Science and Mathematics Education Centre

Developing, Implementing and Evaluating the Use of Ethical Frameworks in Teaching Bioethics Issues in a Year 10 Biotechnology Program

Siew Fong Yap

This thesis is presented for the degree of

Doctor of Philosophy

of

Curtin University

December 2012

Declaration

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

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

Signature: .....

Date: ....4/12/2012....

Abstract

With the re-emergence of values education in the school curriculum in the last decade, science is viewed as one of the key teaching domains, and in particular, socio-scientific education is increasingly perceived as instrumental in helping students explore underlying beliefs and values, develop reasoning and critical thinking skills to make informed decision on socio-scientific issues. This thesis develops a conceptual basis for a model of teaching socio-scientific issues for secondary or high school students. The teaching of controversial issues needs a stronger theoretical base and a more viable pedagogical strategy to facilitate critical thinking, argumentation and decision-making skills. Previous research has shown that science classroom discourse was largely teacher dominated and tended not to foster adequate reflective discussion of scientific issues nor forge well-informed decisions on controversial issues. The use of ethical frameworks serves as a pedagogical tool as well as provides a process to help students make ethical judgements and rationally and relationally justify them. The five ethical frameworks explored in this model are categorised as rights and duties, beneficence/non-maleficence (utilitarian), autonomy, communicative virtues and Christian moral. The features of controversy that are made explicit to the students through the use of ethical frameworks are situated in the area of human genetics and transgenic plants in Australia. Such a study is undertaken in the realm of bioethics within the context of an ethically pluralist society. The present investigation focuses on the teaching of a Year 10 biotechnology class over a period of ten weeks in an evangelical Christian college in metropolitan Perth, Western Australia. Using an interpretative case study approach, a mixed method data collection and action research as the methodology, analyses of instructional strategies, teachers and students' beliefs/values/attitudes and achievement outcomes were conducted and evaluated accordingly.

This study is unique in that it presents one of the few studies that incorporates Christian/faith values in the ethical frameworks that enables the researcher to explore the connection, if any, between cognitive learning and moral reasoning and moral

development, and in the wider sense, the link between cognitive learning (scientific literacy) and ethical reasoning.

Research findings indicate that through the use of the simple framework in comparing the pros and cons, students in the comparison group developed a limited measure of competency in reasoning and developing arguments to express their viewpoints. However, students have also been noted to be more motivated and engaged with learning science because of its increased relevance to their personal lives and societal concerns. On the other hand, the experimental group students utilise the five ethical frameworks to orientate the thinking process to explore possible alternatives, to prioritize conflicting and competing ethical claims, to examine from different perspectives and to integrate their information by linking from knowledge content and/ or claims to well-grounded conclusions. Essentially, the use of ethical frameworks *guides* students' understanding of the socio-scientific issue and helps them to *formulate* the crux of decision-making. Data analysis from both qualitative and quantitative aspects suggest that the use of ethical frameworks has brought about a marked improvement in the students' ability to reflect critically, reason analytically and make rational decisions about their own ethical values in handling socio-scientific issues. Research finding also confirms the the important role of the teacher in implementing the ethical frameworks as a reasoning and argument-developing tool in socio-scientific education. On a modest level, research from the present study has shown that using the frameworks for both comparison and experimental groups has instilled in teachers some measure of confidence; with the five ethical frameworks proven more satisfying and effective as a pedagogical tool. This study suggests that, from a teacher's perspective, the use of ethical frameworks could be a viable tool in socio-scientific education, and this needs to be supported by the teacher taking a procedural neutral stance, role-modelling the scientific reasoning process through carefully crafted questions, creating a collaborative and caring learning environment and a variety of student-centred teaching strategies.

The incorporation of faith values in the ethical frameworks confirms previous research that there is the possibility that *other* concepts besides that of justice and fairness could be the key in determining how one judges what is morally right. The present research also suggests that there are different problem-solving strategies in making moral judgements beside stage schemes of justice described by cognitive

developmental psychologists and educators. The present study also suggests that allegiance to belief systems and ideologies can sometimes override the influence of one's own sense of fairness in making decisions of moral rightness. This is an important factor to consider in mapping out curriculum for moral education and socio-scientific education.

Overall, the analysis suggests that socio-scientific education programs focusing on dialogical and reflective processes could help to facilitate socio-scientific reasoning. The study also argues for the importance of providing a sound epistemological and dialogical environment for socio-scientific education in a science classroom through the use of carefully constructed and evaluative metacognitive tools of learning in scaffolding and structuring reasoning and argumentation process, of which the use of ethical frameworks has proven to be modestly effective.

Acknowledgements

I am indebted to my thesis committee comprised of Professor David Treagust, Professor Vaille Dawson and Professor Darrell Fisher. I would like to specially thank Professor Vaille Dawson for her guidance, encouragement and direction which were always graciously offered permitting this study to progress with minimum delay. It has been a real privilege to learn from her.

I would like to express my gratitude to Professor Darrell Fisher for his indefatigable support in the final stage of the thesis writing. He is the epitome of patience and professionalism as he led me through the last lap – I am deeply thankful.

A special thanks to the leadership, staff, students and parents of Kingsway Christian College whom without their support and contribution to the research, the thesis will only remain a hope and not a realised dream.

I am especially thankful to my husband, Samuel and two daughters, Marcia Ann and Christie May for their understanding, encouragement and support throughout the duration of my doctoral research.

Finally, I wish to thank God, my Abba Father, for sustaining me with the strength and stamina I needed at each juncture to see this thesis through its successful completion.
Soli Deo Gloria.

Table of Contents

List of Tables

List of Figure

CHAPTER 1

INTRODUCTION TO THE RESEARCH STUDY

This chapter serves as an introduction to the present research study where the focus is on the use of ethical frameworks in enabling students confronted with controversial dilemmas in socio-scientific issues. In doing so, I aim to contribute towards a pedagogical strategy that will facilitate critical thinking, argumentation and decision-making skills.

First, the introduction to the research is provided. Second, the background and the rationale for undertaking such a study are presented. Third, the objective of the research is stated. Next the three research questions are listed, followed by a discussion of the significance in undertaking the present research and the definitions of key terms used in the study. Finally, an overview of the research study is included with the chapter's overview.

1.1 Introduction

We live in an age where scientific knowledge has provided human beings with an unprecedented ability to manage and manipulate life and death. Since the publication of the human genome in 2003, major changes are evident in a diversity of practices such as medicine, forensics, the production of bio-fuels, the development of vaccines and cleaning of polluted soil (Netherlands Genomics Initiative, 2007). It has also become increasingly apparent that science and technology are increasing at a rate faster than the human capability to comprehend fully or evaluate effectively the consequences of their utilisations. School curricula usually lag behind scientific innovations and in the definitive effort to address this challenge, science educators from different parts of the world recognised the importance of socio-scientific issue didactics to develop responsible scientific citizenship (Aikenhead, 1986, 1994, 2006;

Driver, Newton & Osborne, 2000; Fensham, 2009; France, 2007; Kolsto, 2001a; Zeidler, 1984).

The purpose of the socio-scientific issues movement was to ensure that students are engaged in meaningful learning of context knowledge to help them identify the interdependence between science and society (Sadler, Chambers & Zeidler, 2004). Socio-scientific issues have also come to the fore in science education because of their central role in promoting scientific literacy (Bingle & Gaskell, 1994; Driver, Leach, Millar & Scott, 1996; Zeidler & Keefer, 2003). This focus on scientific literacy, which is reflected in the standards and reform documents in the United States (American Association for the Advancement of Science, 1990; National Research Council, 1996; Siebert & McIntosh, 2001) and in the United Kingdom (Millar & Osborne, 1998) and in Australia (National Science Standards Committee, 2002; Curriculum Council of Western Australia, 1998; Shape of the Australian Curriculum: Science, 2009), maintains that science students need to develop the ability to make informed decisions regarding scientific issues of particular social import. Scientific literacy, at least in part, entails the ability to analyse, discuss, interpret relevant evidence, and draw conclusions in response to socio-scientific issues.

References to the term `socio-scientific issues' encompass a range of social dilemmas with conceptual, procedural or technological associations with science (Fleming, 1986; Kolsto, 2001a; Patronis, Potari & Spiliotopoulou, 1999; Zeidler, Walker, Ackettt & Simmons, 2002; Sadler & Zeidler, 2005a). In general, socio-scientific issues involve some processes of science or products that generate controversy or debates. These issues may arise from gene technology such as stem cells, therapeutic cloning, genetically modified foods and reproductive technologies involving *in vitro* fertilisation, genetic screening and genetic engineering.

Sadler (2004) pointed out that socio-scientific research focuses on four main directions: relationships between the nature of science conceptualisations and socio-scientific decision-making, ways of evaluating information regarding socio-scientific issues, influence of conceptual understanding on reasoning regarding socio-scientific issues, and socio-scientific argumentation in genetic engineering (Ekborg, 2008; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Osborne, Erduran, & Simon, 2004;

Simonneaux, 2001; Zohar & Nemet, 2002), environmental issues (Kortland, 1996; Osborne, Erduran & Simon, 2004; Wu & Tsai, 2007) and other public health issues (Albe, 2008; Kolsto, 2006; Lee, 2007). Recent studies have also shown that in dealing with difficulties of implementing the curricula, in particular, students' poor argumentation in the context of socio-scientific issues has become a concern in science education (Boerwinkel & Waarlo, 2009; Acar, Turkmen & Roychoudhury, 2010). In the latter study, the authors proposed that explicit teaching of reasoning and argumentation research should provide teachers with a decision-making framework in which students can consider their values about a socio-scientific issue and assess different alternatives as well as incorporate teaching about common heuristics.

In this study, I focus on the use of ethical frameworks in empowering students faced with controversial dilemmas in socio-scientific issues. This is aimed at working towards a viable pedagogical strategy that will facilitate students' critical thinking, argumentation and decision-making skills and provide them with a framework that incorporates faith/values.

1.2 Background and Rationale

Research studies pertaining to the teaching of controversial issues in the science classroom are well-documented (Albe, 2008; Allchin, 1999; Bell & Lederman, 2003; Conway, 2000; Fowler, Zeidler & Sadler, 2009; Kolsto, 2001a; Kolsto et al., 2006; Levinson, 2006, 2008; Oulton, Dillion & Grace, 2004; Sadler & Zeidler, 2004, 2005a; Webster, 2008; Yehudit & Revital, 2003; Zeidler, Sadler, Simmons & Howes, 2005) and have gained increasing interest in the dimension of establishing explicit ways of helping students develop moral values and good citizenship. Despite the many and varied attempts, there are numerous issues that need to be addressed.

First, although resources (including textbooks, laboratory practical protocols and web-based resources) are plentiful, there is little evaluative research (Schallies & Solterer, 1992). It is therefore vital to test the efficacy of a resource, an instructional strategy, a pedagogical tool or a methodology. Competency to utilise the resources

by the teachers and/or pre-service teachers is a plausible area (arising from this observation) that requires some level of research for effective implementation.

Second, there is a growing need to develop critical thinking skills when working through biotechnological issues (Dawson, 2000; Conner & Gunstone, 2004). The aforementioned has discussed briefly this vital need. The nature of socio-scientific issues is such that they are usually open-ended, not very well-structured, debatable problems that necessitate viewing from many and varied perspectives and sometimes require multi-pronged solutions (Sadler, 2009). Hence, the ability to ask meaningful questions and think logically and systematically including related multi-dimensional cognitive skills or higher order cognitive skills needs to be enhanced.

Third, there is a notable lack of attention to values in science which would be needed to resolve conflicts in values perspective (Jorgensen & Ryan, 2004). This observation that value-based reasoning is an integral part of socio-scientific argumentation requires that scientific instruction pays close attention to student values and core beliefs in argumentation discourse. (Acar, et al., 2010; Fensham, 2002; Sadler & Zeidler, 2005b). It has been suggested that educators need to explore ways of framing socio-scientific issues that encourage the use of different modes of reasoning patterns including value-based reasoning that would provide more space to respect student's values in socio-scientific issues (Bell & Lederman, 2003; Conway, 2000; Fleming, 1986; Sadler & Zeidler, 2005a).

Fourth, there is inadequate attention directed to forming new strategies (e.g. argumentation, informal reasoning) for developing the criteria and information to support a point of view (Simmonneaux, 2001 & 2002). Recent science curriculum reform documents in Australia support the idea that improving science literacy of students is the main purpose of science education (Goodrum, Hackling & Rennie, 2001; Tytler, 2007). Since an important aspect of science literacy is `to use their science understanding to contribute to public debate and make informed decisions about their environment, their own health and well-being' (Goodrum et al., 2001, p. 15), it is vital to consider how argumentation competence of our students can be built. While it may be argued that students may have argumentation ability intrinsically, this can only be enhanced by *explicit* argumentation instruction.

Fifth, affective learning is given little emphasis compared to cognitive learning. There is a need to intentionally make provision for students to recognise their emotional response as an important component of learning (Hunt, Fairweather & Coyle, 2003; Ritchie, Tomas & Tones, 2011; Teixeira dos Santos & Mortimer, 2003).

Sixth, the view that socio-scientific issues are inherently moral issues is supported by a number of research reports, which have consistently documented consideration of moral issues in the negotiation and resolution of socio-scientific issues. Research that has provided empirical evidence for the role of moral consideration in socio-scientific issues decision-making by individuals of various ages include middle school (Hogan, 2002; Pedretti, 1999); high school (Fleming, 1986; Fowler, et al., 2009; Sadler & Donnelly, 2006); college (Sadler, 2004; Zeidler et al., 2002); and adults (Bell & Lederman, 2003). These studies document moral considerations in a wide variety of issues including genetic engineering, biomedical research, environmental problems and animal research.

Reiss (1999) highlighted four aims of teaching ethics in biological science courses. Based on a research study by Davis (1999), Reiss drew our attention to the fact that teaching ethics could heighten the ethical sensitivity; increase the ethical knowledge; improve the ethical judgement of students and make students better citizens. An increasing commitment to the moral and ethical dimensions of science education is already evident in numerous countries seeking to enhance science literacy (Zeidler, 2003).

In this respect, the present study incorporates the Christian moral framework as the fifth ethical framework to address the moral dimension in teaching of ethical issues. Given the setting for this research is conducted in a Christian (Protestant Evangelical) College, it is appropriate that the added framework provides an avenue for which the religious faith of the students can be expressed and articulated accordingly.

The National Curriculum Framework Core Values for Australian Schooling (2010) clearly indicates that the teaching of socio-scientific issues has a place in the science and citizenship curricula. In the section on Achievement Standards for Year 10 Science, the following was noted.

