, students learn to make links between scientific knowledge and everyday decisions and actions (NZC, page 28). In this unit, they learn about the takahe, its features and habitat, and why it is endangered. They then consider conservation strategies, culminating in an exploration of whether money should be spent in this way. Under 'participating and contributing', students are expected to explore various aspects of an issue (takahe conservation) and make decisions about possible actions (level 3 & 4).</p>	
Ethics question:	Should money and effort be spent understanding and saving the takahe?	
Relevant science knowledge:	<p>Understand (from the science unit):</p> <ul style="list-style-type: none"> - What it means to be endangered - What it means to be a native species - That the takahe is an endangered, native bird - How the takahe became endangered (its adaptation to an environment with no predators, then the impact of the introduction of pest species including predators and competitors... the effects of changing the ecosystem) - The focus of conservation efforts and the potential advantages and disadvantages of each approach (setting aside conservation land, controlling deer numbers and predators, fertilising tussock grass, specialised breeding facilities...) 	

<u>Ethical approaches and questions</u>	<u>Activities and strategies for intended learning</u>			
Ethics focus question	Activity	Planned interactions	Resources	Learning intentions
Consequentialism – what is it?	Class discussion	What is a consequence? Can be positive OR negative		Children appreciate that consequences are the things that result from a decision or action. They can be positive or negative.
Who/what is affected? What are the benefits? What are the harms?	Class discussion recorded in a table	Who/what is affected? How? <ul style="list-style-type: none"> - takahe (increasing in numbers, individuals are safer, more food – at least initially) - other endangered birds (also increase in numbers) - deer (culled) - predators (killed) - scientists, DoC (jobs, new ideas, excitement, job satisfaction) - general public (pay more tax?; satisfaction from helping to save native birds) - environment (better care of the native environment) 	Paper, pens	Identify that a range of stakeholders are affected by conservation efforts. Whilst some benefit, others might be harmed.

		- tourists, tourism (more native species can be seen?)		
What are possible harms and benefits for different stakeholders? (PMI)	Noisy round robin	Students work in small groups. Ideas from class discussion are expanded.	Worksheets (PMI)	As above – different stakeholders affected differently; some are harmed and some benefit
Are some consequences greater or lesser than others?	Class sharing and discussion	Some benefit (e.g., takahe, other birds, DoC, environment, tourism); some are harmed (e.g., predators, deer, money spent conservation rather than other things, land not available for other uses) – how do you decide what matters most?		Begin to make decisions and judgements by weighing harms and benefits.
Rights and responsibilities – What groups have rights associated with this issue? What are their rights?	Class sharing and discussion	Does the takahe have a right to survive as a native NZ bird? What about natural consequences (survival of the fittest)? (leaving ‘nature’ to take its course). Have we interfered in this process? (not just with protecting the takahe, but earlier, by bringing predators to NZ)		Making decisions/judgements. Thinking about rights from a historical perspective – what occurred that is now causing the takahe to struggle to survive?

Do these groups also have responsibilities? What are their responsibilities?	Class sharing and discussion	Having brought predators to NZ, do we (NZ govt) now have a responsibility to help the takahe survive?		Making decisions/judgments. Thinking about responsibilities. If the takahe has a right to survive, whose responsibility is it to see that this happens?
Virtue ethics - Does saving the takahe make us better people? Why, or why not?	Small group discussion – one person from group to share ideas to the class.	Does saving the takahe cause people to become better people? In what way? (Might become more caring, more giving of time and money, more supportive of environmental protection and restoration)		Appreciating virtues can be developed through ethical thinking – care, generosity, valuing the natural environment.
Ethical deliberation and justification	Debate	Students assigned to plus/minus groups so they have to acknowledge views that might be different to their own.		Making a decision and explaining it to others. Considering the views of others.
<p>ASSESSMENT: An individual report as assessment for both the science unit and the ethical deliberation</p> <ol style="list-style-type: none"> 1. What is the takahe? (Include habitat, food, behaviour) 2. How did the takahe become endangered (its history) 3. What is being done to save the takahe? 4. Do you think it is important to spend money saving the takahe? Why or why not? 				

APPENDIX 16

'Fire retardants: An advantageous solution to fire protection'. An article all teachers had access to

URL: <http://www.fabrics.net/fireproofing.asp>

Fire Retardants: An Advantageous Solution to Fire Protection

By Vince

National Fireproofing Co.

www.natfire.com

The Flammability of Fabrics

All fabrics will burn but some are more combustible than others. Untreated natural fibers such as cotton, linen and silk burn more readily than wool, which is more difficult to ignite and burns with a low flame velocity.

The weight and weave of the fabric will affect how easily the material will ignite and burn. Recommended fabrics are materials with a tight weave. Heavy, tight weave fabrics will burn more slowly than loose weave, light fabrics of the same material. The surface texture of the fabric also affects flammability. Fabrics with long, loose, fluffy pile or "brushed" nap will ignite more readily than fabrics with a hard, tight surface, and in some cases will result in flames flashing across the fabric surface.

Most synthetic fabrics, such as nylon, acrylic or polyester resist ignition. However, once ignited, the fabrics melt. This hot, sticky, melted substance causes localized and extremely severe burns. When natural and synthetic fibers are blended, the hazard may increase because the combination of high rate of burning and fabric melting usually will result in serious burns. In some cases, the hazard may be greater than that of either fabric individually.

Curtains, draperies and other articles in the home can have their burning rates reduced with flame retardants applied through chemical treatment. Such flame-retardant treatment after manufacturing is not recommended for clothing.

In terms of flammability, silk may be the worst with a high burning rate, which may be increased by the dyes and other additives to provide color.

Cotton and linen also have a high burning rate but this can be alleviated by the application of flame-retardant chemical additives.

Acetate and triacetate are as flammable or slightly less flammable than cotton. However, they can be made flame-retardant with chemical treatment.

Nylon, polyester and acrylic tend to be slow to ignite but once ignited, severe melting and dripping occurs.

Wool is comparatively flame-retardant. If ignited, it usually has a low burning rate and may self-extinguish.

Glass fibers and moacrylic are almost flame-resistant. These synthetic fibers are designed and manufactured to possess flame-retardant properties.

What is a Fire Retardant

People unfamiliar with fire retardants are surprised to hear that wood or fabric can qualify as a non-combustible material to a certain degree. Should a fire strike, the chemicals react

with combustible gases and tars normally generated by the material. The tars are converted to carbon char which forms on the surface, slowing the burning rate. The combustible gases are rendered nonflammable for the most part due to dilution with harmless carbon dioxide and water vapor released in the reaction. This happens automatically, driven by the heat of the fire, and requires no coating maintenance, batteries, or plumbing; it is true passive protection.

According to the NFPA's National Fire Safety Survey findings: Although the U.S. has a higher fire death rate than Canada, Western Europe and the Pacific Rim, the majority of Americans are very confident about their fire safety. Older adults express the greatest confidence even though they have the greatest risk of fire death. Men are more confident about fire safety than women; although, of the two groups, men are at a higher risk of fire death. The majority of Americans feel safest from fire in their homes, when in truth, home fires account for roughly 80% of all fires - and they pose the greatest threat to life. The cost of operating public fire prevention services in the U.S. costs the taxpayers billions of dollars per year, most of which is spent on suppression of fire. Many people have the attitude that "fire only happens to other people." But until fire strikes their home and family, fire prevention is ignored. Once fire prevention week comes and goes each October, little thought is given to fire safety and prevention until next year's campaign. Fire suppression is a necessary and vitally important service. It is, however, "after-the-fact". This includes smoke detectors, alarms, sprinklers and extinguishers. The use of fire retardants or firestops are logical "before-the-fact" steps that should be taken. Fire spreads 1100% in the first 4 minutes. Heat rises at 90 feet per second or approximately 60 mph. Approximately 90% of fire fatalities are in the home and 90% of the fatalities occur during the sleeping hours 10pm to 6am. Remember, smoke alarms and sprinklers cannot prevent the fire, but fire retardants in most cases can prevent and/or slow the spread of fire, which can greatly prevent loss of life and property in addition to using smoke alarms or sprinklers. By applying fire retardants to your curtains, furniture, carpeting, etc., is very easy and is an added safety precaution for smokers and small children in the home. Your home and family deserve the best fire protection possible, so why not invest in it.