> By the end of Year 10, students are able with some guidance to…… *demonstrate the ability to use scientific evidence in their decision making and in developing arguments about science-related issues……. They evaluate how advances in science and technology have impacted on society and environment and use scientific knowledge across a range of sciences to critique claims and propose responses to contemporary issues* (e.g. genetic engineering, biodiversity and sustainability). They can identify distinct branches of science and can give examples of the multi-disciplinary nature of much contemporary science. (italics, emphasis mine) [no pages given]

In highlighting the seven general capabilities as key dimensions of the Australian Curriculum, two of the attributes, namely *critical thinking* and *ethical behaviour* are highlighted. These attributes can be cultivated through the teaching of socio-scientific issues in the science curricula. In particular, socio-scientific education is recognised as essential in the implementation of Science as a Human Endeavour strand of the Australian Curriculum in Science because it reinforces the three inter-related organising elements of the ethical behaviour learning continuum in the Australian Curriculum (2012):

1. Understanding ethical concepts and issues
2. Reflecting on personal ethics in experiences and decision making
3. Exploring values, rights and ethical principles

However, given a plethora of educational measures to promote the teaching of socio-scientific issues, there is *relatively little consensus* on how this should be most effectively conceptualised and addressed (Levinson, 2006). Research has also indicated the need for teachers to provide some guidelines to think about scientists' knowledge and behaviour (Millar, 1996; Osborne et.al., 2003) and about the economic and political use of such knowledge and skills. Our deeply rooted human values affect what current knowledge makes possible and how it is used (Lewis, 1997; Massarani & Castor Moreira, 2005). Crosthwaite (2001) suggested that one of the aims of ethics teaching is to provide frameworks for ethical deliberation which students can adopt. This is derived from the overall aim of increasing ethical awareness and ethical reflection in a community. This view is also supported by Reiss (2008) in the use of ethical frameworks in a new context-based course for 16-18 year-olds and by Saunders and Rennie (2011) in the use of ethical frameworks incorporating pluralism as well as evidence from numerous research reports (Acar et

al. 2010; Albe, 2008; Levinson, 2006, 2008). It is in line with this aim of ethics teaching using ethical frameworks that the present study is undertaken.

The ethical framework used by the comparison group is referred to as the `**simple framework**' (essentially *one* framework comparing the pros and consequences) while the ethical framework used by the experimental group is referred to as the `**ethical frameworks**' as it encompasses a set of *five* ethical frameworks.

1.3 Objective of the Research

The present study examined the effectiveness of a model of teaching socio-scientific issues using ethical frameworks with special emphases on reflection, deliberation and decision making in a Year 10 biotechnology program.

1.4 Research Questions

In working towards the objective of the research, the following three research questions were posed.

1. How effective is the simple framework in developing students' ability to reason analytically and make decisions about ethical issues?

2. In what way does the use of the five ethical frameworks affect students' ability to reason analytically and make decisions about ethical issues?

3. In what way does the use of ethical frameworks influence the teachers' approach in teaching socio-scientific issues?

1.5 Significance

This research is significant for a number of reasons. First, developing a model of teaching controversial issues through the use of ethical frameworks could enhance

the student-centred teaching approach in that students are empowered to think critically and are given a useful tool for working through ethical issues. Second, the present study may prove to be a viable model for demonstrating how values education can be incorporated in science education. This would accord well with the Australian Curriculum in Science (2012). Third, the present research could provide a reasonably sound basis and viable model to further examine how informal reasoning (rationalistic, intuitive, emotive and/or moral) and argumentation skills can be built through a structured approach. Fourth, due to the intrinsic case study incorporating religious and faith values within a unique evangelical college setting, this study could provide some insights on the influence of faith and moral reasoning in science education. Fifth, the present study, if proven effective, has far-reaching implications for public understanding and/or applications of science and societal improvement and growth in citizenship.

1.6 Definition of Key Terms in the Research

Socio-scientific issues (SSI)

An agreement on a specific definition of socio-scientific issues does not exist. However, there are some characteristics of such issues that can be reasonably represented in the following definition. **Socio-scientific issues** are open-ended, ill-structured, debatable problems that involve multiple perspectives and interpretations in the discipline of science in daily life, technology and society (Sadler, 2009).

Scientific Literacy

In summarising and synthesising the varied perspectives on the construct of `**scientific literacy**', a useful heuristic was provided by Roberts (2007) who characterised the diversity of views on `scientific literacy' by postulating two visions of the construct. The first approach envisions `scientific literacy' as `thorough knowledgeability within science', that is, looking at the products and processes of science itself. The second approach suggests that `**scientifically literate** individuals should be able to *confront*, *negotiate* and *make decisions* in everyday situations that

involve *science*.' (p.730) The latter approach is the preferred definition as it has direct implications for socio-scientific education.

Decision Making

Decision making is defined as the process of making reasoned choices from among alternatives (Cassidy & Kurfman, 1977, Kortland, 1996, Ratcliffe & Grace, 2003) based on examination of the relevant scientific knowledge involved (Bingle & Gaskell, 1994), explicit awareness of the guiding values and current knowledge relevant to the issue (Aikenhead, 1985) and well-supported evidence. Development of better and more informed decision making involved basing decisions on scientific evidence and understanding of the subjectivity and change related to scientific knowledge. Thus, a decision should not be based solely on emotion or personal experience. The acceptable product of informed decision making is to have students utilise the available evidence (data/observations) as key to their arguments about a socio-scientific issue when they attempt to convince others for their point of view.

Argumentation

Decision making and argumentation in socio-scientific issues represent closely connected competencies in science education. Decision making is an important but a complex process based on argumentation (Patronis, Potari & Spiliotopoulou, 1999, p. 751). Argumentation is defined as a rational process that relies on rigorous application of knowledge evaluation criteria (Jimenez-Aleidandre & Erduran, 2008, p. 13) and the instrumentation of developing argumentation in the present study is the use of ethical frameworks. A preferred definition is suggested by Finocchiaro (2005, p. 15) who defined `argument' as `an instance of reasoning that attempts to justify a conclusion by supporting it with reasons or defending it from objections.'

Ethics and Morals/Morality

`Ethics' refers to the branch of philosophy dealing with questions related to *rights* and *normative judgements*. Traditionally, `morals' are more often used in the personal contexts while `ethics' is more frequently referred to in professional settings (Zeidler & Sadler, 2008). In most modern contexts, including the area of science education, *ethics* and *morality* are used interchangeably and such an understanding is taken for the present study.

Ethical/Moral Reasoning

Ethical/moral reasoning is developed from the process of argumentation and discourse. On the one hand, it is a competency whereby students can evaluate potential decisions with respect to how well decisions are based on scientific knowledge, evidence and data and the extent to which they attend to potential short- and long-term future consequences. On the other hand, it extends beyond mere scientific/technical competence insofar as the student must consider how well their decisions attend to the issue of what is fair, just and equitable. Such reasoning arises out of a special type of reflexive judgment that transcends competency in decision-making because there is *value judgement involved*, and this adds to the formation of conscience and empathy, integral in the larger context of moral/ ethics development, norm acquisition and character formation.

Informal Reasoning

Informal reasoning is reasoning which does not utilise formal logic. It employs rhetorical and dialectical forms of arguments. Rhetorical forms of argumentation refer to arguments in monologues where an individual uses discursive techniques to persuade or convince another. In contrast, dialectical forms of arguments are involved in dialogues involving two or more persons.

The framework designed by the researcher for understanding informal reasoning for the present study is an adaptation of the model of the emergent framework proposed by Sadler and Zeidler (2005a). Four unique patterns of informal reasoning are displayed in argumentation; namely - rationalistic, emotive, intuitive and moral (ethical).

Rationalistic pattern of informal reasoning is based on reason and logic. Students justified their claims based on a reasoned analysis of the situation under consideration.

Emotive pattern of informal reasoning is based on a care perspective where empathy and concern for others are the main features.

Intuitive pattern of informal reasoning is demonstrated by individuals who experienced, shared and based their arguments on immediate reaction to the socio-scientific prompts.

Moral pattern of informal reasoning (which may exist side by side with the above attributes) incorporate values and/ or beliefs in their reasoning and these embedded values actually represent the culmination of an individual's social and cultural identities (Haidt, 2001).

1.7 Overview of the Research Study

In summary, the present study aims to evaluate the effectiveness of an approach to teaching socio-scientific issues through the use of ethical frameworks in a Year 10 biotechnology program of ten weeks using action research and mixed methods approach. The effectiveness of this pedagogical tool is determined by the progress demonstrated in students' informal reasoning, critical thinking, decision-making ability and integration of values in their argumentation. From a teaching perspective, the effectiveness of such an approach is also evaluated in terms of enhanced level of the teacher's confidence, if any, in the implementation of the ethical frameworks in a science classroom setting. The integration of Christian/religious values in the framework and their implications are given due consideration as the research is conducted in an evangelical Christian school.

1.8 Chapters Overview

Chapter 1 starts with a general introduction to the research study and identifies the purpose of the socio-scientific issues movement and surveys briefly the four main directions undertaken. The background and rationale for the present research are stated both from the perspectives of previous and current research as well as from the viewpoint of fulfilling the educational outcomes of the Australian Curriculum newly

implemented (from 2011 onwards). The objective of the present research and the three research questions are also stated, followed by a reinstatement of its significance and a treatment of key terms used in this research.

Chapter 2 entails reviewing relevant literature related to use of ethical frameworks in dealing with socio-scientific issues. A survey of the socio-scientific issues movement and its attendant challenges provides a platform to discuss and delineate implications for the present study.

Chapter 3 provides a description of the research methodology involved in this investigation that addresses the research questions stipulated above.

Chapter 4 provides the data collected from the investigation followed by an analysis of the results obtained both from qualitative and quantitative analyses and seeks to address the three research questions.

Chapter 5 provides an in-depth discussion of the research findings gleaned from both quantitative and qualitative analyses and concludes with a summary of the research findings to the three research questions.

Chapter 6 concludes by providing a summary of the thesis, enumerating the research findings based on the qualitative and quantitative data analyses, highlighting the significance of the findings and the limitations of the research as well as discussing practical implications and making recommendations/suggestions for a way forward towards science education reform and practice in the context of socio-scientific issues.

The appendices section provides a list of questionnaires, pre-tests, post-tests and interview questions posed during the investigation and some of the raw data collected from students and teachers.

This chapter is followed by Chapter 2 which provides the literature review on the thematic areas of recent research connected to socio-scientific issues, ethical thinking and rationale for and the use of ethical frameworks, and lastly, focuses on morality and religious values in socio-scientific education.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The objective of Chapter 2 is to review literature that supports the value and the purpose for the present study. This chapter is divided into three parts that review literature on the thematic areas of recent research connected to socio-scientific issues, ethical thinking and rationale for and the use of ethical frameworks and lastly, morality and religious values in socio-scientific education.

The first section of this chapter concerns the thematic areas of recent research connected to socio-scientific issues. It explores the four main facets of socio-scientific issues research; primarily nature of science issues, classroom discourse issues, case-based issues and evaluating informal reasoning and decision-making in socio-scientific issues, followed by the implications of research findings stemmed from these areas of studies. In view of these four main facets and the implications for future studies, the position of the present study in the research of socio-scientific issues movement is also stated.

The second section of this chapter begins by defining `ethical thinking' and stating the rationale for constructing ethical frameworks. This is followed by a review of the types of ethical frameworks that have been commonly used; namely, the Conventional Ethical Framework, Ethical frameworks – the Four Principles Approach, Ethical Frameworks Integrating Pluralism and Ethical Frameworks for Classroom Approach.

The third and final section of this chapter discusses the relationship between morality and religious values in socio-scientific education. This section also outlines the use of domain theory used by several researchers as well as delineating three broad moral philosophies that could be applicable to socio-scientific decision-making; primarily deontology, consequentialism and care-based morality. The importance of

creating a `construal' is also emphasized in relation to integration of scientific issues with values and ethics to facilitate well-informed decision making. A `construal' refers to the process which an individual assesses the morality in a given situation. The meaning of `construal' is further expanded on page 38.

2.2 Thematic Areas of Recent Research Connected to Socio-Scientific Issues (SSI)

Socio-scientific issues are gaining increasing importance and hence, the attention of science educators in many parts of the world as it emerges as a vital means to make science learning more engaging and more relevant to students' lives. Socio-scientific issues are recognised as a tool for addressing learning outcomes such as an appreciation for and understanding of *the nature of science* (Bell & Lederman, 2003; Sadler, Chambers and Zeidler, 2002; Zeidler et al., 2002), improved dialogical argumentation in *classroom discourses* (Driver, Newton & Osborne, 2000; Patronis, Potari & Spiliotopoulou, 1999; Zohar & Nemet, 2002), developing scientific literacy through *case-based issues* (Hogan, 2002; Kolsto, 2001b; Sadler & Zeidler, 2004; Simmonneaux, 2001; Sprod, 2011; Walker & Zeidler, 2003; Zeidler et.al., 2002; Zohar & Nemet 2002) and the ability to *evaluate scientific data and information* (Jimenez-Aleixandre et al., 2000; Kolsto, 2001b; Korpan et al., 1997).

Given the vital role that socio-scientific issues play in science education, an overview of the four pedagogical issues (nature of science, classroom discourse, scientific literacy through cultural and case based issues, competency evaluation method/instrument) identified above is presented to synthesize current lines of research relevant to the exploration of socio-scientific issues in science education and further articulate a research-based model of issues central to ethics/moral education in the context of science education. The purpose is to provide educators and researchers with a thematic understanding of how these areas are at once fundamental and interdependent, and when linked through the exploration of domains of socio-scientific issues, address morality.

2.2.1 Nature of Science Issues

The Nature of Science (NOS) issues highlight the importance of students' epistemological beliefs in shaping their decisions regarding socio-scientific issues (Bell, 2004; Bell, Lederman & Abd-El-Khalick, 2000). Epistemological orientations regarding the nature of science influence how students attend to evidence in support of, or in conflict with, their pre-instructional belief systems regarding social issues. In this context, moral reasoning proper is understood to be the result of the opportunity for learners to make meaning using empirical and social criteria in both formal and informal educational contexts through rational discourse. Zeidler et al. (2002) have shown that students who have naïve and relativistic conceptions of science will likely dismiss scientific knowledge as irrelevant to decision making when reasoning about SSI because they tend to distort whatever data, evidence or knowledge claims are available to them in order to support a pre-determined viewpoint with respect to the issue under consideration. Related research informing socio-scientific issues reasoning and NOS confirms students tend to rely more on personal relevance over evaluative decisions based on serious consideration of presented evidence (Sadler, Chambers & Zeidler, 2004). Their study also showed that while some students were able to recognise data and not able to tell its significance, there were many who could not distinguish between data, unfounded opinions and predictions.

Bell and Lederman (2003) in a study of reasoning patterns of professors and science educators, philosophers and research scientists found that these groups demonstrated similar reasoning patterns based on personal philosophy and commitments over reasoning based on scientific evidence.