For more information or to order a fire retardant, please visit National Fireproofing Co. at: www.natfire.com We supply non-toxic, non-staining formulas specifically for fabrics.

APPENDIX 17

Notes on chemical fire retardants that were given to the teachers

These notes were given to the teachers by the researcher – information collated from discussions with fire engineers and the Internet.

Chemical fire retardants

- Why we need chemical fire retardants.

Basically it is about saving people's lives. People need time to evacuate safely. Fire behaviour is such that people don't often get the time they need to get out in time. It's unpredictable, can be very fast, and can lead to a flashover. People need time to evacuate from a fire safely. Chemical fire retardants have been shown to slow burning and save lives by giving people the time they need to evacuate.

- What are chemical fire retardants?

They are chemicals that help delay or prevent combustion. Different chemicals delay combustion in different ways.

- What effect do chemical fire retardants have when burning?

Some interrupt the chemical reaction in the gas phase of combustion (e.g., halon and phostrex). However, in some situations the released gas from adding these chemicals is toxic.

Some chemical fire retardants break down the polymers in the solid phase of combustion so that they melt and flow away from the flame.

Other solid phase chemical fire retardants cause a layer of carbon char to form on a polymer surface. The carbon char layer is very difficult to burn.

Intumescent materials are materials that have chemicals that cause swelling up behind the protective char layer, providing even more insulation.

- What are the environmental problems involved in producing chemical fire retardants?

There is concern that the production of chemical fire retardants can result in risk to human health and the environment. Studies have shown that some toxic chemicals have been found in human tissue and the environment where the chemicals are produced (not in New Zealand). There is concern about human contact during the production of the chemicals and over the disposal of waste products.

- What are some potential problems with using chemical fire retardants in furniture?

Some of the chemicals are toxic and may be dangerous for small children who might suck on furniture. Some scientists have expressed concern that fumes may be emitted from the chemicals even without a fire. The smoke from burning furniture that has (certain) chemical fire retardants can be extremely toxic causing death.

Glossary

Carbon char: To burn down to carbon by incomplete combustion

Halon and phostrex: Chemicals used to suppress fire.

Insulation: A substance or material that will slow down or prevent heat transfer

Polymers: Large molecules usually found in plastics

Banning fire retardant chemicals

<http://www.timesargus.com/article/20090219/NEWS02/902190318/1003/NEWS02>

PDF – concerning environmental and human health issues

www.epa.gov/dfe/pubs/flameret/altrep-v1/altrep-v1a-execsum.pdf

APPENDIX 18

'Slowing the burning' – an article all teachers had access to

The researcher wrote this article for the Science Learning Hub (Fire context) (www.sciencelearn.org). All teachers had access to it.

Slowing the burning

Flammability – our stuff burns

In New Zealand we have a number of house fires. These house fires are fuelled by the things we have in our houses – our furnishings. Our furniture is flammable and often causes fires to burn quickly and fiercely.

Can we slow down the burning?

Fire Engineers, Charley Fleischmann and Mike Spearpoint, have been thinking carefully about these fires and are working on ways they can help save people's lives.

Most things will burn. We can't stop the burning, but if we can slow the fire down it would give people a chance to get out of a house or building.

Couches and chairs are partly made up of fabrics (coverings) and foams (the soft padding in the middle). Charley and Mike are investigating these materials. First, they need to see how quickly and how fiercely different types of fabrics and foams burn. Are these materials easy to ignite? They investigate the effects of burning in combinations of fabrics and foams. Then they try different things to slow down the burning.

Adding chemicals to foam

One of the things that can be done is to change the way something burns - make it burn more slowly. Adding certain chemicals (fire retardants) to the materials slows down the burning.

Chemicals have been added to some of the foams that the fire engineers are investigating. These foams are called combustion-modified foams.

The chemicals interfere with the combustion process making the foam difficult to ignite and then, if it does ignite, difficult to burn. It burns more slowly. This works really well in the early stages of a fire. If the fire is already well established the chemical retardants are not that effective.

Fabrics

Charley and Mike are also investigating the fabric coverings on our couches and chairs. A lot of coverings are inexpensive, but highly flammable. These

coverings are often oil or hydrocarbon based and burn very easily and quickly.

The fire engineers have found that natural materials, such as wool, cotton and leather, are difficult to burn. For example fire has trouble penetrating wool fibres so it tends to just char. The charred layer is difficult to burn and provides a protective barrier between the fire and the foam.

Chemical retardants can be added to these natural materials to make them even more fire resistant. The problem is that natural fabrics are expensive. Chemical retardants are also expensive and adding them to furniture increases the total cost of the furniture.

Leather is another natural fabric that is even more difficult than wool to ignite and burn, but it also is very expensive for people to buy.

Interliners

Interliners are fire retardant materials that could go between the outer fabric and the foam. It means the fire would burn through the top fabric but would be slowed down by the interliner. Fire engineers are testing interliners to see which ones are the most effective. It is a requirement that all aircraft have interliners in the seats.

Charley and Mike's main aim is to slow the burning down to give people time to escape.

Nature of Science

Decisions are not always made according to science but depend heavily on politics, which include finances and social conventions.

APPENDIX 19

Science Unit Plan: The science of fire

SCIENCE EDUCATION PLANNER

<p>SCIENCE STRANDS: Material World Physical World</p> <p>Nature of Science – understanding, investigating, communicating and participating and contributing.</p>	<p>MACRO TASK: Identify and describe the effects of fire, and understand how having a scientific understanding of fire can help us make decisions that can reduce and even prevent the effects of fire.</p>	<p>LEVEL: 2 3</p> <p>YEAR: 2009</p> <p>TEACHER: Barbara Ryan</p>	
<p>STRANDS: AOs Covered – Properties and changes of matter – compare chemical and physical changes during combustion. Chemistry and society – issues around the use of chemical fire retardants. Physical inquiry and physics concepts – exploring and describing heat energy</p>			
<p>KEY COMPETENCIES: Thinking – using scientific evidence and knowledge of fire to understand fire and to make decisions relating to keeping safe. Language – using scientific language related to fire and its effects. Managing self – Students become aware of fire safety, both in relation to experiments in class and everyday living. Relating to others – listening, discussing and sharing ideas within groups and in class. Participating and contributing – working together in investigating activities and subsequent discussion.</p>			
<p>INTENDED LEARNING OUTCOMES: The children will:</p>			
Conceptual LOs	Procedural LOs	Nature of Science	Technical LOs
<ul style="list-style-type: none"> • have an understanding of what fire is. • have an understanding of heat energy • have an understanding of why and how fires behave differently • have an understanding of what smoke is 	<ul style="list-style-type: none"> • Research/fact finding using the Internet, DVD's and books. • Investigate fire by setting up and carrying out some simple experiments and activities. • Debating issues in fire safety* 	<ul style="list-style-type: none"> • We can use science knowledge (of fire) to keep ourselves safe. • Understand that scientists need to use models to learn about some aspects of science when it is difficult to work with the actual thing, for example, fire and molecules. • Understand that scientists often get caught up with societal issues that involve the focus of their study (e.g. the production of fire retardant 	<ul style="list-style-type: none"> • Make detailed observations • Use own ideas and ideas of others' to make testable predictions • Carry out simple experiments in groups in a safe manner • Be able to strike a match, light and extinguish a candle • Evaluate investigations and report back to class • Discuss scientific issues in small groups and present arguments (debating skills)*

		chemicals and the effects of that on society)*	
MANAGEMENT/MATERIALS:			
Resources – http://science.howstuffworks.com/fire1.htm http://www.teara.govt.nz/TheSettledLandscape/ChangingTheLandscape/FireAndAgriculture/1/en http://www.cbsnews.com/stories/2008/05/20/eveningnews/main4111791.shtml Draft work for the Science Learning Hub, National library books. Artefacts – Pictures, DVD – Chemistry of Fire and Flashover X3, Equipment for experiments (see experiments).			
ASSESSMENT:			
Assessment Activity: 1. Describe some ways of putting out fire and explain why this would work. 2. Draw a bird’s eye view of your home and plan an escape route, in the event of a fire, for you and your family. Write an explanation of your escape, including that of other family members. Include in your explanation ideas about where you think the fire could have started from and why. How does your escape plan relate to the behaviour of the fire?			

INSiTE Project: March 2006, CSTER University of Waikato, Planning Document

*These learning objectives later became part of the ethics exploration for the teachers involved in these case studies.

APPENDIX 20

Consequences for specific stakeholders as identified by students in the noisy round robin activity

What effect might chemical fire retardants have on...	Positive	Negative
Me	<ul style="list-style-type: none"> - They will give me more time to get photos and treasures – then I get out and go to the letterbox 	<ul style="list-style-type: none"> - Toxic smoke - Will transfer onto my clothes - People with asthma will get worse - Cause brain damage - Burn my eyes - Damage your immune system - Clog my throat - Give me a rash or give me eczma
My family	<ul style="list-style-type: none"> - It slows the burning to help them get out - It slows the burning process of your couch - Lowers the death possibility rate - It can save lives 	<ul style="list-style-type: none"> - Little children would suck on the furniture - Poisonous gases go into the air - They are bad chemicals - Poisonous gases might filter through the air vents - You don't know what chemical fire retardants might do to young kids
Children	<ul style="list-style-type: none"> - More time to get out 	<ul style="list-style-type: none"> - Chewing/sucking on furniture with toxic chemicals - It might give them heart problems - New born babies would really suffer - Make asthmatics worse - Gives them lung cancer - They might inhale toxic fumes
Firefighters	<ul style="list-style-type: none"> - It keeps them safe because they have the chemicals in their clothing - It makes their job easier - It gives them more time to get to the scene to put the fire out 	<ul style="list-style-type: none"> - There are too many fires to go to because the people depend on the chemical fire retardants - They could kill themselves - They could inhale the toxic fumes - They're in there longer because they have to climb up more flights to get to the top and save the save up the top (because they haven't burnt down)
Homes and buildings	<ul style="list-style-type: none"> - More time for us to get out of a house - Slows down the burning - Prevents damage 	<ul style="list-style-type: none"> - Toxic fumes may go into the air - Firefighters have no notification of chemical fire retardants in the building – may give them breathing problems - Cost (of furniture in houses)
Furniture factories and store owners	<ul style="list-style-type: none"> - More money and sales from furniture 	<ul style="list-style-type: none"> - If people know that the chemical produce toxic gas they won't buy it and they will lose money - It will cost them more because they have to buy the chemical fire retardants - The council could shut down the factory - The chemicals could harm the workers
Workers at the factories where the chemicals are produced	<ul style="list-style-type: none"> - Good wages if lots of people buy the furniture 	<ul style="list-style-type: none"> - Fumes could cause health issues such as lung cancer, heart disease and it could make asthma and allergies worse - If less people buy the furniture their wages will go down

Scientists	<ul style="list-style-type: none"> - Awards - Internationally recognised - Scientific breakthroughs - Create more jobs - More money - More testing - Different subjects (interesting work) 	<ul style="list-style-type: none"> - Could lose jobs - Make mistakes - Muck up the plans - Experiments could be risky - Toxic fumes - Unhealthy lives
Environment	<ul style="list-style-type: none"> - Less fires in the environment and of trees getting burned (not so likely to spread there) - Less chance of wildlife getting burnt/killed 	<ul style="list-style-type: none"> - Chemicals get into the environment. They could poison animals, plants or people - Fumes from fire pollute the air - Trees are affected from toxic smoke - Pollution may be caused while making chemicals in the factories - Chemicals may get into piping and then run out into the sea - Will cost money if city gets polluted and people have to try to get rid of the pollution. Also will cost money for protective gear. The chemicals could be a bio-hazard

APPENDIX 21

Consequences for specific stakeholders as identified by students in a PMI analysis

Adding chemical fire retardants to foam or material in furniture means I may face the following			
I am a...	Benefit (Plus)	Harm (Minus)	An interesting idea
Qantas owner	<ul style="list-style-type: none"> - The carbon char forms a protective layer that is very difficult to break - You get a warning to get out - More time to get out - More sales because they [travellers] know how safe they [planes] are 	<ul style="list-style-type: none"> - Toxic fumes might kill the pilots - Might kill people - High cost - Might depend on it and it might go wrong 	<ul style="list-style-type: none"> - What would happen if something goes wrong? - What happens to the people when it does work?
Doctor	<ul style="list-style-type: none"> - Will slow burning - Will give patients time to escape - Will make patients feel more secure - Will produce carbon char around objects that might be harmed by fire 	<ul style="list-style-type: none"> - Some equipment may be damaged - Could transfer onto clothing and skin when toxic fumes are released from the chemicals - Medicines and vaccines may be harmed by toxic smoke - Small children may suck the furniture 	<ul style="list-style-type: none"> - We slow down the burning by producing carbon dioxide and anti-oxygen gases (like halon and phostrex). What affect [sic] does that have? - What kinds of gases are released by chemical fire retardants when they burn?
Accident and Emergency worker (1 st group)	<ul style="list-style-type: none"> - Give us more time to get patients out - It will give the fire brigade more time to get there - It could save hundreds of lives – just think of how many people could be at A & E at once - It will give firefighters more time to get the fire out 	<ul style="list-style-type: none"> - Small children suck on furniture - We think it lets out fumes even if there's no fire - Chemicals have been found in human tissue 	<ul style="list-style-type: none"> - Sick people could get even sicker when inhaling toxic gases
Accident and Emergency worker (2 nd group)	<ul style="list-style-type: none"> - More time to get out - More warning - More time to get critical patients out - Interrupts the chemical reaction and slows down the burning 	<ul style="list-style-type: none"> - More toxic fumes because the chairs are close together (and there are more of them) - Risk to people and the environment - Cost more money - Dangerous for small children 	<ul style="list-style-type: none"> - Can fumes come out even if they are not on fire? - It is both plus and minus (gives us time to get out but is toxic)

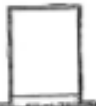

Airline officer* (1 st group)	<ul style="list-style-type: none"> - More time for us to get out/slow down the burning - More time for a warning - More chance of survival - More time to extinguish the fire - Time to get belongings 	- Toxic gases inhaled in compact place such as a plane	- Some countries make it compulsory to have chemical fire retardants in a plane
Airline officer* (2 nd group)	<ul style="list-style-type: none"> - It doesn't spread easily - When chemical retardants burn they cause a layer of carbon char, which is hard to burn. They can also cause a swelling up which makes an insulation - Only one section of the plane may be effected [sic] by a fire 	- Toxic fumes	- The chemical fire retardants could affect you on the plane. You could get dizzy and bang your head.
Executive of Waikato Rugby Union	<ul style="list-style-type: none"> - Even if there are toxic gases they will escape into the air and go out of the stadium - They could put the least toxic chemicals in the seating in the corporate boxes 		- If there was a flashover would the chemical fire retardant furniture catch alight?

* Students had learned that all aircraft must have chemical fire retardant seating.

APPENDIX 22

An example assessment checksheet for transactional writing from Lynda's classroom

Students used the points to check their own writing and then made a self-evaluation in the yellow and black hat boxes. Lynda later ticked off the points against student writing and made a comment.