These findings underscore the importance of explicit instruction in NOS so that careful evaluations of evidence regarding socio-scientific issues and subsequent decisions can be utilised. This implies that a step forward is to consider the goal of teaching NOS Science in classrooms which is to develop students' ability to critically evaluate competing scientific claims; then they can be guided to synthesise and apply their understanding of the NOS as they evaluate and make decisions regarding socio-scientific issues. Students need not articulate the meaning of the nature of science and describe its relevant attributes; but suffice for them to use their

understanding of NOS to effectively evaluate the efficacy of many different kinds of claims – scientific or otherwise - based upon the merit of supporting evidence in everyday life. This goal of developing transferable reasoning skills is one that is central to promoting the use of socio-scientific issues in the science curricula.

However, when you look into socio-scientific issues, not all decisions are based purely on `reasoning'. There are multiple perspectives of looking at an issue. These involve values, beliefs and principles.

There are other factors to consider. First, science is not the only aspect to consider when studying a socio-scientific issue; financial, ethical, legal, political and social aspects are also to be considered. Due to the inter-relatedness of science and society, science cannot be considered to be neutral. This is important in evaluating scientific expertise. Second, science is process based, relying on argumentation and peer criticism. To understand the temporary nature of scientific results, there is an inherent need to debate controversial issues (Molinatti et. al, 2010, p. 2237).

2.2.2 Classroom Discourses Issues

The classroom discourse issues highlight the importance of discourses in peer interactions and its impact on reasoning. This research underscores the importance of developing students' views about science through *argumentation* in the construction of shared social knowledge via discourse about socio-scientific issues.

Argumentation and decision-making use *values and beliefs* (italics mine) as well as `social means for comprehending reality' (Kneupper, 1981). Such an interaction of these two competencies provides students with the opportunity to construct, store and access data in the social context in which it occurs (Kaufer & Geisler, 1990; Kolsto & Ratcliffe, 2008; Perry & Dockett, 1998) while drawing on their previous knowledge (Coburn, 1993). During this process of reasoning through a given socio-scientific context, students are actively involved in meaning-making and interpretation of ideas and the construction of explanations (Coburn, 1993; Ertmer & Newby, 1993) from the information provided in that context (Osana, Tucker & Bennett, 2003). This leads to decision making in that situation (Baumberger-Henry, 2005; Osana et.al, 2003) and the developing of decision making skills they will use

outside the classrooms and hence exercising responsible, active citizenry (Molinattia, Giraulta & Hammond, 2010).

While many science educators acknowledge the importance of rich and diverse classroom discussions in the promotion of scientific literacy (Aikenhead, 1985, 2000; Dawson & Venville, 2009; Driver, Newton & Osborne, 2000; Kubli, 2005; McNeill & Pimentel, 2010; Vellom, 1999; Zeidler, 1984, 1997; Zeidler, Lederman & Taylor, 1992), those who seek to study have difficulty locating substantive argumentation or classroom discussions in school (Newton, Driver & Osborne, 1999) or find the quantity and quality of discussions with explicit content of science very low (Levinson, 2003). Perhaps, science teachers attending to moral and ethical issues may be given unrealistic expectations; other teachers representing interdisciplinary studies may offer support in facilitating the dynamics of argumentation and discourse. Other strategies used are documented with the use of `dilemmas' in high school science students by Sadler & Zeidler (2003). The value of argument in the development of moral reasoning has been demonstrated in the research literature (Acar et al., 2010; Berkowitz, 1985; 1997, 2002; Grace & Ratcliffe, 2002; Keefer, 2002; Keefer, Zeitz & Resnick, 2000; Sadler, 2004) in terms of creating dissonance to provide opportunity for re-examining one's beliefs and thought processes.

In a comprehensive review of literature, Sadler (2004) summarised trends related to argumentation as a means of expressing informal reasoning and reiterated that the personal experiences of decision makers emerged as a consistent normative influence on informal reasoning related to socio-scientific issues. More specifically, informal reasoning was found to either mediate scientific knowledge or prevent further consideration of scientific knowledge.

It would seem that the opportunity to engage in informal reasoning through argumentation allows for the evaluation of evidence as well as thought, but finding appropriate pedagogical strategies to seamlessly integrate such dynamic social interaction in the science classroom remains a high priority. Teaching science in this context includes attention and sensitivity to students' moral commitments, emotions and moral behaviour. The development of character in children (as seen in

development of moral reasoning) becomes an additional important pedagogical outcome arising from the intrinsic nature of argumentation as pedagogy.

In a recent study on Western Australian high school students' argumentation and informal reasoning abilities about biotechnology, Dawson and Venville (2009) demonstrated levels of argumentation competencies quite similar to the UK and other countries but students tended to use intuitive and emotive informal reasoning more frequently than rational. So there is a need to explore strategies to build rational informal reasoning that is associated with more sophisticated arguments.

2.2.3 Case-Based Issues

The case-based issues highlight the importance of developing scientific literacy and active citizenship through the use of socio-scientific issues. As defined in page 8 - 9 of this study, `scientific literacy' is envisioned in terms of abilities to use science in students' everyday lives. Science education thus has a significant role to play in the process of preparing active and informed citizens. Therefore, context becomes an important factor in learning, and not just a backdrop against which learning takes place. The introduction of case-based issues and problems in setting the relevant context will involve the use of the mind and the heart. It has also become increasingly obvious that hands-on science is not enough: we need to have minds-on science (Sprod, 2011). Studies involving example cases of genetically modified foods (Walker & Zeidler, 2003), human genetic engineering (Sadler & Zeidler, 2004; Zohar & Nemet, 2002), animal experimentation (Simmonneaux, 2001; Zeidler et.al., 2002) and environmental dilemmas (Hogan, 2002; Kolsto, 2001b) provide strong support for the efficacy of using controversial socio-scientific case studies to foster critical thinking skills and moral and ethical development. These studies strongly suggest that curricula using such issues provide an environment where students become engaged in discourse and reflection that affect cognitive and moral development. The essence of using a socio-scientific issue as a strategy has been described as follows:

If we hope to stimulate and develop students' moral reasoning abilities, then we must provide students with rich and varied opportunities to gain and hone such

skills. The present argument rests on the assumption that using controversial socio-scientific issues as a foundation for individual consideration and group interaction provides an environment where students can and will increase their science knowledge while simultaneously developing their critical thinking and moral reasoning skills (Sadler & Zeidler, 2003, p.5)

Similarly, other researchers have developed (or modified existing) protocols that have addressed the implementation of case-based issues in science classrooms. Pedretti (2003) has had successful experiences with pre-service teachers who embraced the idea of incorporating socio-scientific issues via STSE (science-technology-society-environment) in the curriculum. Using Radcliffe's (1997) model as an organizational framework has allowed Pedretti's (2003, p. 231) students to develop their own decision-making models for pedagogy outcomes and includes the following:

Table 2.1 Pedretti (2003) Organizational Framework for Pedagogical Outcomes

1.	Options – Identify alternative courses of action for an issue
2.	Criteria – Develop suitable criteria for comparing alternative actions
3.	Information – Clarify general and scientific knowledge/ evidence for criteria
4.	Survey – Evaluate pros/cons of each alternative against criteria selected
5.	Choice – Make a decision based on the analysis undertaken
6.	Review – Evaluate decision-making process identifying feasible improvements

Keefer (2003) has reported the results using case studies with undergraduate and graduate science students and has noted that the values of the domain of concern for the issue, rather than the gender or a general disposition for a particular moral orientation (*contra* Gilligan) accounted for the differences in students' reasoning. His work examined ethical care responses in professional contexts and led to an empirically derived model for decision-making in practical contexts using moral case studies. Keefer's (2003, p. 253) model entails the following as shown in Table 2.2:

Table 2.2 Keefer (2003) Model for Decision Making in Practical Contexts

1.	Identify the moral issues at stake.
2.	Identify the relevant knowledge and unknown facts in a problem
3.	Offer a resolution
4.	Provide a justification
5.	Consider alternative scenarios that argue for different conclusions
6.	Identify and evaluate moral consequences

This moral heuristic has been used successfully in the analysis of engineering ethics case studies for professionals and is strikingly similar to Pedretti's six-component model described above. Keefer makes it clear in his analysis that ethical instruction is most successful when it is integrated into those *authentic* contexts that will subsequently be practised by students.

Another complementary approach to case-based socio-scientific issues provides a *more explicit critical* examination of students' *personal interests and values* as they provide arguments that evaluate scientific knowledge claims. Kolsto (2000) reported on a consensus project model that used mainly with upper secondary science students which emphasizes that scientific knowledge is formulated by consensus building via critical discourse among (competent) peers. The major premise of the consensus approach is that a general knowledge of the human nature and limitations of scientific claims is needed to place scientific statements in adequate terms so consensus decisions regarding socio-scientific issues can be achieved. Necessarily broad in nature, the consensus projects tended to have four key attributes (Kolsto, 2000, p. 652).

Table 2.3 The Four Attributes of Kolsto (2000) Consensus Project

1.	Presentation and defense of data/conclusions against possible opposition from the teacher and fellow students with a goal toward consensus of issues;
2.	Views of professionals and non-professionals are solicited on a particular SSI so balanced recommendations can be formulated and passed on to politicians and/ or policy-makers.
3.	Students search for a common conclusion on which they can all agree while seeking input from `experts' defined as anyone with relevant knowledge exceeding general knowledge.
4.	Students write a report containing their assessments and conclusions, which is made available to the public or politicians or policy makers.

Such an approach places great demand on the teacher whose role is that of a counsellor, consultant and critic, as well as expeditor. Students realise from the onset that their positions will be challenged and met with critical appraisal in the process of consensus building. There are several approaches teachers can adopt in teaching socio-scientific issues; namely advocacy, affirmative neutrality or procedural neutrality (Hodgkin, 1985). The objective is for teachers to transform their pedagogical focus and scientific epidemiology so students can better understand how such knowledge is generated and validated (Abd-El-Khalick, 2006). Teachers can thus create a classroom environment where students can develop meaningful understanding of scientific concepts in relationship to real-world circumstances. In this respect, teachers can transform their pedagogical orientation `from being purveyors of scientific knowledge to moderators and mediators of a classroom culture that mirrors society in which students are challenged to make informed scientific decisions and exercise moral reasoning' (Zeidler, Applebaum & Sadler, 2011, p.277).

From these perspectives, socio-scientific issues may be equated with the consideration of ethical issues and construction of moral judgements about scientific topics via social interaction and discourse. Students will be confronted with multiple perspectives to moral problems that inherently involve discrepant viewpoints and information, sometimes at odds with their closely held beliefs. The joint construction of scientific knowledge that is at once personally relevant and socially shared therefore relies on exposure to, and careful analysis, of cases involving considerations of data, and argumentation that may be in conflict with one's existing conceptions regarding various socio-scientific moral ethical issues.

In their study, Berland and Reiser (2009) made use of an instructional framework to help students make sense of argumentation and explanation using IQWST materials (Investigating and Questioning our World through Science and Technology). IQWST research and design initiative is a middle school science curricula designed to use project-based investigations as a context for student participation in scientific practices (such as constructing and defending explanations).

This framework structures how students articulate their understandings to guide their sense-making. To that end, the IQWST instructional framework for constructing and defending scientific explanations builds on Toulmin's argumentation model and similar design endeavours (Clark & Sampson, 2007; Erduran, Simon & Osborne, 2004; Sandoval & Reiser, 2004; Suthers et al., 1997) to make explicit the importance of making claims that can be justified with evidence and scientific ideas. This framework, presented by McNeill and Krajcik (2007) contains these components.

Table 2.4 McNeill and Krajcik (2007) Argumentation Model

Claim	: the answer to question
Evidence	: information or data that support the claim
Reasoning	: a justification that shows why the data count as evidence to support the claim.

The framework is used to support whole class discussions and provide scaffolds in the written materials. This IQWST framework supports sense-making and articulation by identifying the types of knowledge that are necessary when engaging in the practice of constructing and defending scientific explanations. However, this framework does not appear to address the social challenges facing students – that is, one of persuasion. The weakness of this framework is that it does not address the moving beyond the point of viewing science as `building knowledge' to a higher level of defending ideas against alternatives and reaching consensus.

2.2.4 Evaluating Informal Reasoning and Decision Making

Development of test instruments for measuring students' competence in reasoning and decision-making are still subject to debate because science education research on

these competence areas are still comparably new and measurement procedures are more intricate in comparison to test instruments for scientific knowledge, for example. In addressing this lack, more emphasis must be placed on socio-scientific reasoning and decision making, necessitating a more detailed look at how to design test instruments and how to measure competencies. More effort needs to be expended in finding out what students gain by engaging in socio-scientific enquiry (Sadler, Barab & Scott, 2007).

With regard to the assessment of socio-scientific competence in reasoning and decision making, researchers have explored the use of trade-offs (Seethaler & Linn, 2004; Wilson & Sloane, 2000) and cut-offs in weighing decision criteria (Hogan, 1999; Hong & Chang, 2004) and prioritizing conflicting values (Bogeholz & Barkmann, 2005; Jimenez-Aleixandre, 2002; Kolsto, 2006) or reflecting on argumentation and reasoning processes (Sadler & Zeidler, 2005ab). These are commendable efforts to identify students' competencies as well as development of such competencies. Eggert and Bogelholz (2009) developed a test instrument to measure competencies in socio-scientific decision making based on the Rasch Partial Credit Model and succeeded in establishing a hierarchy of different strategies in terms of increasing difficulty. Reiss (2008) developed a coding system based on the number of ethical frameworks used by students in writing their examination reports after completing the Salters-Nuffield Advanced Biology course for 16 – 18 year-olds.

To respond to some of the difficulties encountered in students' decision making competence, Kolsto (2006), among others, suggested that presenting different reasoning patterns can be a means to induce meta-reflection about decision making processes and inherent value conflicts and thus can be a way of fostering students' decision making competence. The present study seeks to complement the evaluation of decision making competence by also identifying and evaluating the number of different reasoning patterns used in resolving dilemmas of socio-scientific issues as well as using a decision-making code as a measuring instrument.

2.2.5 Implications

The implications for the present study are stated as follows:

i. The socio-scientific issues approach addresses societal implications of science and technology as well as taps into students' personal philosophies and belief systems.

ii. The introduction of a case-based socio-scientific issue represents a pedagogical strategy addressing not only the sociological but also the psychological ramifications of curriculum and classroom discourse.

iii. According to Endicott, Bock and Narvaez (2002), "encountering multiple frameworks should be an effective way of enhancing both moral and inter-cultural schemas, thereby facilitating more advanced ethical and intercultural problem solving and attitudes (p. 2)". Socio-scientific issues provide engaging and complex contexts in our increasingly pluralistic society.

iv. Educators also need to structure the learning environment which provides room for epistemological growth supported by socio-scientific issues framework which facilitates decision making via social discourse.