Argument Writing - Point Of View	
<p>An argument gives a point of view. It tries to persuade others of that point of view.</p>	
STRUCTURE	
<ul style="list-style-type: none">• The argument begins with a strong sentence which gives a clear statement of the problem. ✓• Subsequent paragraphs develop the point of view and give reasons. ✓• The end has a strong and convincing statement clearly giving the point of view outlined. ✓	
STYLE	
<ul style="list-style-type: none">• Written in the first person ("I" statements). ✓• Convincing. ✓• Personal Voice. ✓	
SKILLS	
<ul style="list-style-type: none">• Varied sentence beginnings ✓• Use of descriptive language. ✓• Complex / Compound sentence structures. ✓• Well developed editing skills. ✓• Clear paragraphing. ✓	
<p>Superb work Laura. Very well structured and informative</p>	
Yellow Hat Things I have done well 👍 Lots of reasons to have fire retardents 👍 Very Convincing 👍 Paragraphing 	Black Hat Areas for Development 👎 Vary sentence beginnings 👎 Work on spelling 

CLASSROOM ETHICS-IN-SCIENCE PLANNER

Science/technology context:	Fire Retardants	Year: 5/6 Level: 3/4 Teacher: Lynda		
Science curriculum links:	<p>Properties and changes of matter: Compare chemical and physical changes.</p> <p>Chemistry and society - Relate the observed, characteristics chemical and physical properties of a range of different materials.</p> <p>Nature of Science – By learning science, students learn to make links between scientific knowledge and everyday decisions and actions. In this unit, they will learn about fire retardants, and how scientists can slow down the burning process. They will then consider the harms and benefits of fire retardants. Under participating and contributing, students are expected to explore various aspects and issues and make decisions.</p>			
Ethics question:	Should fire retardants be used in furniture?			
Relevant science knowledge:	<p>Understand (from the Science unit of fire)</p> <p>What is fire? The combustion process.</p> <p>Fire hazards in and around the home,</p> <p>Action to take in the event of a fire at school and home.</p> <p>Which fabrics are flame resistant and/or highly inflammable?</p> <p>How can scientists slow down burning?</p>			
<u>Ethical approaches and questions</u>	<u>Activities and strategies for intended learning</u>			
Ethics focus question	Activity	Planned interactions	Resources	Learning intentions
What in our classroom would fuel a fire?	Brainstorm	Work with a partner. Move around classroom and identify items which would fuel a fire. What type of fabric has been used? Look at own clothing. How flammable would these items be? Why?		Identify items which are flammable in the classroom.

		Share with the class.		
All fabrics burn but some are more flammable than others. How could we place fabrics on a continuum?	Chart, continuum – flame resistant – highly inflammable fabrics.	Discuss with a partner how we could record information to show how inflammable fabrics are. Work in groups of 3 or 4. List fabrics on the board. Make a group chart. Predict where items would be placed. Read article and change prediction and record new views. Explain why. Have fabric cards. Set up continuum on the floor and children stand and explain their reasoning.	Article Laminated cards – fabrics.	Place fabrics on a continuum showing how flammable they are.
How can scientists slow down the burning? What is a fire retardant? What is <u>consequentialism</u> ?	Peer/shared reading activity. Use COW for research. Class discussion Dictionary/computer. Drama: <u>Spacejump</u> with positive and negative consequences.	Work with a partner. Record: How can scientists slow down the burning? What is a fire retardant? Share with the class. What is a consequence? Can it be positive or negative? Work in a drama circle. One child to create action, next child to repeat action and add a consequence, positive or negative, then <u>freeze</u> . Next child in circle complete another consequence. Discuss.	Research article. Topic Book, dictionary, COW – <u>google</u> .	List ways burning can be slowed down and what a fire retardant is. Children appreciate that consequences are the things that result from a decision or action. They can be positive or negative.
Who or What is affected by adding fire retardants to furniture? (Consequential)	Think, peer share. Class discussion.	Who/what is affected by the use of fire retardants in furniture? <u>Children think</u> , peer/ share. Share back with the class. Make a class list. Have charts headed up: What effect might my choice to have/not have fire retardant furniture have on _____? Children to work in	Large sheets of paper, <u>vivids</u> . Photocopied articles for reference, topic book.	Discuss who can be affected by fire retardants. Consider how they are affected.

*Students have been given pseudonyms.

		groups of 3-5. Dan, Mike, Hamlyn, Will, Anna, Fred, Maxina, Lana, Madison, Sue* to select partner, then a second partner. Large charts placed on the floor around the room. Children rotate around each sheet when the instruction 'fire' is given. Once they have finished share back to the class and group items. (maybe harms/benefits)		Group and prioritise effects.
What are the harms and benefits of adding fire retardants to foam or material in my furniture?	PMI	Consider a group of people or an organisation that may need to consider the use of fire retardants. Brainstorm plus, minus, interesting. Share back to the class.	PMI chart	Consider the harms and benefits of fire retardants in furniture.
Should fire retardants be used in the seating at a new movie theatre?	Mantle of the Expert	Client: Movie theatre owner. Commission –Should I add fire retardants to the seating in my new movie theatre? E-mail sent to class inviting community organisations to attend a meeting to discuss this issue. Children consider who would be affected. Select a role. eg. Children, owner, fire fighters, scientists, parents. Meet in the board room, introduce yourself and colleagues. (Could have name tags and roles) Owner present as effigy –identified and only able to hear but not respond. Leave owner to contemplate decision. Reporters arrive to interview visitors.	Letter from client. Charts Room set up for a meeting. Owner's chair and identification tag.	List the harms and benefits of retardants. Debate the issue and justify responses.
What do you think about NZ having a regulation that says	Class discussion Record individually	Work independently write 1-2 reasons to support your argument for or against the use of fire	What do you think sheet.	Record reasons for or against the use of fire retardants.

fire retardants must be added to foams and fabrics in NZ furniture.		retardants in NZ furniture. Place on to large charts and discuss.	Charts.	
Should fire retardants be used in furniture?	Transactional writing debating the issue.	Discuss format of writing in Reading programme. Use powerful words. introduce issue and state which side you are adopting, paragraph ideas and finish with conclusion.	A4 lined refill.	Identify 2 reasons why we should or shouldn't use fire retardants in our furniture.
<p>ASSESSMENT: Observational data - involvement in discussion, individual and group ideas on charts. Transactional writing – debate issue. An individual piece of writing.</p> <ol style="list-style-type: none"> 1. Introduce the topic or issue, say which side you will be taking. 2. Give 2/3 reasons supporting this argument. 3. Finish with a powerful conclusion where you sum up the key points. 				

APPENDIX 24

'The flammability of fabrics'. An article used by Amy's class (questions by Amy)

Fire Retardants: An Advantageous Solution to Fire Protection

By Vince

National Fireproofing Co.

The Flammability of Fabrics

All fabrics will burn but some are more **combustible** than others. Untreated natural fibres such as cotton, linen and silk burn more readily than wool, which is more difficult to ignite and burns with a low flame velocity.

The weight and weave of the fabric will affect how easily the material will ignite and burn. Recommended fabrics are materials with a tight weave. Heavy, tight weave fabrics will burn more slowly than loose weave, light fabrics of the same material. The surface texture of the fabric also affects flammability. Fabrics with long, loose, fluffy pile or "brushed" nap will ignite more readily than fabrics with a hard, tight surface and in some cases will result in flames flashing across the fabric surface.

Most synthetic fabrics, such as nylon, acrylic or polyester resist ignition. However, once ignited, the fabrics melt. This hot, sticky, melted substance causes localized and extremely severe burns. When natural and synthetic fibers are blended, the hazard may increase because the combination of high rate of burning and fabric melting usually will result in serious burns. In some cases, the hazard may be greater than that of either fabric individually.

Curtains, draperies and other articles in the home can have their burning rates reduced with flame retardants applied through chemical treatment. Such flame-retardant treatment after manufacturing is not recommended for clothing.

In terms of flammability, silk may be the worst with a high burning rate, which may be increased by the dyes and other additives to provide color.

Wool is comparatively flame-retardant. If ignited, it usually has a low burning rate and may self-extinguish.

Cotton and linen also have a high burning rate but this can be alleviated by the application of flame-retardant chemical additives.

1. What does **combustible** mean?
2. Name three things that affect how combustible a material is.

3. Name two natural fibre materials

4. Name two synthetic materials.

5. Describe what happens to synthetic materials after they catch fire and why this is dangerous.

6. Why do you think wool might have fire retardant properties? (Discuss with your group)

APPENDIX 25

Viewpoints on the use of chemical fire retardants selected from the Internet by Amy.

Students were required to determine whether the authors were for or against and why they thought this. The nature of science introduction was written by Amy.

The Nature of Science:

Scientists were once only concerned with the science (e.g. how to make the chemical fire retardants) but now they must consider all the effects the production of these chemicals may have on the environment and society as well as keeping people safe. This is decision time!

Help the scientists to come to an informed decision based on the following arguments.

A Dutch research institute says that treating sofas, chairs and mattresses with a fire retardant would reduce the number of deaths and injuries from household fires by a quarter.

The Netherlands Institute for Safety, Nibra, which studied the role of furniture in home fires, says that strict rules introduced in Great Britain and Ireland 20 years ago have saved an average of some 500 lives a year. In countries where furniture makers do not apply fire retardants, sofas, chairs and mattresses often burn so fast that people cannot leave their homes in time.

Home fires damage about 400,000 homes, and cause just under 7 billion US dollars in direct damage annually in the United States. Because of the importance of prevention, fire retardation has become a very notable industry.

Basically, it's about saving lives. People need time to get out of a house fire safely. Fire usually behaves in a way that could mean people do not have enough time to get out. Fire is unpredictable, can be very fast spreading and can lead to a flashover. Chemical retardants have been shown to slow down the burning process.

All smoke is harmful to humans, not just the smoke given off from furniture with chemical fire retardants in them. Either way smoke is harmful so why not increase the amount of time people have to get out of the way of the smoke by slowing the burning process down?

These chemical retardants may be harmful to children who might suck on furniture and the smoke from burning furniture with chemical fire retardants in it can be extremely toxic, causing death.

Although use of flame retardants saves lives and property, there have been unintended consequences. There is growing evidence that Flame Retardants persist in the environment and accumulate in living organisms, as well as toxicological testing that indicates these chemicals may cause liver toxicity, thyroid toxicity, and neurodevelopmental toxicity. Environmental monitoring programs in Europe, Asia, North America, and the Arctic have found traces of several Flame retardant chemicals in human milk, fish, aquatic birds, and elsewhere in the environment. The mechanisms or pathways through which chemical flame retardants get into the environment and humans are not known yet, but could include releases from manufacturing or processing of the chemicals into products like plastics or textiles, aging and wear of the end consumer products, and direct exposure during use (e.g., from furniture).

California furniture manufacturers are required to use potentially toxic chemicals which are bad for children, and are being found in the milk of breastfeeding mothers--the very same chemicals that were removed from children's sleepwear thirty years ago! All this in the name of fire retardancy which can be achieved without toxic chemicals. Now the chemical industry wants to put similar chemicals in bedding and pillows as well.

Assembly member Mark Leno explains, "These toxic chemicals have been shown to cause cancer, reproductive problems, learning disabilities, and thyroid disease in laboratory animals and house cats. At the same time, these chemicals are climbing the food chain in increasing concentrations and are found in fish, harbor seals in San Francisco Bay, polar bears, bird eggs, and the animal at the very top of the food chain - breast-fed human babies."

There is also concern about the impact of making the chemicals. How are these chemicals produced and how does this production effect the environment? Does it pollute the environment? Is it safe for the people working at the manufacturing factories?

APPENDIX 26

Class-generated lists of stakeholders affected by whether chemical fire retardants in furniture should be made a regulation in New Zealand (from both Amy and Anton's classes)

List of stakeholders generated by Amy's class

Stakeholders in 'making chemical fire retardants in furniture a regulation in New Zealand'.	
Furniture makers	Advertisers
Furniture store owners	Consumers
Furniture sellers	Government
Furniture buyers	Builders
John Key	People with allergies
Kids	Everyone who lives in New Zealand
Firefighters	Fire department
Families	Public over the age of 18
Scientists	People with health problems
Chemical factory workers	Marketers
Environmentalists	Green Party
Human Rights Committee	Babies and children
Political people	Hospitals
Sponsors	Ambulance officers
Insulation makers	

List of stakeholders generated by Anton's class

Stakeholders in 'making chemical fire retardants compulsory in all furniture including furniture in transport in New Zealand'.
Commuters
Firefighters
Babies (because of the toxic smell)
People who make furniture
Everyone (because people buy furniture)
The people who might not be able to afford it
The government
People who buy and sell the wool to make fire retardant fabrics
Bus companies
Transport companies
People who make fire extinguishers and smoke alarms
Greenies and people who care about the environment
Scientists who make the chemicals

APPENDIX 27

A list of stakeholders and consequences generated by student groups.

Selected stakeholders and consequences for them should chemical fire retardants in furnitures be made a regulation in New Zealand.		
	Stakeholders chosen	The consequences
Group 1	John Key Firefighters Evironmentalists	- because it would cost the government money and he may not want to spend it on this (negative) - because there would not be as many fires (positive) - because they could get there before the whole house burnt down (positive) - because the chemicals are not environmentally friendly (negative)
Group 2	Chemical manufacturers Firefighters Government	- It gives them a job and money (positive) - They have to work with poison which could make them sick (negative) - People's lives get saved because they can put the fire out more easily (positive) - There could be more poisonous smoke. (negative) - They would have to spend more money (negative)
Group 3	John Key Firefighters Builders	- Because he makes all the decisions - It costs money (negative) - They can save more peoples lives and their houses (positive) - They have to spend more time making more buildings (it is unclear what these students meant by this)
Group 4	Public over 18 Firefighters Marketers	- The chemicals might affect them – they might have health problems (negative) - People's kids and property might get damaged (negative) - It will make it easier for them (positive) - People might not agree with it and not buy their furniture (negative)
Group 5	Furniture makers People who make the chemicals	(this group had identified these stakeholders as important but had not listed any consequences)
Group 6	John Key Scientists Furniture manufacturers Firefighters Young people	(this group had identified these stakeholders as important but had not listed any consequences)

Group 7	<p>John Key</p> <p>Furniture manufacturers</p> <p>Furniture store Owners</p> <p>Government</p>	(this group had identified these stakeholders as important but had not listed any consequences)
Group 8	<p>John Key</p> <p>Firefighters</p> <p>People with health problems</p> <p>Furniture makers</p> <p>Furniture sellers</p>	<p>- Because he is the Prime Minister of New Zealand</p> <p>(all other stakeholders had been identified as important, but no consequences were given)</p>

APPENDIX 28

Class results from PMIs asking whether chemical fire retardants should be used in furniture.

Should chemical fire retardants be used in furniture? (PMI)			
From the perspective of	Positive	Negative	Questions and Ideas
Firefighters	<ul style="list-style-type: none"> - The chemicals slow the burning and give you time to get out. - They save lives. - It's not so dangerous for firefighters. 	<ul style="list-style-type: none"> - There might be a big fire somewhere but we get called to a smaller one (because of the chemical retardants). - it makes more smoke and smoke is more dangerous than the fire itself. - The fire may be unnoticed for a longer time. 	We might get more money by helping to advertise the chemical fire retardant furniture.
Furniture manufacturers	<ul style="list-style-type: none"> - You will get more money. - We could give the consumers a choice if they want chemical fire retardants or not. - We would not get sued because people would have a choice. - Scientists are testing for us – to have the best products. 	<ul style="list-style-type: none"> - You have to spend time doing something you hate doing [if you do not want to deal with the chemicals]. - What if the chemicals reacted with something else – like someone spills something on the furniture and it reacts with the chemicals. Would we be responsible? - If something goes wrong maybe we could get sued. - You have to do what people want or no one will buy the furniture. 	Do chemical fire retardants affect your furniture?
Consumers and scientists	[unable to obtain these results]		
Environmentalists		<ul style="list-style-type: none"> - Chemicals are bad for children. - Chemical spread through the environment. - The chemicals could get into things we eat. - It might give people cancer. - The smoke from the chemicals is worse than normal smoke. - Animals could die because of the smoke. 	
Government/parliament	<ul style="list-style-type: none"> - Doesn't have to pay as much [to replace buildings]. - They don't have to worry about fires as much. - Since they saved money they can use it on other things. 	<ul style="list-style-type: none"> - They would have to pay to put the chemicals in furniture. - They might get riots because they have to make taxes higher to pay for fire retardants. - People would expect more pay because the government has more money. 	