2.3 Positioning the Present Study in the Socio-scientific Issues Movement

While socio-scientific issues (SSI) have become increasingly prominent within the science education literature, it is recognised that the socio-scientific issues movement has built upon other approaches that share the goal of equipping learners to engage in discourses and decisions related to socially relevant issues. Notably, these approaches that have laid some foundation for the socio-scientific movement are science-technology-society (STS; Yager, 1996) and other approaches such as science-technology-society-environment (STSE), education for sustainability and context based science education share many common features with the socio-scientific issues approach. While these approaches highlight the significance of

educational contexts in socio-scientific issues, it is important to explore *classroom-based studies of socio-scientific issues implementation and outcomes* so that they are more focussed and effective in addressing the goals of science education that these approaches seek to fulfil.

In recent years, there have been several notable studies of socio-scientific features in classrooms (Albe, 2008; Barab et al., 2007; Dawson, 2011; Fowler et al., 2009; Passmore & Svoboda, 2012; Sadler, 2009; Wong et al., 2011; Zeidler et al.,, 2009). Recognisably, these classroom-based studies situated in diverse contexts incorporated the four features according to Sadler (2011); namely, the motivation or origins of the work, teacher-researcher relationships, nature of socio-scientific issue intervention and implications for teaching, learning and research.

The present study has its emphases on the latter two features; namely, the nature of socio-scientific issue intervention and implications for teaching, learning and research. The present study not only offers an approach which portrays how teaching in the context of socio-scientific issues supports student learning of science content, presents students' perspectives on learning in this context and examines decision-making practices of students through the innovative use of ethical frameworks. It also serves to explore how the classroom teacher implements and modifies socio-scientific issues based programs to support student learning of the nature of science, increase students' ethical awareness as well as raise the awareness of moral reasoning and influence of faith/religious values in a socio-scientific discourse.

2.4 Ethical Thinking and Rationale for and the Use of Ethical Frameworks

2.4.1 What is ethical thinking?

Ethics is a branch of philosophy concerned with deciding what is morally right or wrong. Sometimes, the words `ethics' and `morals' are used interchangeably. According to Reiss (2003), they can, perhaps, be usefully distinguished. Moral decisions are usually made on a daily basis, on matters great or (more often) small about what is the right thing to do. Ethics, on the other hand, is `a specific discipline

which tries to probe the reasoning behind one's moral life, particularly by critically examining and analysing the thinking which is or could be used to justify one's moral choices and actions in particular situations' (p.14).

Ethics can apply to matters ranging in complexity governed by the following features: First, they can range in *focus*. Some concern what *individuals* do. For example, is it right to skip a tutorial class when one deems it is a waste of time. Others pertain to how one handles *one-to-one* relationships. Should I lie to my friend to avoid more hurt and discouragement? Yet others are about how we should act as a *group*. There are concerns pertaining to *non-human* world as well. Second, these matters may range from the *present to the future*. This concerns how and what we do now affects people (or the environment/the earth) in the future. Third, the complexity arose because of the different forms of *language* associated with it; commands and rules, settled habits of action and feeling (e.g. `care' and `honesty') and weighty abstract terms (e.g. `right', `injustice', `freedom', `exploitation'). Last, there are many areas of life included in this realm of ethics.

While it is inevitable that some moral decisions have to be made, ethics is a form of discipline which involves some kind of reasoning and thoughtful analysis so that we can justify why we make those decisions.

Justifying one's decision and action does not necessarily make the action right or wrong. That is, the validity of our ethical conclusion may be called to question. Concerns about the validity and worth of an ethical conclusion can be addressed by checking if three criteria are met (Reiss, 1999). First, if the arguments that lead to the ethical conclusion are well-substantiated by reason. Second, if the arguments are consistent within a sound ethical framework. Third, if an acceptable degree of consensus is found in the validity of the conclusions, which has come about as a result of an authentic debate. The use of such a criterion to determine the validity of an ethical conclusion is helpful provided reason is a sole guiding factor. In dealing with ethical issues, reason alone cannot be relied upon; perhaps the `reasonableness' of an ethical reasoning is the preferred indicator. In this regard, there is no single universally accepted framework within which ethical questions can be decided by reason. Nevertheless, ethical frameworks can be useful as guidelines in developing

ethical reasoning and providing a structure for considering alternatives, clarifying values and justifying decision-making.

2.4.2 Rationale for Constructing Ethical Frameworks

In addressing the needs for socio-scientific education, practical work alone is insufficient to create the bridge between observation and the ideas of science (Wellington & Osborne, 2001). The focus is essential both on the minds-on activity such as written discourse as well as hands-on activity. In line with this view, Lemke (1990) suggested that students should be provided with opportunities to `integrate writing, talking and reasoning with other forms of actions such as making observation and measurement' (p. 154). Thus when conducting scientific inquiries, students need opportunities to reflect on what they are doing while engaging in talking, reasoning, analysing, writing and sharing findings. In this regard, recognizing the importance of teaching of science as inquiry in socio-scientific education also means emphasizing to students that science involves the construction of arguments, proposing knowledge claims based on evidence from data accessed in the inquiry or reasoning process (Yore, et al., 2003).

Several researchers have suggested that one way to incorporate knowledge construction component of science is through the use of writing activities in the classroom as they provide unique opportunities (Emig, 1977: Halliday & Martin, 1993; Lemke, 1990). However, students need guidance and support which `scaffolds' their sense of what is effective writing (Bereiter & Scardamalia, 1987). Where genres of writing are not familiar, it has been recommended (Wray & Lewis, 1997) that `writing frames' can be useful in supporting the process of writing in the form of giving vital support and clues where needed.

More recent efforts in examining design research focused on fostering student participation in scientific argumentation confirm such an observation by showing that designers are moving beyond teaching argumentation skills through the means of combining explicit instruction in the skills of argumentation with the *engineering of situations* that motivate argumentation (Berland & Hammer, 2012, italics mine). To provide students with explicit guidance, Osborne, Erduran and Simon (2004)

included a writing framework of sentence stems to help students identify the types of information necessary in their arguments and discussion of the criteria they should use to evaluate arguments. Students are also asked questions with multiple plausible answers and positioned in small groups to argue about the questions at hand. The first half of the strategies are designed with the explicit assumption that students need to be taught how to argue: “argument is a form of discourse that needs to be appropriated by children and explicitly taught through suitable instruction, task structuring and modelling”. In contrast, the second set of strategies is implemented because “there is the need to establish a social context that fosters dialogic discourse” (p. 998).

The shared emphases on giving explicit instruction in the structure and components of an argument while simultaneously attending to the appropriate context is noted in many research efforts (Cavagnetto, Hand & Norton-Meier, 2010; Chin & Osborne, 2010; Clark & Sampson, 2007; Kenyon et al., 2006; Venville & Dawson, 2010; Zohar & Nemet, 2002). In a recent study of current research concerning ways to foster student participation in scientific argumentation, Cavagnetto (2010) found that authors of 25 of the 54 reviewed articles revealed some combination of “scaffolds such as prompts [i.e. explicit instruction], strategic selection for group collaboration, and use of student misconceptions [i.e. engineering situations to motivate argumentation]” (p. 347). Such a combination is vital because “One must see the point of argument if one is to invest significant effort in it and in developing the skills it entails” (Kuhn & Udell, 2007, p. 101). These recent research efforts underline the importance of designing classroom activities to provide a purpose for the argumentative interactions to enable students to understand how they should be involved in those types of interactions – it helps cue them to use their argumentative skills.

It is precisely the perceived need to design teaching situations effectively that brings about further consideration and exploratory study of how students may come to “see the point of the argument” that the present study is undertaken. It is suggested that through the use of writing frames such as the ethical frameworks in the present study that students are engaged actively with and constructing arguments, and as a result, learn to think critically and actively implement appropriate reasoning strategies.

2.4.3 Ethical Frameworks

The following section provides a description of ethical frameworks. It also outlines the different types of ethical frameworks that have been commonly used and suggests reasons why a particular one is adopted and modified for this present study.

2.4.3.1 Conventional Ethical Framework

Ethical frameworks are conventional ethical theories that can be divided into duty-based (deontological) approach and effect-based (utilitarian-consequentialist) approach.

The duty-based (deontological) framework works on the following two principles. First, the act-deontology principle assumes that people intuitively know how to choose in moral dilemmas and moral choice is a personal moral intuition. Second, the rule-deontology principle assumes that moral principles can guide moral choices. Rules are valid across situations and these are often expressed in professional codes of practice. The weakness of the deontological approach is that too much latitude is provided and this can become basically self-serving, arbitrary and indefensible in the pluralistic context. In addition, there is no single rule that is valid across all situations.

The effects-based (utilitarian-consequentialist) approach works on a case-by-case basis determined by that which creates the optimal consequences. Such an approach requires one to strive to achieve the greatest good for the greatest number. Inherently, such an approach requires definition of good, computation of amount of good, places public good over private good and may cause harm to the minorities and individuals. It is the ends that justify the means. The weakness of such an approach is that consequences are taken seriously; the ends justify the means is `flawed' as the `common good' becomes increasingly contested.

Given the increasingly democratic, pluralistic and multi-cultural nature of societies, such deductive approaches to moral choices are increasingly problematic. One way forward is through the use of a contextualist approach which evolved through dialogue and consensus. Ethical reasoning utilising such an approach is a process

involving identifying the problem, generating alternatives and making a decision based on a selected alternative that maximises the most important ethical value while achieving the intended goal.

2.4.3.2 Ethical Framework - The Four Principles Approach

Beauchamp and Childress (2001) presented the Four Principles Approach that has been one of the most widely used frameworks and offers a broad consideration of biomedical ethical issues generally. These four principles are general guidelines which make provision for special consideration and judgement in specific cases.

(1) Respect for autonomy: This principle works on the basis of respecting the decision-making capacities of autonomous persons; enabling the individuals to make reasoned informed choices.
(2) Beneficence: This principle considers the balancing of benefits of treatment against the risks and costs; for example, the healthcare professional should act in a way that benefits the patient.
(3) Non-maleficence: This principle avoids causing or inflicting harm. All treatment involves some harm, even if minimal, but the harm should not be disproportionate to the benefits of treatment.
(4) Justice: This principles ensures the benefits, risks and costs are distributed fairly. Each person in similar positions should be treated in a similar manner.

This ethical framework provides some form of guidelines with a strong focus on autonomy, albeit more from the perspective of biomedical ethics (largely consisted of theoretical research) and which in practice, may be subject to different interpretations. The term `bioethical principles' set here in the ethical framework as general norms leaves considerable room for judgement in many cases. They do not act as precise action guides that inform us in each circumstance how to act in the way that more detailed rules and judgements do'(Beauchamp & Childress, 2001). Generally, the critique of Beauchamp and Childress' theory points to two significant weaknesses: First, this framework focuses too much on individualism and individual rights. Second, there is a narrow focus on `self' as independent and rationally

controlling to the extent of lacking consideration of the affective component, communal life and reciprocity.

First, in utilising a coherence theory of truth for justification, Beauchamp and Childress have chosen what they designate as `reflective equilibrium' to be the arbiter by which all else must cohere. This reflective equilibrium ultimately becomes the intuition of the particular person performing the justification process. Thus, justification is reduced to subjectivity. Hence, the focus is inclined very much towards individualism (Rae & Cox, 1999).

Second, there is this inherent idea that medicine or the practice of biomedical science is value-neutral. This seems to overlook the fact that there is an asymmetry of power between the caregiver and the patient. The fact that the health care professional wields an extreme amount of power over the patient points to the fact that medicine is inherently moral. Thus, the state of medicine uncovers the importance of two factors which must be addressed by anyone discussing ethics in the biomedical realm: the character of the professionals and the balance of power needed by the patient.

2.4.3.3 Ethical Framework Integrating Pluralism

In developing a pedagogical model that scaffolded teachers through a series of stages in exploring controversial socio-scientific issues with students, Saunders and Rennie (2013) integrated `pluralism' as an additional ethical framework on existing frameworks of ethical thinking. Their study argues on the premise that today's society is becoming more pluralistic and thus traditional frameworks need to be extended to acknowledge other worldviews and identities. Pluralism is proposed as an additional framework of ethical thinking in their pedagogical model to accommodate the inclusion of multiple identities, cultural, ethnic, religious and gender perspectives. To some extent, this model has been validated as a tool that can support and assist teachers in addressing and teaching socio-scientific issues in secondary science classrooms.

2.4.3.4 Ethical Frameworks for Classroom Approach

The ethical framework that has been chosen to be adapted for the present study is based on the ethical framework used in the context-based advanced level biology course for 16 – 18 year-olds (Salters-Nuffield Advanced Biology, SNAB) studying biology in England and Wales from 2002-2005. The course was taught through contexts that emphasised bioethics issues and focused on developing ethical reasoning – similar to emphases shared in the Year 10 bioethics course in the present study.

SNAB introduces four different ethical frameworks of rights and duties, utilitarianism, autonomy and virtue ethics. Reiss (2008, p. 894) stated that "the approach to ethics is distinctly pluralistic and that the validity and worth of an ethical conclusion is based on fulfilling three criteria"; namely arguments are well supported by "reason, conducted within a well-established ethical framework and that a reasonable degree of consensus exists as a result of a genuine debate" (Reiss, 1999, p.125).

Table 2.5 Hall, Reiss and Scott (2002) Four Ethical Frameworks: A Summary

EF1	**Rights and Duties (Deontological)**
Rights define what people can expect as their due, so far as it is under the control of people or human society. There is always a duty associated with a right, though in many cases, the duty on other people is simply that they do not interfere with or prevent others claiming their rights. Any right or individual has relies on other people carrying out their duties, then other people's rights may be neglected.	
EF2	**Maximising the amount of good in the world (Utilitarian)**
This framework balances the benefits of an action against the risks and costs. It promotes the common good to help everyone have a fair share of the benefits in society, a community or a family. This framework is often described as `the greatest happiness for the greatest number'. It could be seen as a `right' to override the rights of the individuals in order to bring about happiness in the wider community.	
EF3	**Making decisions for yourself**
Autonomy is concerned with the respect due to individuals. People act autonomously if they are able to make their own informed decisions and then put them into effect. The principle of autonomy is the reason why people should be provided with access to relevant information, for example, before consenting to a medical procedure or taking part in a clinical trial.	
EF4	**Leading a Virtuous Life**
Justice is about equality, fair treatment and the fair distribution of resources of opportunities. For example, private medical care could be seen as making superior resources available to those who can pay; alternatively, it could be seen as providing a `choice'. This framework supports the moral `rightness' or `wrongness' of actions. An action can be described as right or wrong independently from any consequences of the action. It is not the consequences that make an action right or wrong but the principle or motivation on which the action is based. Traditionally, the seven virtues were said to be justice, prudence (i.e. wisdom), temperance (i.e. acting in moderation), fortitude (i.e. courage), faith, hope and charity.	

(Hall, Reiss & Scott, 2002, pp.93-94)

2.4.3.4.1 Rationale for the Fifth Framework Added

The fifth ethical framework added by the researcher is stated in Table 2.6 and this is followed by a presentation of the rationale for this framework added to the above four by Hall, Reiss and Scott (2002).