APPENDIX 29

Responses made to the prime minister about whether chemical fire retardants in furniture should be a regulation.

Stakeholders	Justifications
Firefighters	<p>We are for the regulation because:</p> <ul style="list-style-type: none"> • We would make more money because we would help to promote fire retardant furniture • We would have more time to get to fires and save lives • We would save people's lives • It's not so dangerous for us to be at fires
Furniture manufacturers	<p>We are for the regulation because:</p> <ul style="list-style-type: none"> • We would get more money because the prices would go up • You should be able to choose your furniture – it's your own risk • We would not get sued for fires • Fires often begin in furniture • Scientists test everything and choose the best chemicals
Government	<p>We are against the regulation because:</p> <ul style="list-style-type: none"> • There are many arguments and issues against having chemical fire retardants, so we don't want to rush into a regulation • People should have the right to choose their own furniture – not told what to do • The cost of furniture with chemical fire retardant would be more expensive • Smoke damage would be greater • Toxic smoke may cause injury like burns or death
Consumers	<p>We are against the regulation because:</p> <ul style="list-style-type: none"> • Furniture is not the main problem anyway – fires can start anywhere and catch lots of things alight other than furniture • Allergies to chemicals are a problem • The smell of the chemicals would not be pleasant • We can use wool instead of chemical fire retardants, especially living here in New Zealand. There's wool everywhere. • The price will go up on furniture with chemical fire retardants and it will be too expensive • Chemical fire retardants may contribute to cot deaths • The chemicals can get into the body and are harmful • It doesn't actually stop the fire • We are concerned about what the furniture might look like. You would have to give up your own furniture for something you may not like – it might be ugly and have an awful texture and smell.
Environmentalists	<p>We are against the regulation because:</p> <ul style="list-style-type: none"> • The chemicals could cause cancer • The smoke is more toxic • Chemicals could get into things we eat • The chemicals are bad for children • The chemicals could spread throughout the environment
Scientists	<p>We are against the regulation because:</p> <ul style="list-style-type: none"> • Chemical fire retardants are toxic to humans • The chemicals create more toxic smoke which is dangerous for people • The chemicals could make people with allergies even sicker • You won't notice the fire and the smoke will keep being produced – which is dangerous for people.

CLASSROOM ETHICS-IN-SCIENCE PLANNER

Science/technology context:	Chemical Fire Retardants in Furniture			Year: 5 &6 Level: 3 Teacher: Amy
Science curriculum links:	<p><u>Material World:</u> Properties and changes of matter – Compare chemical and physical changes</p> <p>Chemistry and Science – Relate the observed characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.</p> <p><u>Nature of Science:</u> Identify ways scientists work together and provide evidence to support their ideas. Use science knowledge when considering issues of concern. Explore various aspects.</p>			
Ethics question:	Should chemical fire retardants be regulation in production of furniture in <u>NZ</u> .			
Relevant science knowledge:	Understand what is fire, how it behaves, what happens on a molecular level, what are the components required to start a successful fire.			
<u>Ethical approaches and questions</u>	<u>Activities and strategies for intended learning</u>			
Ethics focus question	Activity	Planned interactions	Resources	Learning intentions
What is a highly flammable material?	Silent Card Shuffle	Place all fabrics on a continuum to show least flammable to more flammable	Silent cards set	Children will understand what is more flammable and why
What is a chemical fire retardant?	Class shared reading activity and discussion	Watch flashover DVD – Discuss what we see Read through reading together, discuss in groups	Flashover DVD Reading Sheets	Children will understand what/when/how chemical fire retardants are used.
What is <u>consequentialism</u> ?	Quick buzz, think, pair, share activity Class discussion	What is a consequence? Can be positive or negative Real life examples of each	Record on whiteboard	Children will understand that consequences are a result of an action or decision
What is a stakeholder?	Class discussion to unpack and compare to our world		Record ideas on whiteboard	Children will understand that when a decision or action is made people are effected differently

Who/what is affected by our question? I.e. who are the stakeholders?	Class discussion	Read scenario cards and discuss who the stakeholders are that are involved in our big ethics question	Scenario cards	Children will identify many possible stakeholders and discuss whether they are affected negatively or positively by our question
Are some consequences greater or lesser in importance than others?	Buzz group discussions. Look at scenario cards and prioritise viewpoints	Discuss how we can decide what we should consider more than other ideas.	Scenario cards Whiteboard to record thoughts	Children will listen to opposing viewpoints and attempt to see where they are coming from
Who has rights in regards to our big ethics question?	Discussion whole class Think, pair, share	Look at the stakeholders identified and reflect on <u>yesterdays</u> discussion to decide who has rights and who has responsibilities – Should these stakeholders have more say?	Whiteboard to record ideas	Children will begin to rationalise their prior thinking and challenge pre conceived ideas as to who's view is more important
So... Should chemical fire retardants be compulsory in the manufacturing of NZ furniture?	Whole class debate. Formulate viewpoints in groups where each group represents a different stakeholder. Barbara Ryan to stand in as Prime Minister to come to a decision based on hearing all stakeholders opinions	Group discussion and planning Debate		Children will listen to opposing views and challenge their own thinking to come up with potentially new ideas on the subject. Children will formulate their own informed opinion based on our big ethical question.
ASSESSMENT: Debate and group interaction observations Transactional writing if time allowed <u>to check</u> individual articulation of ideas.				

APPENDIX 31

Controversy over fire-retardant chemicals. Selected and used by Anton in his class.

Controversy Over Fire-Retardant Chemicals

Two States Are Phasing Out Use Of Deca, But Are Industry Lobbying Powers Stopping Others?

By Wyatt Andrews

(CBS) For the last 30 years, manufacturers have infused millions of pounds of brominated flame-retardant chemicals into upholstery, electronics and children's products to slow down fires.

But some of those chemicals - called PBDE's - are leaching out, building up in people, and may be toxic, CBS News correspondent Wyatt Andrews reports.

"They can affect the developing brain and they can affect the developing reproductive system," said EPA senior toxicologist Linda Birbaum.

Birnbaum is one of many scientists worried about the chemical Deca, the last PBDE made in America. It causes serious health effects in young animals - a red flag, she says, for humans.

"I am very concerned for the human population," Birnbaum said.

So far, two states, Maine and Washington, are phasing out Deca. Six others, including California, are considering similar bans.

Despite the growing concern over flame-retardant chemicals, the industry, and groups aligned with industry, is lobbying to increase the use of chemicals in a wide range of consumer products.

For example, to fight the state bans, the bromine industry creates neutral-sounding front groups like "Californians for Fire Safety" to argue that Deca is safe and saves lives.

Another example: When the Consumer Product Safety Commission proposed new standards for furniture, "without requiring the use of [any] flame retardant chemicals," another group close to industry, the National Association of State Fire Marshals, began lobbying for standards that would require chemicals.

Fire Marshals President John Dean says his group is not pro-chemical, just pro safety.

"We just don't want to put ourselves in the position of losing more lives and property," he said.