Table 2.6 The Fifth Ethical Framework

EF5	**Christian (Moral) Ethics**
This framework is based on principles and standard stipulated in the Scripture (Holy Bible). The Scripture provides the basis and motivation for which a decision is based. This framework promotes the values undergirding the belief which centres on the person, the work and the teachings of Jesus Christ, whom, through his life, death and resurrection points to the existence of a Triune God and to the nature and character of God, the Father, and whose work continues on earth is instrumental by the empowered community of faith – the Christians.	

First, the fifth framework on Christian ethics is added because, on a pragmatic level, the present study is conducted within an evangelical Christian college. With due consideration of the Christian ethos of the college and the curriculum that is governed by a biblical worldview, it is vital to provide an avenue where students can express their ethical thinking/decision making based on the morals and values integral to the faith beliefs.

Second, just as the scientists' study of various forces in the universe (gravity, electromagnetism, sub-atomic bonds and quantum mechanics) could be made more coherent by correlating and integrating all elements together in a unified field theory to explain all the forces in the same language, the Christian faith and values has the same kind of effect for *ethics*. Rules, rights, values and results are all endeavours of some kind to contribute towards an understanding of what moral knowledge is. Christian values (or preferably *Christian ethics*) present a way of interpreting these various forms of moral language and how they are interrelated.

Third, the fifth framework centres on the person of Jesus Christ because Christians believe that he shows what a correctly functioning human looks like, and partly because he releases humanity from what is burdensome in ethics. They consider he holds things together, enabling humanity to participate in life and living as they were meant to.

Essentially, this fifth framework captures an approach to ethics that is not a reductive formula on how to live well, nor reduce life to a series of decisions, a list of rules, a list of rights; and finally does not measure all actions by their results. It presents a Christian alternative with a completely different starting point which rests on the *person* and the *character of God in Jesus Christ* (Colossians 1:15- 20).

As a whole, the five ethical frameworks are established based on three primary ethical building blocks; primarily deontology (from Greek `dei' – must or duty), virtue (Greek `virtus' – skill, strength and excellence) and teleology (Greek `telos' – end, purpose or goal). These vital building blocks can be outlined using different alliterations as `commands', `character' (or `virtues') and `consequences' or `rules, roles and results' (Preece, 2002).

Table 2.7 Preece (2002) Primary Ethical Building Blocks

Commands	Rules	Principles	Social	**Deontological**	**EF 1** **EF 5**
Character	Roles/Responsibilities	Persons	Personal	**Virtue ethics**	**EF 3** **EF 4** **EF 5**
Consequences	Results	Purpose	Eschatological	**Teleological**	**EF 2** **EF 5**

Such a representation makes it clear that the added fifth ethical framework is embedded in all three categories, regardless of the types of alliterations.

Deontological ethics deal with acts in themselves, the principles (general ones include care of the environment and earth, love that transcends self /towards a divine presence, and love for one another), commands, laws or rules (more specific). These are normally absolute principles, which may be drawn from revelation from different religions' scriptures or from various world religions or from reasoning as in some kind of universally accessible natural law (Aristotle, Dharma, Talmud, Roman Catholic canon or Quran).

Virtue or Character ethics are concerned with the qualities, traits and motivations of the character or agent, whether individual or corporate (reflecting the *Imago Dei*). The intents of the heart must cohere with the outward acts. (Scripture Jeremiah 17:9, cf. Hosea 10:2 "the heart is deceitful above all things"). The internal and more subjective dimension of ethics are weighed by the external and more objective commands/rules and consequences/results. In addition, the development of right

character is on a continuum, not just occasional or *ad hoc* attitudinal basis or adjustment (Hauerwas, 1981, 1984; Thiessen & Wells, 2000).

Consequential (teleological) ethics are focused on the results of an action. Utilitarianism is an extreme form of consequentialism which excludes the other aspects of ethics. Utilitarianism "focuses on consequences or goals of action, not character (virtue) nor divine commands or any absolute rules" (Preece, 2002, p. 19). Preece also highlighted that Peter Singer and others offer a modification of utilitarianism, called `preference utilitarianism' which consists in `maximising the preference or choices of the greatest number of all rational, choosing persons and minimising the pain of all sentient (feeling) creatures' (Preece, 2002, p. 19).

It is noteworthy that the five ethical frameworks affirm the necessity of all three elements of the ethical process. It would be reductionist to attempt to sift one out and use it exclusively. Ethics is a multi-dimensional discipline. It is also worthwhile to consider how interdependent the three categories are, and what interconnections can be made between them. For example, there are important links between deontological and utilitarian ethics summed up in the biblical concept of "you reap what you sow" (compare and contrast with the Hindu/Buddhist concept of karma):

> Some consequences are not just a matter of chance. Acts that are bad in themselves can be expected to have bad effects of a particular kind that is not just accidental… There is a rational, conceptual link between them and their results. These consequences are a sign of what was wrong with the act in the first place. (Preece, 2002, p. 28)

In sum, given all these factors, we should give due emphases to *commands, character* and *consequences* or *principles, person and purposes* (including the fifth ethical framework) to have an adequate one to work with.

In the context of many and varied competing ethical perspectives, we need a *comprehensive* ethical framework as structured above. This framework provides a process for making ethical judgements as well as avenues to rationally and relationally justify them. Students can reason and articulate their ethical framework clearly so that they are equipped to make ethical decisions as well as challenge the flaws, if any, in other ethical frameworks that may confront them in the future.

2.5 Morality and Religious Values in Socio-scientific Education

The nature of socio-scientific issues is usually controversial and characterised by dilemmas and debatable from various perspectives. As such, they are usually inextricably linked with morality and ethics. Bioethical issues raised in the biotechnology unit include genetic engineering and reproductive technology and these aspects of biotechnology are pertinent in highlighting the significance of moral and ethical considerations in decision-making regarding science-related issues (Sadler & Zeidler, 2003). Extensive research by bioethicists and science educators in connecting the socio-scientific issues of genetic engineering, such as cloning and gene therapy to moral reasoning have been conducted (Evans, 2002; Haker & Beyleveld, 2000; Pedretti, 1999; Stock & Campbell, 2000; Zeidler, 1984). Such research underlined the importance of socio-scientific decision-making that involves the consideration of morality and ethics.

In making the connection of socio-scientific issues with morality and ethics, this implies that socio-scientific issues are *moral* issues. By `moral', domain theorists suggest that such a quality is an intrinsic aspect of particular events, situations or issues irrespective of the culture from which the incident arises (Blair, 1997; Nucci, 2001; Tisak, 1995; Turiel, 1983; Turiel & Smetana, 1984). They suggest that social knowledge and decision making reside in one of three universal domains: conventional, personal and moral. The conventional domain categorises issues that are best handled with the application of social norms. The personal domain represents decisions that are subject to an individual's personal choice and preference. On the other hand, the moral domain is defined by universally recognised prescriptions based on conceptions of human welfare, justice and rights. The domain account of social knowledge would suggest that socio-scientific issues are inherently moral because they involve objective, prescriptive and generalizable standards.

Although domain theory has been used by several researchers (Blair, 1997; Killen, Leviton & Cahill, 1991; Nucci & Turiel, 1993; Smetana, 1989; Tisak & Turiel, 1988; Wainryb, 1991), it is deficient because it depends only on one particular philosophical perspective, namely, Kantian morality (Schneewind, 1998). The

Kantian model has a significant place in the history of moral philosophy but it does not include *all* approaches to morality.

At least three broad moral philosophies could theoretically be applicable to socio-scientific decision-making: deontology, consequentialism and care-based morality. These three aspects are taken into consideration in four of the ethical frameworks (rights & duties [deontological], maximum benefits [utilitarian/consequentialism], virtue-based and making decisions for oneself) used in the present study. The inclusion of the religious values (as an alternative framework) provides *another* avenue for the exploration of the moral aspects of socio-scientific decision-making. The present study highlights the importance of the individual in playing a critical role in assessing the extent to which morality (including religious values) contributes to decision making. The process by which individuals assess the morality of a situation has been termed as `*construal*' (Bersoff, 1999; Saltzstein, 1994).

According to Hoffman (2000), for a person to determine the use of deontological principles, evaluate moral consequences or respond to a situation with a care perspective, s/he must first recognise that the situation involves moral considerations. *Construal* is the process by which individuals recognise, perceive, and/or interpret particular situations or decisions as moral (Saltzstein, 1994). Construal does not necessarily have to be a conscious process. In fact, it is more likely a person's immediate reactions, which are informed by emotions, previous experiences, and habits, that contribute significantly to construal (Bersoff, 1999). Although bioethicists (Evans, 2002; Haker & Beyleveld, 2000; Stock & Campbell, 2000) and science educators (Andrew & Robottom, 2001; Pedretti, 1999; Zeidler et al., 2002) may profess the intrinsic morality of socio-scientific issues, the ultimate arbiters of morality are the individual decision-makers. In order for moral considerations to contribute to socio-scientific decision-making, the individual decision-makers must construe *socio-scientific issues as moral problems.*

The realisation to integrate science and morality is recognised with the growing impetus to develop sophisticated epistemologies of science, which includes an appreciation of the social context (including morality) in which science operates, among students (Abd-El-Khalick & Lederman, 2000; American Association for the Advancement of Science, 1990; Driver et al., 2000; Geddis, 1991; Kolsto &

Ratcliffe, 2008; Kuhn, 1993; National Research Council, 1996; Siebert & McIntosh, 2001). In order to move to a place where pedagogy and curriculum enable students to integrate ideas about scientific issues and their own values and ethics, the community needs to understand how an individual naturally construes these issues. The present study is an attempt to address the needs, in particular, how students construe genetic engineering issues as moral problems and how their moral values (faith and/or religious) influence their decision-making regarding these issues.

2.6 Chapter Summary

Chapter 2 consists of a review of literature relevant to the present study. The chapter begins with an outline of the four thematic areas of recent research connected to socio-scientific issues. These four pedagogical issues capture essentially the key areas of research relevant to the exploration of socio-scientific issues in science education, posits the present study in the research of socio-scientific issues movement, and establishes the need for a research-based model of socio-scientific issues with a focus on ethics/ moral component that is integral to the ethical frameworks approach undertaken in the present research study.

The first section of this chapter is followed by a definition study of the term `ethical thinking' supported by the rationale for constructing ethical frameworks. It highlights the need for both the `minds-on' and the `hands-on' aspects of the scientific inquiry process in socio-scientific education. A review of the different types of ethical frameworks commonly used, such as the Conventional Ethical Framework, the Four Principle Approach Ethical Framework, Ethical Frameworks Integrating Pluralism and Ethical Frameworks for Classroom Approach was provided. Together with these frameworks, the innovative use of the modified Ethical Frameworks (incorporating the fifth framework) for the present study illustrates the breadth and scope of the many and competing ethical perspectives as well as supports the basis for the present research to incorporate and modify one such framework as an avenue to enable students to rationally and relationally justify their decision-making in socio-scientific issues.

The third and final section of this chapter emphasizes the need to link morality and ethics with socio-scientific issues. A review of research in socio-scientific issues in science education underlines the importance of incorporating at least, broadly, three moral philosophies; primarily the deontology, consequentialism and care-based morality. To enable pedagogy and curriculum to be more effective in addressing the concerns of socio-scientific education, the teaching community needs to understand how students construe the socio-scientific issues as moral issues and how students' values (moral, faith and/or religious) influence their decision making. The realisation of such a need provides yet another justification for the present study.

This chapter is followed by Chapter 3 which describes the research the research design of my study, the methods that were used to gather data, and the data analysis techniques that were selected in order to address the three research questions.

CHAPTER 3

RESEARCH METHODS

3.1 Introduction

Chapter 3 describes the research design of my study, the methods that were used to gather data, and the data analysis techniques that were selected in order to address the research questions.

The chapter begins with a statement of the three research questions of the present study, describes the interpretive case study approach, the mixed methods research design, the rationale for the particular design, the purpose statement and provides a brief description of how the design was implemented and the data were collected based on the mixed methods triangulation convergence design.

The research methodology used is the action research and a description of the triangulation in the action research process and the role of the teacher as the action researcher are also provided. Both internal and external validity are ensured in the research process, and reliability is ascertained from both the researcher's and the participants' positions, followed by ethical considerations which include informed consent, withdrawal rights and anonymity.

The experimental protocol is defined in terms of its design, method and process of data collection and data analyses based on sources comprising questionnaires, classroom observations, interviews with students, journal writings of students and teachers and concurrent data analysis. A description of the research environment incorporating the college profile, the students' profile, the teachers' profile and a learning model of teaching science/ ethics are also provided.

This chapter closes with an overview of the course structure depicting a list of teaching strategies and a week-by-week course outline and completes with the overall chapter summary.

3.2 Research Questions

Research Question 1

How effective is the simple framework in developing students' ability to reason analytically and make decisions about ethical issues?

Research Question 2

In what way does the use of five ethical frameworks affect student's ability to reason analytically and make decisions about ethical issues?

Research Question 3

In what way does the use of the ethical frameworks influence the teachers' approach in teaching socio-scientific issues?

The methodological approach selected for this study is designed to determine the effectiveness of the use of ethical frameworks in empowering students in their ethical reasoning and development of argumentation and decision-making skills in socio-scientific issues in biotechnology. The use of mixed methods research in this study is a methodology with a pragmatic worldview, epistemological and theoretical perspectives as well as methods that include sampling, measurement and scaling, questionnaires, observations, interview, focus group, case study, life history, narrative, visual ethnographic methods, statistical analysis, data reduction, theme identification, comparative analysis, cognitive mapping, interpretative methods, document analysis, content and conversation analysis (Crotty, 1998).

Pragmatism as a worldview is a set of ideas that has long been articulated by many scholars from historical figures such as Dewey, James and Pierce, to contemporaries such as Cherryholmes (1992), Murphy and Rorty (1990) and more recently by Tashakkori and Teddlie (2003). It draws on many ideas, including that which is practical, using diverse approaches, and valuing both objective and subjective knowledge. The pragmatism worldview adopted in this study is based on the following two points noted by Tashakkori and Teddlie (2003) in linking pragmatism and mixed methods research (Creswell & Plano Clark, 2007, p.26).

First, both quantitative and qualitative research methods may be used in a single study.

Second, the research question should be of primary importance – more important than either the method or the philosophical worldview that underlies the method.

The *epistemology* underlining this study is one of constructivism where multiple realities are examined so the researcher will obtain different perspectives from the data. The *theoretical framework* is one of interpretivism where symbolic interactionism, phenomenology and hermeneutics are key elements. The *methodology* is one of action research based on methods that include case study, questionnaires, interviews, observations, narratives, documentary analysis and quantitative methods that include statistical analysis and comparative analysis.

In summary, this study utilises a mixed methods research in which the investigator collects both quantitative and qualitative data and the methods involve multiple forms of data collection and analysis (Creswell & Plano Clark, 2007).

3.3 Interpretive Case Study Approach

The research approach here entails both qualitative and quantitative research.

First, this study is *qualitative* in nature as it utilises an interpretive case study approach (Merriam, 1998). Based on the concept of fourth generation evaluation as delineated by Guba and Lincoln (1989) and naturalistic inquiry (Lincoln & Guba, 1990), the principles of hermeneutic dialectic approach have informed the qualitative aspects of this study. This methodological approach essentially aims to understand the subjective and evolving realm of human experience, set within a qualitative case study which is `an intensive, holistic description and analysis of a single instance, phenomenon or a social unit'(Merriam, 1998: p. 21). Yin (1994) defined the case study as an `empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident' (p. 13). Stake (1994, 1995) however, focused on a single unit of study – the case. The case study as a research method is further

expanded by Yin (2009) in defining it as one that `relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as a result, benefits from prior development of theoretical propositions to guide data collection and analysis' (p. 18). So, the strength in adopting this method allows the researcher to retain the holistic and meaningful characteristics of real life events for analysis and evaluation.

Second, this study is *quantitative* in nature in that it follows the scientific method of focussing on theory testing and standardized questionnaires and quantitative measuring or statistical analysis tools are used to measure carefully what is observed or tested. In evaluating results, statistical criteria are used to form conclusions (Johnson & Christensen, 2008). Such a quantitative research approach usually provides strong conclusions about the presence of cause-and-effect relationship. So, the strength lies in its internal validity (i.e. causal validity) but weaker on external validity (generalising validity). However, the findings can be corroborated by increasing the generalisability through the qualitative data analysis to get at the research participants' perspectives and meanings that lie behind the experimental research findings and numbers.

3.4 Research Design – Mixed Methods

The research design for the present research is the mixed methods and a summary table is provided as follows:

Table 3.1 Research Design – Mixed Methods: A Summary Table

RESEARCH DESIGN – MIXED METHODS	
Worldview	Pragmatism
Epistemology	Constructivism
Theoretical Perspective	Interpretivism
Methodology	Action Research
Data	
Qualitative Analysis – Case Study	Questionnaires Observation Interviews Narratives Document Analysis Journal Analysis
Quantitative Analysis	SPSS Analysis and Alpha Reliability Test

3.5 Rationale for the Mixed Methods Selected

The mixed method utilised as the research design in this study combines two important traditions of interpretivism and postpositivism in that an attempt is made `to ground knowledge claims in the lives of the participants' studies and that also have some generality to other participants and other similar contexts, that enhance the understanding of both the unusual and the typical case, that isolate factors of particular significance while also integrating the whole, that are full of emic meaning at the same time as they offer causal connections of broad significance' (Greene & Caracelli, 1997, p.13).

Thus, in this study, a mixed method design is used to bring together the strengths of both quantitative and qualitative research in a single phase to compare results, or to validate, confirm, or corroborate quantitative results with qualitative findings, as one form of data is inadequate by itself. This is in congruence with *the fundamental principle of mixed research* as articulated by Johnson and Christensen (2008, p. 443) which commends the use of collecting multiple sets of data using different research methods and approaches in such a way that the resulting mixture or combination has complementary strengths and non-overlapping weaknesses (Brewer & Hunter, 1989;

Cohen, L. et al., 2011; Johnson & Onwuegbuzie, 2004; Lincoln & Guba, 1985; Teddlie & Tashakkori, 2009).

3.6 Statement of Purpose

A mixed method design was used in this study to address the issue of effectiveness of ethical frameworks in enabling students to develop ethical reasoning skills in a Year 10 Biotechnology program. This was a quasi-experimental design where there was a comparison group of 32 students taught by a teacher (fictitiously initialled as D.R.) and an experimental group of 31 students taught by the researcher. These two classes typified a sample of Year 10 class in a suburban school in Australia. All students were 14 - 15 years of age with quite similar socio-economic and religious backgrounds. These students were in the third year of secondary school science and their levels of exposure to science teaching in the primary school years (Foundation to Year 7) were quite variable.

Data were collected from a pre-program questionnaire (Appendix 1B), throughout the implementation of the program and also a post-program questionnaire. A triangulation mixed methods design was used – a type of design in which different but complementary data were collected during a ten-week program. In this study, the quantitative data (namely the pre- and post-program questionnaires) were used to determine the effectiveness in the use of ethical frameworks. Concurrent with this data collection, qualitative data such as interview transcripts, observation of participants by the researcher, journals and audio-recordings of small group discussions, were used to explore the central phenomenon of ethical reasoning and argumentation skills development. The reason for collecting both quantitative and qualitative data is to bring together the strengths of both forms of research to compare, validate and corroborate results.

3.7 Implementing the Design and Data Collection

This design was a single phase research as both types of data were given equal emphases; the two sets of data – both the quantitative and the qualitative were collected simultaneously and converged during the interpretation, and the intent was to draw valid conclusions about the research problem and the choice was the "triangulation-design convergence model" (Creswell & Plano Clark, 2007, p. 85).

Table 3.2 Creswell & Plano Clark (2007) Triangulation-Design Convergence Model

Design Type	Variants	Timing	Weighting	Mixing	Notation
Triangulation	Convergence	Concurrent	Usually equal	Merge the data during the interpretation or analysis	QUANTITATIVE (**QUAN**) + QUALITATIVE (**QUAL)** Using Morse's Code (2003)

3.8 The Research Methodology – Action Research

Action research, sometimes called practitioner based research (McNiff, 2002, p.6) is an important tool for change and improvement at the local level. It combines action, diagnosis and reflection. Zuber-Skerritt (1996, p.85) suggested that action research is `critical (and self-critical) collaborative enquiry by reflective practitioners being accountable and making results of their enquiry public, self-evaluating their practice and engaged in participatory problem solving and continuing professional development.'

Action Research is chosen as the research methodology for the present study because it fulfils the characteristics of the nature, scope and purpose of this research whereby the researcher as the participant develops through self-reflective spiral of planning, acting, observing and reflecting and then re-planning, further implementation,

observing and reflecting. Accountability is given an avenue for expression through a reasoned justification of one's educational work for others by providing evidence for data collected and analysed to create a developed, tested and critically examined activity (pedagogy in this case) and rationale for the work that is done. The constant self-evaluation in the process constitutes the ongoing professional development for the participant-researcher.

3.8.1 Triangulation in Action Research

Triangulation may be defined as the use of two or more methods of data collection in the study of some aspect of human behaviour. This technique sets to map out or explain more fully the richness and complexity of human behaviour by studying it from more than one standpoint and, in so doing, by making use of both quantitative and qualitative data (Cohen, Manion & Morrison, 2011). In the present study, triangulation involves gathering accounts of a teaching situation from three quite different points of view; namely, those of the teacher, the students, and a participant/observer /researcher. *Who* in the `triangle' gathers the accounts, how they are elicited, and who compares them, depends largely on the context.

In this study, the teacher is in the best position, via introspection, to gain access to the participants' (students and teacher) own intentions and aims in the situation. The students are in the best position to explain how the teacher's actions influence the way they respond to the situation. The participant-observer-researcher is in the best position to collect the data about the observable features of the interaction between teachers and students. The notion of reflexivity characterised in this approach is central to action research because the teacher as participant and practitioner of the action research is a part of the social world that they are studying (Hammersley & Atkinson, 1983, p. 14). Hall (1996, p. 29) suggests that reflexivity is an integral element and epistemological basis of action research because it takes its basis from a view of the construction of knowledge in which data are authentic and reflect the experiences of all participants.

On the other hand, a possible weakness with such an approach is that reflexivity may also link to possible bias in that the practitioner as the action researcher may present a rosier picture of the outcome of the action research than is really the case (Cohen,

Manion & Morrison, 2011, p. 359). Hence, to maintain rigour and authenticity, the action researcher needs to record as much detail as possible (with a vigilant eye to both positive and negative outcomes) to form the data base for analysis.

3.8.2 The Teacher as the Action Researcher

As the researcher, I took on the role of teaching the experimental group and hence directed the classroom teaching according to the curriculum I had planned. Such a direct involvement enabled action research to be conducted effectively as one is immersed in participatory or self-reflective research, that is, in a constant cycle of thinking, reflecting and acting. So, I can deliberately experiment with my own practice, monitor the actions and circumstances in which they occur, and then retrospectively reconstruct an interpretation of the action as a basis for future action. One of the advantages was that different solutions to the problems could be weighed and much could be gathered from testing ideas in that process. Effectively, in assuming the role of the teacher-researcher here, I was actively engaged in a spiral of self-reflection (Kemmis, 1994; Mills, 2000).

3.9 The Experiment Protocol

3.9.1 Design

As discussed on page 45, a mixed methods design based on qualitative and quantitative data analysis was used. Data were collected from a pre-program questionnaire (Appendix 1B) throughout the implementation of the course and a post-program questionnaire from two Year 10 (14 – 15 years of age) Biological Science classes over a ten-week period. There was one comparison group of 32 students taught by D.R. and one experimental group of 31 students by the researcher. The comparison and experimental classes were both representative of a typical sample of Year 10 Biological Science class in a suburban school in Australia. Both class sizes were similar and consisted of students aged 15 years with somewhat similar socio-economic religious background. These students were in the third year

of secondary school science, and exposure to science in primary school (Foundation to Year 7) varied from school to school.

In the context of the present study on use of ethical frameworks and their effects on reasoning and decision-making abilities, it has been noted that some researchers (Ford & Lowery, 1986; Gilligan, 1982) highlighted the divergent patterns of moral reasoning in the different genders. Although the present study has proceeded under the assumption that males and females do not engage inherently different forms of moral decision making (Friedman, Robinson & Friedman, 1987; Hekman, 1995; Singer, 1999; Tronto, 1987), the sample for the present study has been constructed so that both male and female voices in total were represented relatively equally. Thirty females (12 girls in comparison; 18 girls in experimental) and thirty-three males (20 boys in comparison and 13 boys in experimental) comprised the sample.

3.9.1.1 The General Background, Composition and Rationale of the Questionnaire

Quantitative and qualitative data were collected based on pre-program and post-program questionnaires that assessed the students' *understanding* and *ethical thinking, attitude and opinions* of biotechnology, scientific knowledge and ends with a section on the students' *religious faith*.

The questionnaire was designed to assess the students' *understanding* and *scientific knowledge* which can be determined from the test questions (set by researcher to determine student's knowledge of content) and case studies (Sadler & Zeidler, 2005b). The set of questions designed by the researcher to evaluate *ethical thinking* was based on a range of indicators of progression in ethical thinking proposed by Jones et al. (2007). The concept of *attitude and opinion about biotechnology* was built on the theoretical tripartite model of attitudes (Breckler, 1984; Eagly & Chaiken, 1993; Katz & Stotland, 1959; Rosenberg & Hovland, 1960). This model encompasses three basic attitude components: an affective, a cognitive and a behavioural component.

> "We here indicate that attitudes are predispositions to respond to some class of stimuli with certain classes of responses and designate the three major types of responses as cognitive, affective and behavioural." (Rosenberg & Howland, 1960, p.3)

The concept of attitude and opinion towards biotechnology can be described as follows:

First, the cognitive component is the evaluation of biotechnology that follows from beliefs, thoughts and (previous) knowledge of the object.

Second, the affective component of attitudes reflects how student feels about biotechnology, for example, their anxieties and fears about genetic modified food and reproductive technologies.

Third, the behavioural component is quite difficult to operationalize. Secondary school students usually have not personally encountered the contexts where they had to act or make a decision about biotechnological issues. One can only describe behavioural intentions as proxy for actual behaviour. Behavioural intentions can be described by providing situations in which one does or does not act (for example, buying a genetic modified food/product from a supermarket).

It needs to be emphasized that these three components, do not, however, add up to an overall attitude. The overall attitude is dependent on the accessibility of beliefs and the tendency of individuals to base attitudes on the cognitive and affective component. This aspect will be further highlighted in the analyses of the types of informal reasoning used by students to justify their response to different case studies.

Overall, the questionnaires for the pre-program and post-program were similar. Quantitative questions used a Likert (`strongly agree' to `strongly disagree') scale or a five point scale type response choices. Refer to Appendix 1B for the questionnaire from Part A to Part E.

Part A of the questionnaire was designed by the researcher. This section comprised 18 statements which utilised some of the indicators of progressions in ethical reasoning (Jones, et al., 2007) to evaluate students' perception of the breadth of outlook on biotechnology, attitude to biotechnology capabilities, ability to perceive

the connection between scientific knowledge and ethical thinking and acceptance of ethical frameworks and its usefulness. Students were also given opportunities to justify their responses.

Part B of the questionnaire comprised 25 questions that assessed students' knowledge and understanding of biotechnology based on topics of genetics and gene technology taught in a Year 10 biotechnology program in the Australian curriculum. Students' knowledge was measured through 25 true-false items (bivariate items). Students should (or could) have also learned about these subjects in school or from popular science programmes or magazines. Some items cover the existing alternative conceptions about biotechnology. Incorrect responses may be attributed to not only lack of scientific knowledge (textbook knowledge) but also a tendency to associate biotechnology with several alternative conceptions. For the present study, these results are complemented by a preliminary test before the commencement of the program and an end-of-program test.

Part C of the questionnaire comprised 40 statements using a five-point Likert scale to determine their opinions and concerns on different aspects of biotechnology. This section asked students about their cognitive and affective and behavioural evaluation about biotechnology. The affective evaluation was represented by questions concerning negative and positive feelings and emotions towards different aspects of biotechnology. A cluster of 13 items on cognitive evaluation was an attempt to capture beliefs, expectancy and perceptions of modern biotechnology.

Part B and C of the questionnaire have been modified to suit the Australian curriculum context from a specially designed questionnaire constructed according to the general tripartite theory of attitudes (knowledge, cognitive and affective, behavioural) for a research study determining the attitudes of secondary school students to biotechnology in the Netherlands (Klop, 2009). The concept of attitude based on the theoretical tripartite model of attitudes (Breckler, 1984; Eagly & Chaiken, 1993). This model encompasses three basic attitude components: an affective, a cognitive, and a behavioural component. These components, however, do not simply add up to an overall attitude. The overall attitude is dependent on the accessibility of beliefs and tendency of individuals to base attitudes on the cognitive or affective component.

Part D of the questionnaire comprised 26 questions using a five point Likert scale to evaluate students' religious beliefs, faith and practice. Religiosity is a complex concept that comprises various aspects of belief, behaviour, intelligence and cultural factors. A literature review of the reliability of several religious scale beliefs by Hogge and Friedman's (1967) Scriptural Literalism Scale (SLS), McClean (1952) Religious World Views Scale (RWV), King and Hunt's (1970) Religious Position Scales (RPS), Christie and Harvel's (1958) California F Scale, and Shure and Meeker's (1965) Religiosity Scale and Koenig. Parkerson and Meador's (1997) Duke University Religion Index (DUREL) shows that in terms of scale reliability (internal consistency), the Christian Orthodoxy Scale (COS) by Hunsberger (1989) was preferred. Hence, this `religiosity' section of the questionnaire is an adaptation of the Short Christian Orthodoxy Scale (COS) survey developed by Hunsberger (1989).