Critics point out the Marshals have accepted money from the bromine industry, and shared a lobbyist, Peter Sparber and Associates.
"Is there a conflict there, where you are sharing a lobbyist with the chemical industry?" Andrews asked.

"I have not seen it to be a problem," Dean said.

Read Andrews' previous report on the controversial chemical.
Watch Web-only video: Toxins In Children's Toys?

Here's who does see a problem - the nation's firefighters.

"You think the Fire Marshals association is too close to the chemical industry?" Andrews asked.

"Well, it concerns me," said Harold Schaitberger, who opposes brominated flame retardants, because when they create toxic fumes when they burn.

"There's other ways to provide time and to inhibit flame spread without using these products, which I think are unnecessarily dangerous," he said.

Some companies, like IKEA and Dell have already phased out brominated chemicals.

The bromine industry which declined our requests to go on says studies prove Deca is safe. But leading scientists, manufacturers, and the firefighters say after decades of literally sitting on PBDE's ... it's time to walk away.

APPENDIX 32

Articles on chemical fire retardants selected and used by Anton in his class

Fire Retardants: An Advantageous Solution to Fire Protection

By Vince

National Fireproofing Co.

www.natfire.com

The Flammability of Fabrics

All fabrics will burn but some are more combustible than others. Untreated natural fibers such as cotton, linen and silk burn more readily than wool, which is more difficult to ignite and burns with a low flame velocity.

The weight and weave of the fabric will affect how easily the material will ignite and burn. Recommended fabrics are materials with a tight weave. Heavy, tight weave fabrics will burn more slowly than loose weave, light fabrics of the same material. The surface texture of the fabric also affects flammability. Fabrics with long, loose, fluffy pile or "brushed" nap will ignite more readily than fabrics with a hard, tight surface, and in some cases will result in flames flashing across the fabric surface.

Most synthetic fabrics, such as nylon, acrylic or polyester resist ignition. However, once ignited, the fabrics melt. This hot, sticky, melted substance causes localized and extremely severe burns. When natural and synthetic fibers are blended, the hazard may increase because the combination of high rate of burning and fabric melting usually will result in serious burns. In some cases, the hazard may be greater than that of either fabric individually.

Curtains, draperies and other articles in the home can have their burning rates reduced with flame retardants applied through chemical treatment. Such flame-retardant treatment after manufacturing is not recommended for clothing.

In terms of flammability, silk may be the worst with a high burning rate, which may be increased by the dyes and other additives to provide color.

Cotton and linen also have a high burning rate but this can be alleviated by the application of flame-retardant chemical additives.

Acetate and triacetate are as flammable or slightly less flammable than cotton. However, they can be made flame-retardant with chemical treatment.

Nylon, polyester and acrylic tend to be slow to ignite but once ignited, severe melting and dripping occurs.

Wool is comparatively flame-retardant. If ignited, it usually has a low burning rate and may self-extinguish.

Glass fibers and moacrylic are almost flame-resistant. These synthetic fibers are designed and manufactured to possess flame-retardant properties.

What is a Fire Retardant

People unfamiliar with fire retardants are surprised to hear that wood or fabric can qualify as a non-combustible material to a certain degree. Should a fire strike, the chemicals react with combustible gases and tars normally generated by the material. The tars are converted to carbon char which forms on the surface, slowing the burning rate. The combustible gases

are rendered nonflammable for the most part due to dilution with harmless carbon dioxide and water vapor released in the reaction. This happens automatically, driven by the heat of the fire, and requires no coating maintenance, batteries, or plumbing; it is true passive protection.

According to the NFPA's National Fire Safety Survey findings: Although the U.S. has a higher fire death rate than Canada, Western Europe and the Pacific Rim, the majority of Americans are very confident about their fire safety. Older adults express the greatest confidence even though they have the greatest risk of fire death. Men are more confident about fire safety than women; although, of the two groups, men are at a higher risk of fire death. The majority of Americans feel safest from fire in their homes, when in truth, home fires account for roughly 80% of all fires - and they pose the greatest threat to life. The cost of operating public fire prevention services in the U.S. costs the taxpayers billions of dollars per year, most of which is spent on suppression of fire. Many people have the attitude that "fire only happens to other people." But until fire strikes their home and family, fire prevention is ignored. Once fire prevention week comes and goes each October, little thought is given to fire safety and prevention until next year's campaign. Fire suppression is a necessary and vitally important service. It is, however, "after-the-fact". This includes smoke detectors, alarms, sprinklers and extinguishers. The use of fire retardants or firestops are logical "before-the-fact" steps that should be taken. Fire spreads 1100% in the first 4 minutes. Heat rises at 90 feet per second or approximately 60 mph. Approximately 90% of fire fatalities are in the home and 90% of the fatalities occur during the sleeping hours 10pm to 6am. Remember, smoke alarms and sprinklers cannot prevent the fire, but fire retardants in most cases can prevent and/or slow the spread of fire, which can greatly prevent loss of life and property in addition to using smoke alarms or sprinklers. By applying fire retardants to your curtains, furniture, carpeting, etc., is very easy and is an added safety precaution for smokers and small children in the home. Your home and family deserve the best fire protection possible, so why not invest in it.

For more information or to order a fire retardant, please visit National Fireproofing Co. at: www.natfire.com We supply non-toxic, non-staining formulas specifically for fabrics.

Fire retardants and baby products: This isn't kid stuff

A battle is waging in the Legislature over the use of the highly toxic chemicals.

By Russell Long

July 13, 2009

For decades, California has been the only state in the nation to require the use of highly toxic fire-retardant chemicals on cribs, infant carriers, strollers, nursing pillows, changing tables, high chairs and other baby products.

Regulations mandating the treatment were well intentioned. Who wouldn't want to protect children from fire?

But there is a complete lack of evidence that using the chemicals saves lives, and a growing body of research suggesting that exposure to fire retardants is dangerous.

Last year, the Consumer Product Safety Commission issued statements strongly discouraging the use of fire retardant in home furniture, including baby products. The

federal agency's scientists cited numerous studies linking fire retardant exposure to cancer, birth defects, reproductive problems, thyroid disorders, hyperactivity, learning disabilities and a plethora of other health concerns.

Making matters worse, California's law has meant that baby products are often treated with the chemicals even in states that don't require such treatment. To avoid manufacturing two separate lines, one for California and another for other states, many manufacturers make their products sold in other states to California standards.

A study published last year in the journal *Environmental Science and Technology* found the flame retardant penta-BDE in the dust of California homes at four to 10 times the concentrations found elsewhere in the U.S., and 200 times higher than in Europe. It also found that Californians have twice the concentration of the chemical in their blood as people who live elsewhere in the United States.

Last year, the environmental group Friends of the Earth released a study: "Killer Cribs: Protecting Infants and Children from Toxic Exposure." Our testing showed that 56% of infant carriers, 44% of car seats and 40% of portable cribs have high levels of toxic fire retardants.

Those may be falsely low numbers. Since we did the testing, we have learned that some baby-product manufacturers no longer use the fire retardants we tested for, having switched to a different one, a chemical cousin so dangerous that the Consumer Product Safety Commission forced manufacturers to stop using it in children's sleepwear 32 years ago.

State Sen. Mark Leno (D-San Francisco) has introduced a bill that would end the requirement that many baby products be treated with fire retardants. But the fate of this bill, which has enjoyed bipartisan support until now, has also taken a strange turn.

Fire retardants and baby products: This isn't kid stuff

A battle is waging in the Legislature over the use of the highly toxic chemicals.

By Russell Long
July 13, 2009

At an Assembly hearing last week, the deputy director of the state Department of Consumer Affairs, which regulates baby products and reports to the governor, unexpectedly said that the agency was coming out in opposition to the bill. Under intense questioning, she acknowledged that her department had decided to oppose passage only hours before the hearing.

Some legislators now question how trustworthy the department was in the matter and whether intense lobbying by chemical companies against the bill have influenced the governor's staff.