Part E of the questionnaire presented four gene technology applications, modified from the six scenarios postulated by Sadler and Zeidler (2005b, pp. 90-91); namely genetically modified food, genetic screening of embryos, *in vitro* fertilisation and therapeutic cloning and students were asked to indicate if they agreed or disagreed with the use of the gene technology with justification. The rationale for utilising *four* scenarios with open-ended questions at the end of Part E (Appendix 3) was to allow comparative analysis to take place between four different socio-scientific contexts to see if the context is a factor affecting the use of ethical frameworks and their effectiveness.

The questionnaire was thus constituted to address the first two research questions primarily with regard to the measure of growth (if any) in students' ethical awareness, ethical thinking and ethical/moral reasoning of socio-scientific issues using the simple framework or the ethical frameworks and how this development may relate to students' attitude towards biotechnology (and vice versa) and subsequently how ethical/moral reasoning may be influenced by one's religious beliefs and values.

3.9.1.2 The Choice of Ethical Frameworks and the Rationale

With the widely recognised need to include socio-scientific issues in science curricula in recent years, science teachers are increasingly expected to address ethical issues with controversial topics with their students (Jones, et al., 2010, p. 25). In most of the current models of teaching socio-scientific issues, teachers are encouraged to present resource materials (real life situations, scenarios, moral dilemmas, etc.) with a range of different viewpoints and invite students to articulate their opinions based on their evaluation of the evidence (Dawson, 2003; Lock, Miles & Hughes, 1995; Reiss, 1993). In this regard, the choice for the comparison group was to utilise a simple framework that would enable students to explore a range of viewpoints (refer to Appendix 2A) serving as an example of a template that may be most likely and currently used in existing teaching approaches to socio-scientific issues. This simple framework takes into consideration the positive and negative consequences of choices made; that is, by weighing the pros and cons of a number of viewpoints, students seek to establish some kind of justification based on the range of viewpoints.

The simple framework used by the comparison group is set in contrast with that of five ethical frameworks utilised by the experimental group (refer to Appendix 2B). The five ethical frameworks based on Reiss (1999, 2003) provide a selection of ethical perspectives drawn from well-established approaches to ethics and ethics education. These four established approaches are rights and responsibilities, consequentialism (specifically in the form of utilitarianism, which is concerned with both the beneficial and harmful consequences of action); autonomy (recognition of the individual's right to free choice) and virtues (emphasising motives and good characters rather than actions). In addition to these four, the *fifth* one incorporates a Christian perspective, not only as a means of studying a particular religious moral outlook (if expressed, and how, in a predominantly religious institution) but also to explore the possible link between faith and ethical/moral reasoning development.

Various researchers have suggested that the use of writing activities (using frameworks for both comparison and experimental) provide unique opportunities for students to become personally active and involved in learning (Emig, 1977; Halliday & Martin, 1993; Lemke, 1990). With the use of written form of ethical frameworks,

students are given the support which `scaffolds' their sense of what is effective writing (Bereiter & Scardamalia, 1987; Wray & Lewis, 1997). These `writing frames' that support the process of writing can provide vital support and clues to what is needed.

3.9.2 Data Collection – Tabulated Form

Table 3.3 is a summary table showing the sequence of steps taken in the data collection for the present study.

Table 3.3 Data Collection – Tabulated Form

Steps taken to collect data	
Preliminary data was collected in a trial run with a Year 10 Biological Science Class and a Year 11 Human Biology Class for one term in the previous year. (Please refer to Appendix 1A for Year 10 Biotechnology Term Overview).	
Step 1	Parents' consent for their child to participate in both the comparison and experimental group of the course were obtained. This also included the teacher participating in the program. Any reasons for parents' not wishing to have their child participate in the program were noted.
Step 2	Students from both comparison and experimental groups were given a pre-program questionnaire to complete. This was followed by a pre-program test.
Step 3	Students from both comparison and experimental groups participated in a 2-hour lecture on `Argumentation Skills' by a well-respected, qualified and experienced staff from the college `Philosophy and Ethics' faculty.
Step 4	Students from comparison group participated in a 10-week program (6 periods of 50 minutes) on biotechnology lectures, practicals, small group discussions and various classroom activities, utilising the simple framework. Student's data were collected in the form of self-reflection journals, class work and teacher's observations and journals. Students from experimental group shared a similar program (similar tasks and activities) except for the implementation of the use of ethical frameworks.
Step 5	Students from both comparison and experimental groups completed the post-program questionnaire and a test.
Step 6	Select groups of students from both comparison and experimental groups participated in post-program interviews to capture in depth explanations of quantitative data results.
Step 7	The comparison teacher completed a post-program feedback questionnaire and was interviewed by the researcher.

3.9.3 Data Analysis – Tabulated Form

The following is a summary table showing the sequence of steps taken in the data analysis for the present study.

Table 3.4 Data Analysis – Tabulated Form

Table 2 Analysing the data	
Step 1	Pre-program and post-program tests were compared to determine if there was improvement in knowledge, progress in ethical thinking and forms of informal reasoning and attitude towards application of biotechnology.
Step 2	Using SPSS analysis and quantitative analysis, pre-program and post-program questionnaire were compared to determine if there was improvement in *ethical reasoning* within each group. With the experimental group, a comparison between the pre-and post- was conducted to see if the use of five ethical frameworks and if the application made a difference to their ethical reasoning and argumentation skills. A similar comparison was made for the comparison group with the use of a simple framework.
Step 3	Using SPSS analysis, a comparison between the comparison and experimental groups was made to see if there was any statistically significant difference in terms of *knowledg*e and *attitude* towards biotechnology. Qualitative analysis was conducted on class pre- and post- questionnaire on ended questions to determine progress in ethical thinking, reasoning (including informal reasoning) and complexity of argumentation and decision making process.
Step 4	Qualitative analysis on interviews, journal entries and teachers' observations are conducted for in-depth explanation for any observations made from quantitative and qualitative analyses. This involves the design of a model to describe different informal forms of reasoning and the determination of a coding system to describe the levels and complexity of reasoning in decision-making.

3.9.4 Sources

3.9.4.1 Questionnaires

The pre-program questionnaires were completed with the comparison group and experimental group (n=63) at the start of the program and the whole procedure repeated with the same questionnaire after they completed the entire program (n=63). These questionnaires were administered as part of the regular course activity. The pre- and post-program questionnaires were the same and were conducted to: evaluate students' knowledge and understanding of the biotechnology, ascertain their attitude towards biotechnology, determine the level of acceptance of use of ethical frameworks and ethical reasoning (including informal reasoning) skills as well as

provide some indicators of their religious beliefs, values and practice (for better appreciation and understanding of the operating context and socio-religious background).

3.9.4.2 Classroom Observation

Classroom observation is an important method used to identify effective pedagogical techniques (Ayres et al., 2004; Berliner, 1986). Observation of a class in action usually takes place over one or two periods (an entire lesson on its own). The researcher looks out for particular events or behaviour that may provide indicators as to how students are responding to the intervention or non-intervention, and takes note of `extraordinary' moments/time frames that may need further clarification by interviewing the teacher or students. The use of observation allows the researcher to experience the classroom environment and activities occurring with the context at first hand. So, during observations, the researcher takes notes or records that can be utilised in the follow-up interviews with the teacher as a point of reference for discussion (Cooper & McIntyre, 1996; Tobin & Fraser, 1990). This commonly shared experience can provide a useful focal point for an interview.

However, due to the presence of the researcher, the classroom situation may not function the way it would normally do so the researcher may not have a very accurate assessment of what actually happened (Gray, 1999). It must also be recognised that classroom observations only capture a brief snapshot of what is happening at a particular time at a particular context and may not be representative of what usually occurs in class (Gray, 1999). Nevertheless, the classroom observations provide opportunities for comparison to be drawn with what the researcher perceived and the teacher/students' actual response(s) to the situation.

Class observations for the present study were made with reference to the type of teaching strategy of socio-scientific issues that engaged the students, the type and level of reasoning employed by the students for each context and any development, if any, with the use of the simple framework or the five ethical frameworks in facilitating the individual student's and small group's argumentation, reasoning and

decision-making over the ten-week period as well as students' attitude and overall response, both positive or negative towards science learning using socio-scientific issues.

3.9.4.3 Interviews with Students

One of the most important sources of case study information is the interview. Yin (2009) suggested that there are three types of interviews – in-depth interview, focused interview and survey. For the purpose of this research, the focused interview is used (Merton, Fiske & Kendall, 1990). In this case, a student or a group of students was interviewed for a short period of time, about 10 – 15 minutes. The value of the focused interview is that the interaction within a group in discussing a topic supplied by the researcher yields a collective rather than an individual view (Morgan, 1988, p.9). Such an approach is not only economical on time, producing a large product of data in a short time (Hyden & Bulow, 2003, p.19), but also useful to triangulate with more traditional forms of questionnaire and observation.

Both comparison and experimental groups were given the same set of questions. Although a list of questions as shown in Table 3.5 was used, the interview remained open-ended and assumed a conversational manner. That is, while a consistent line of inquiry was being pursued, the actual stream of questions was fluid rather than rigid (Rubin & Rubin, 1995). Such a fluid nature allowed the researcher to corroborate certain facts that may have already been established earlier or to corroborate interview data with information from other sources.

Table 3.5 Student Interview Questions

Student Interview Questions
(i) Which was the most enjoyable activity in the biotechnology program so far?
(ii) Is case study analysis an engaging way of learning? How much time do we spend on one case study?
(iii) Do you think ethics is relevant in a science course?
(iv) How has the course help your study of science?
(v) How do you find the use of ethical framework? Explain why.
(vi) Is the ethical framework easy to use? Why?
(vii) How do you think the ethical framework can be improved?
(viii) What would you like to see happening more in the biotechnology curriculum?
(ix) Did the biotechnology course increase your interest in science?
(x) Among the various ethical issues, what areas do you think is most controversial to you? Why?

Each interview was recorded using an audio-digital recorder and transcribed. Altogether, there were 16 interviews (8 rounds for comparison group and 8 rounds for experimental group) ranging from 15 – 20 minutes were conducted and transcribed. The interview questions are provided in the table above. Notes were taken during the interviews, including prompts that were used to facilitate the discussion. Actual words used by students were recorded *in verbatim* from the audio-digital recorder after each interview.

The data collected from the interviews were triangulated with classroom observations, student questionnaires and class case analyses to identify emergent patterns or themes characterising development of ethical thinking and different forms of reasoning skills.

3.9.4.4 Journal Writing

Journal writing can be used for both professional development and research. Research journals are usually a mix of analytic and interpretive notes that assist in the process of reflecting on, clarifying observations, discussions, thoughts and feelings connected to the research process. In keeping a research journal, it is important to keep comprehensive, descriptive documentation, to record procedures and interactions (including verbal information), and to keep analytical and

interpretive notes. The analytical and interpretive notes should be recognised as such, for they should lead to reconstruction of the project from objective and subjective dimensions (Holly, 2002, p. 8). For this study, a daily research journal practice has been carried out by the researcher. Keeping a research journal has helped me in my role as the researcher, to facilitate observation, documentation and reflection of current and past experiences in the educational context (and not limited to these settings of course).

For the students, it was not mandatory for them to write their journals although they were strongly encouraged to do so. In addition, with both comparison and experimental class, the frequency of journal writing was also different depending on the subject teacher's teaching style and the availability of time as lessons may be paced somewhat differently for each class. Students were provided about 5 – 10 minutes at the end of a double-period lesson to reflect on a class activity and respond to the following three questions.

(i) What have I learnt today?
(ii) What was the one thing that was interesting about today's lesson?
(iii) What else would I like to find out more from today's lesson?

So, journal writing could occur at least once a week, and for some students, the frequency of writing reached up to two or three times a week (as journals were permitted to be brought home upon students' request for a more thorough and thoughtful response).

Not all students developed the habit of journal writing and this may be attributed to different learning styles. But for those that completed each journal entry as requested, it became a useful tool for analysis (Holly, 2002, p. 55) on the part of the researcher as well as serving the purpose of promoting meta-cognitive awareness on the part of the student.

3.9.4.5 Questionnaire Data and Concurrent Data Analysis

Questionnaire data were triangulated with student observations, students' interviews, class samples, students' and teachers' journals. Not all students who participated in

the pre-program questionnaire took the post-program questionnaire as two students left halfway through the program for reasons not related to the research. In total, the number of students who completed both the pre- and post-program questionnaires were 63. Student data from pre- and post-program were compared within the comparison and experimental groups, and across the two groups.

Classroom observations were also used to yield records of how some of the lessons went. In sum, data were collated, analysed and categories of patterns observed were coded on all factors contributing to our understanding of the effectiveness of the model in utilising ethical frameworks for both students and from teachers' perspective. Particular attention was given to the product (student written responses) on the questionnaire which evidenced specific components of the ethical thinking and forms of informal reasoning (rationalistic, emotive, intuitive, moral) based on his/her understanding of each ethical framework. Field notes or journal notes taken after each lesson for both comparison and experimental groups guided the formulation of tentative assertions and subsequent observations, members' checks (Swanborn, 2010, p. 111) and interviews.

3.9.4.6 Concurrent Data Analysis

The following questions are addressed in the concurrent data analysis.

1. To what extent do the quantitative and qualitative data converge? How and why?
2. To what extent do the same types of data confirm each other?
3. To what extent do the open-ended themes support the survey/questionnaire results?
4. What similarities and differences exist across levels of analysis?
5. How can a comparative study between the two different sets of data be conducted through a discussion or a matrix (a specially designed model or code)?

In the course of data analysis, the researcher also attempted to delineate the overarching validity by "drawing evidence from different data sets that provide better results than either data set (qualitative or quantitative) alone" (Yin, 2009, p. 101). This is called the `consequential validity' or `triangulation validity'. The validity of this experiment was also enhanced by identifying potential threats to

validity that arose during data collection and analysis. This was discussed in greater depth earlier in this chapter in pages 70 - 72 under *3.12 Validity.*

3.10 Research Environment

3.10.1 College Profile

All students in this study come from various evangelical Christian backgrounds (namely, the Baptist, Church of Christ, Independent, Presbyterian, Pentecostal, Uniting Church, etc.) because this institution is a non-denominational Christian college and either one or both parents need to be practising Christians before their child is enrolled in the college. This is an important factor to consider when analysing their values-based reasoning capacity and how this may affect their decision making.