The bill would be unnecessary if the governor exercised the authority he has to modify the regulations himself.

Despite the administration's opposition, the bill, which is supported by professional firefighters, makers of juvenile products and conservation, consumer and environmental justice groups, passed the Assembly Business and Professions Committee 7 to 2 and now heads to the Appropriations Committee.

For the benefit of California's infants, let's hope the Legislature holds firm.

Russell Long is vice president of Friends of the Earth.

Healthy Home Tip 3: Avoid fire retardants

By [Lisa Frack](#)

AUGUST 25, 2009



Are you trying to reduce your family's exposure to flame retardants?

It's a good idea since they're associated with long-term health effects - especially in children whose developing bodies are more sensitive to chemical exposures. Plus, they're all over your house.

We'd like to believe our government is effectively protecting us from toxic chemicals that are increasingly linked to health problems and found in many common household items, but it's not.

We think you deserve better. So we created a Healthy Home Tip Series to make it easier to safeguard your family's health from the poorly studied toxic chemicals in use today.

Tip 3: Learn to minimize your exposure to fire retardants at home.

Our [Healthy Home Tip](#) makes it easy for you to identify fire retardants in your home and take some simple steps to reduce your family's exposure to them. You'll learn:

- Why you should minimize your family's exposure.
- What household products contain fire retardants.
- How you can reduce your family's in-home exposure.

Get the guide. Our [1-page guide to PBDEs](#) sums it up well.

[Tell your friends about our Healthy Home Tips.](#) They, too, will appreciate being informed when wondering how to minimize unnecessary exposure to fire retardants.

This tip is part of our Healthy Home Tips Series. You can find our first two tips and sign up to get the rest in your inbox [right here](#).

Talk to you in a month when we discuss our next Healthy Home Tip: How to pick plastics carefully.

APPENDIX 33

Benefits and harms to stakeholder groups, collated from the PMI worksheets

Fire retardants should be compulsory in all furniture in New Zealand (including public transport)			
From the perspective of:	Positive	Negative	Other
Firefighters	<ul style="list-style-type: none"> - Slows down burning - Have more time to get there - They don't have a bigger fire to put out - Less work - Less injuries and burns 	<ul style="list-style-type: none"> - Less money, because there are less fires - Less jobs 	<ul style="list-style-type: none"> - Might be more smoke for firefighters
Furniture makers and furniture sellers	<ul style="list-style-type: none"> - Furniture is more resistant to fire - They get more money selling it - If regulated everyone will have to buy it, more \$\$ - Workers get more pay 	<ul style="list-style-type: none"> - They are working with chemicals - They have to pay more for the chemicals - They have to import the chemical materials - If furniture is expensive people will resist buying it – less \$\$ - Harder to make –there are more steps in the making process - They get tired from all the work 	<ul style="list-style-type: none"> - Need lots of testing - Some people might be allergic to chemicals - They will need to source the materials they need to make it
Adults/children/babies	<ul style="list-style-type: none"> - More time to get out - Feeling more safe - Better chance to get out in the case of a fire 	<ul style="list-style-type: none"> - Children/babies chewing/sucking on toxic chemicals - Toxic gases may be flowing from furniture - People may have allergies to the chemicals - Poor people may not be able to afford this kind of furniture - Pets might be affected by chemicals and die - Smoke might not rise to the fire alarm to let people know there is a fire 	<ul style="list-style-type: none"> - Are there some chemicals that do not have toxins? - Will the chemicals react with anything?
Scientists	<ul style="list-style-type: none"> - They will get more money - They might get famous - They get to see lots of explosions and fires - They get lots of work 	<ul style="list-style-type: none"> - It will be bad for their health working with the chemicals - The fumes may affect them - People get angry with them 	
Schools	<ul style="list-style-type: none"> - More time for us to get out - You won't have to rebuild the school (can put the fire out in time) - More children will be safe - We might get better furniture - Feeling of being safe - Slows down the burning - Everyone can escape - Less fire danger 	<ul style="list-style-type: none"> - Toxic fumes may go into the air - Getting so many children out takes longer so they might inhale the smoke - Big cost to the school - Our money is spent on something we think is unsafe - Children may be affected by the chemicals in the furniture (going into their skin) - Children may have allergic reactions to the chemicals - It doesn't stop fires or slow them down too much if they get really big 	<ul style="list-style-type: none"> - Some chemicals might be more toxic than others - there is a space of clean air underneath the smoke layer (in a fire)

Environmentalists	<ul style="list-style-type: none"> - People get to keep more stuff than they would in a normal fire - Less fires in the environment (not so likely to spread there) - So there's more oxygen because there are more trees (that haven't burned) - More animals will be saved - They get more time to get out of fires - They get to figure out how to make the chemicals safe (get jobs) 	<ul style="list-style-type: none"> - Chemicals get into the environment. They could affect or kill animals, plants or people - Pollutes the air 	<ul style="list-style-type: none"> - Can you make it so the chemicals are not toxic and will not affect the environment?
Politicians	<ul style="list-style-type: none"> - More things to argue - More laws to make - Extra work - more money 	<ul style="list-style-type: none"> - Concern about air pollution from the chemicals - Cost of furniture for people - Cost of making the furniture (extra power) - People might be affected or might die - We will get sued more often - We might not get voted for in the next election (less money) 	<ul style="list-style-type: none"> - Might cause more debate in our country
Commuters and transport agencies	<ul style="list-style-type: none"> - Harder for vehicles to burn - More safe - Help to stop other vehicles (close to a vehicle on fire) from catching alight - More time for planes to land to get people to safety - Get more money because people feel safer so use the transport 	<ul style="list-style-type: none"> - Cost of furniture - Could be toxic fumes - People might have to pay more because of increased costs - so less people might use transport 	<ul style="list-style-type: none"> - There might be chemical reactions
Police	<ul style="list-style-type: none"> - They won't have as many jobs to do (fires to attend) - They have more time to get to a scene - It will be harder for criminals to set cars on fire 	<ul style="list-style-type: none"> - They could get paid less if there is less work 	
Farmers	<ul style="list-style-type: none"> - Slow burning. They will get out 	<ul style="list-style-type: none"> - Chemicals are not good for the animals and environment - Furniture could be expensive 	

CLASSROOM ETHICS-IN-SCIENCE PLANNER

Science/technology context:		Year: 5/6 Level: 3 Teacher: Anton
Science curriculum links:		
Ethics question:	Should we make the use of fire retardants compulsory for New Zealand furniture?	
Relevant science knowledge:	How fire works	
<u>Ethical approaches and questions</u>	<u>Activities and strategies for intended learning</u>	
Ethics focus question	Activity	Planned interactions
	Resources	Learning intentions
1. Should it be compulsory for there to be flame retardants?	Conviction continuum	Watch Flashover video What is a retardant? Introduce topic Sign consent forms On a scale students need to decide where they stand on statements such as, All furniture should be flame retardant and all airplanes should be flame retardant
2. Who/what is affected by this issue? 3. What are the benefits for those involved? 4. What are the harms for those involved?	Reciprocal reading to get the understanding	Gain understanding of flame retardants through reciprocal reading. 1 st person is leader, 2 nd clarifier, 3 rd is predictor, 4 th is questioner. Go through article and unpack. Have 2 opposing views as well.
		Flashover video
		Retardants article

5. Are some consequences greater or lesser than others?	Noisy round robin	Start off questioning. Who is affected by making flame retardants compulsory? Using a PMI go around using a noisy round robin. Debrief and see different angles	PMI sheets	
If one is harmed and another benefits, how do you decide who or what matters most?	Role play – everyone takes on the role of a member of the committee to argue their point across. Debate	Everyone takes on the role of the noisy round robin people and hold a meeting in regards to Fire retardants becoming compulsory in New Zealand and what the benefits are.	Name tags	
	Letter to company			
	Work sheet			
	Mantle of the expert			
ASSESSMENT:				