Historically, the Christian College had its humble beginnings in 1984 when four Christian families gathered together with a hope of creating an educational community that was one of partnership between home, parents, church and school. It arose out of a desire to provide their children with a truly `Christian' education. The real imperative behind the birth of this school was to enable parents to fulfil the biblical mandate of taking responsibility for their child's learning and development in regard to the Word of God and for Christian life itself within their family and the community out there. The Christian College was established in the hope of establishing a thriving community with Christian curriculum and behaviour, a heart for mission, service, giving, excellence and leadership. In so doing, a community with Christ-centred focus in education was made available to all Christian parents who desired to be a part of the vision. Till this day, the Christian College as a K - 12 school of 1100 students remains one of two Christian colleges in Perth with a closed enrolment policy (up till end of 2011) which means that every student in the college comes from an evangelical Christian background. The resulting move towards having a more open enrolment policy is in keeping with a view towards a more outreach-oriented approach to meet the needs of the rapidly growing community.

Table 3.6 represents the denominations of churches these students are members of or affiliated with.

Table 3.6 Profile of Students' Membership or Affiliation with Church Denominations

Total Student Population: 1100	
Denominations	Percentage for the college %
Christian Church - Independent	59.8
Baptists	12.5
No church affiliation/ unassigned	8.9
Reformed	5.7
Catholics	5.4
Presbyterians	2.7
Assembly of God / Pentecostals	2.2
Anglicans	1.2
Seventh Day Adventists	0.4
Uniting Church	0.10
Methodists	0.08
Orthodox	0.08

That the student sample was drawn from a distinctly Christian college setting meant that while some measure of homogeneity is ensured in the experimental process, there is also an implicit limitation in that this may not be fully representative of a typical `Christian' college in most independent schools setting – a factor that is considered in the analysis of data.

3.10.2 Student Profiles

All the participants for this study were Year 10 Biological Science students. Students were taught the basic concepts of genetics; namely variation and genetics in humans based on the Mendel's Laws of Genetics (monohybrid crosses and pedigree analysis) as well as the environment, heredity and natural selection. This was completed in the term prior to this study. All students also learned additional concepts which include DNA, gene manipulation in humans (IVF, stem cells, cloning, gene splicing, gene

therapy, germ-line genetic engineering) and gene manipulation in industry (selective breeding, GM foods, forensics, conservation genetics).

There were 63 students who participated in this program; experimental (n=31) and comparison (n=32). Both classes have students of mixed abilities studying in the same classroom. In terms of abilities, both classes were fairly similar in its composition of students. This was evidenced from the grades and mark distributions over topic tests as well as semester reports. Biological science was taught for six periods (50 minutes per period) a week according to the guidelines from the Curriculum Council of Western Australia. Both groups studied the concepts for the same period of time. Both groups were taught a special unit on `Argumentation Skills' by the same Philosophy and Ethics teacher. The length of the entire Biotechnology program spanned over ten weeks for both groups.

In the experimental group, there were two special needs students, one who had been diagnosed with some level of autism, and the other with a specific learning disability that primarily affected literacy and numeracy. Their responses to the program from the analysis of the results make for some interesting insights into the learning process.

3.10.3 Teacher Profiles

While it is acknowledged that curriculum materials are vital in enabling teachers to engage students in the learning process (Davis & Krajcik, 2005), it was also crucial to understand how teachers draw on their own resources and capacities to read, make meaning, evaluate and adapt curriculum materials (Remillard, 2005). In this respect, for the purpose of this study, it is important to present brief profiles of the teachers who participated in this study. Classroom practice is influenced, to a significant extent, by the teachers' understanding of the curriculum, beliefs about what is important, and ideas about the roles of the teacher and students. The role of the teacher is essential for students' successful engagement in scientific educational process (Crawford, 2000; Reiser et al., 2001). As teachers create opportunities for students to use tools that allow students to participate in socially constructed

discourse in the classroom, increases in scientific reasoning skills have been observed (Hogan and Maglienti, 2001; Martin & Hand, 2009).

As the action researcher, I also worked collaboratively with D.R., the teacher taking the control class. As both classes studied a similar program, D.R. and I worked through a common plan of action. There was close communication on a regular one to one basis as well as online exchange of short anecdotal notes and/or feedback for each activity implemented.

D.R. and I had eight years of teaching Biological Sciences so the past experience and expertise served as a good foundation to begin exploring the model of utilising ethical frameworks in bioethics. We both had a Bachelor of Science with a special focus on Biological Sciences. Prior to the research study, we had taught the students for six months. Thus, we were familiar with each student's learning style by the time the bioethics was introduced in the second half of the year. In addition, the students also had the opportunity to be more comfortable or accustomed to our teaching style and our classroom/ laboratory expectations.

3.10.4 A Model of Teaching and Learning Science /Ethics

Usually, not all science teachers are always explicit about the theories which guide their practice. The nature of this research requires that both the comparison and experimental teachers agreed on some of the underlying features that underpinned our pedagogical practices.

First, we agreed that we would be intentional about using the *social constructivist model* in our teaching. So, concerning the nature of science (for students), we viewed `Science' as plausible explanations for phenomena primarily accessed through argument. In our teaching approach, we provided opportunities for reflective interaction (eg. through discussion and argument) to support the co-construction of knowledge. We also created student-centred activities that would encourage students themselves to take more responsibility for their own learning. This was reflected in the term overview as outlined in Appendix 1A.

Second, we agreed on the scientific content that needed to be taught (consistent with the course requirements and the Australian Curriculum Framework) and determine to what extent ethical teaching will be structured within the course. We discussed the

aims of teaching ethics and what it exactly involved. We agree on using a `case-based' or `issue-based' approach for reflection. As the student-centred model is our preferred model, much of the preparation actually took place in selecting the issues and the right kind of questions to facilitate, guide and structure student's exploration of the issues. Although the comparison group did not use the ethical frameworks outlined for the experimental, a form of framework using structured questions was provided (Appendix 2A). This is intentional as scaffolding (being constructivist) was necessary to enable students to reason within a stipulated guideline and/or structure.

Third, to counteract any inclinations towards dogmatism, or worst, `indoctrination' at one extreme or moral relativism or subjectivism at the other, a teacher needs to be aware of his/her teaching approach of ethics, and students, on the other hand, are encouraged to explore and debate issues as a basis for informed *social* decision making. References to some type of social or professional response (e.g. GTEC [Gene Technology Ethics Committee], GM [Genetically Modified] Act 2000), legislation or guidelines for practice, will facilitate ethical reasoning that moves beyond mere personal convictions, individual rights to communal well-being and shared moral truths.

3.11 Program Structure – Year 10 Biotechnology Program

3.11.1 Biotechnology/Bioethics topics in focus – Gene Technology - Genetically Modified Food, Genetic Engineering and Reproductive Technologies

The Year 10 Biological Science program (Appendix 1A) is a single term (10 weeks). These students in Year 10 science are aged fifteen and are in the third year of secondary school science. The extent to which science is taught in primary schools in Australia is quite varied. In this program, each student attended six periods of lesson/practical per week. Each period lasted for 50 minutes. Each lesson may take the form a lecture (with Powerpoint presentation) over a period or a laboratory session (practical) that will take two periods, usually once a week. Students complete weekly readings and submit homework (review exercises). Students also completed activities involving case studies and media articles. In addition, students participated

on the Biotechnology-Online program (http://www.biotechnology.gov.au) which enables them to cover key concepts and terminologies used in biotechnology. Students also completed a major task of writing an illustrated book on `Biotechnology Applications' targeting at Year 8 level. Students also completed a formative and a summative assessment (including the major task and lab reports) which constituted 70% of the grade.

3.11.2 Teaching Strategies and Week by Week Program

3.11.2.1 List of Teaching Strategies/ Activities

The list of teaching strategies, unless otherwise stated, used by both comparison and experimental teacher during the ten-week program. The number of times the teaching strategies were used, were also specified which may be an indication of the popularity and usefulness of certain teaching strategies among the students

Table 3.7 is a summary listing the teaching strategies used in the ten-week program.

Table 3.7 List of Teaching Strategies

Quantity	Type of Activity/Strategy/Task
5	Powerpoint Presentations – Argumentation Skills/ Genetics & Health/ Genetics & Industry/ Genetic Modified Food / Christian Response to Life Sciences
2	ClickView Presentation – Genetic Diseases / Gene Technology
2	Debates
2	Role plays
Numerous	Small group and class discussions
1	Place Mat Activity
1	Concept Mapping
1	Project – Creating an Illustrated Booklet on `Biotechnology' for Year 8 students
3	Guest Speaker – Philosophy and Ethics Teacher – Argumentation Skills University of Western Australia Doctor/Lecturer – Huntington Disease Sci-Tech (Special Funded Incursion) – Lab Session on DNA Profiling
1	DVD Presentation – My Sister's Keeper and Class Discussion/ Activity
Numerous	Activities using Media Articles (some based on SNAB Resource) Discussion and Self- Journal/ Reflection
1	Activities – Genetics in the 21st Century
1	Biotechnology On Line (http://www.biotechnology.gov.au)
1	Class Generating their own Biotechnology Quiz Pre-Program and Post-Program Questionnaires
Weekly	Lab Work/ Lab Assessment
Weekly	Interviews/ Student Journals

3.11.2.2 Week by Week Program

The following is a list of the content, teaching strategies and activities used in correspondence to address the specific research question(s).

Table 3.8 lists the content, teaching strategies and activities as well as the type of research data collection used to address the three research questions.

Table 3.8 Week by Week Program

W	Content	Teaching Strategies/ Activities	Research Data Collection RQ 1 – Data collected to address Research Question 1 RQ 2 – Data collected to address Research Question 2 RQ 3 – Data collected to address Research Question 3
1	**Biotechnology** What is Biotechnology? Applications of Biotechnology Traditional and Modern Biotechnology Microbes/ Selective Breeding	Powerpoint Concept teaching Concept mapping Project 1 assigned – creating an illustrated biotechnology booklet for Year 7 and 8s.	Pre-Program Questionnaire (RQ1, RQ2) Student Journal –weekly (RQ 1, RQ2, RQ3) Teacher Journal (RQ 1, RQ2, RQ3)
2	**Supplement-Biotechnology** Gene Technology IVF, Stem cells Gene therapy	Power point Concept teaching Place mat activity Lab Session 1	Student Journal (RQ 1, RQ2, RQ 3) Teacher Journal (RQ 1, RQ 2, RQ 3)
3	**Supplement: Biotechnology** Science in Biotech GM, Forensics Conservation Genetics	Power point Concept teaching Science in Society Issue - discussion Graphic Organiser – Pro/Con/ Consequence/ Value Chart Debate	Student Journal (RQ1, RQ2, RQ3) Teacher Journal (RQ 1,RQ2, RQ3)
4	**Supplement: Biotechnology** Ethics in Biotech – Overview of Issues GM food Organ Transplant Gene Tech	2 Workshops on teaching `argumentation skills' Framing questions Presenting arguments Weighing arguments Decision Making Process	Informal observations on student centred learning (RQ1, RQ2) Student Journal (RQ1, RQ2, RQ3) Teacher Journal (RQ1, RQ2, RQ3)
5	**Ethics in Biotech** Class Discussion of Various Issues From Newspaper /Media articles	Advantages and Disadvantages Developing Viewpoints **Use of Ethical frameworks (Experimental)** *Use of Simple Framework (Control)*	Student Interviews (RQ1, RQ2) (Audio-digital recordings and transcribed) Student Journal (RQ1, RQ2, RQ3) Teacher Journal (RQ1, RQ2, RQ3)
6	**Scenarios-** Use of Ethical Frameworks Medical Biotechnology Organ Transplant	Workshop on `Ethical Framework' Practice on different scenarios 1 Written Worksheet – Sister Keeper	Student Journal (RQ1, RQ2, RQ3) Student Written Responses (RQ1, RQ2) Teacher Journal (RQ1, RQ2, RQ3)
7	**Activity** Use of Ethical Frameworks Gene Technology View – My Sister's Keeper	In class assessment Practice – Use of Ethical Frameworks/ Simple Framework in a given scenario Interviews DVD Presentation Evaluation of Use of Ethical Frameworks	Student Interviews (RQ1, RQ2) Student Written Responses to Class Activity (RQ1, RQ2) Student Journal (RQ1, RQ2, RQ3) Teacher Journal (RQ1, RQ2, RQ3)
8	In-House Gene Technology Electrophoresis (Incursion**)**	Lab Session on DNA Profiling Revision Assessment Incursion	Student Journal (RQ1, RQ2, RQ3) Teacher Journal (RQ1, RQ2, RQ3)
9 / 10	Review	Students conduct their own quiz based on their questions generated from Week 4 – 8.	Student Journal (RQ 1, RQ2, RQ 3) Student Interviews (RQ 1, RQ2) Teacher Journal (RQ1, RQ2, RQ3) Comparison Teacher Evaluation (RQ1) Post-Program Questionnaire (RQ 1, RQ2)

3.12 Validity

Validity is essentially a demonstration that a particular research instrument or design measures what it purports to measure, or that an account accurately represents "those features that it is intended to describe, explain or theorise" (Winter, 2000, p.3) and validity has taken many forms of late. In qualitative data, validity might be addressed through honesty, depth, richness and scope of the data achieved, the participants approached, the extent of triangulation and the disinterestedness, or the objectivity of the researcher (Winter, 2000). In quantitative data, this might be improved through careful sampling, appropriate instrumentation and appropriate statistical treatment of data.

In the present study, both qualitative and quantitative methods are designed so that they both address internal and external validity.

3.12.1 Internal Validity

Since internal validity seeks to demonstrate that the explanation of a particular event, issue or set of data which a piece of research provided can actually be sustained by the data, it is vital that the findings must describe accurately the phenomena being researched. Onwuegbuzie and Leech (2006, p. 234) stated "the `internal validity' as the truth value, applicability, consistency, neutrality, dependability, and/or credibility of interpretations and conclusions within the underlying setting or group".

The following measures are taken to ensure validity according to a number of researchers (Lincoln & Guba, 1985; Merriam, 1998; Onwuegbuzie & Leech, 2006; Teddlie & Tashakkori, 2009).

Prolonged engagement and persistent observations in the field – The practice of data collection, reflection and analysis began as early as one year (via a pilot project to define the parameters of the research and refine the questionnaire) before the implementation of the research data collection, and continued during the course of the research project (ten weeks) until about a year after the end of the research

project. The teacher/action researcher had the benefit of being in communication with many of the students in the process of teaching them in their high school years.

Triangulation – this includes triangulation of methods, sources and investigators/researcher and theories (Patton, 2002).

- *Triangulation of methods* – with the mixed methods research, the outcome of the questionnaire survey (quantitative analysis) was used to correlate with observational analysis (qualitative analysis) from student responses to open-ended questions in class activities (e.g. debates, role play), interviews and journal entries. This is also an important means of corroborating internal, external, content, concurrent and construct validity.
- *Triangulation of sources* – The integration of quantitative data and qualitative data (both given equal weighting) in responding to the research questions eliminates the issue of selective use of data or under-representation of one data against another and minimises the risk of accentuating the positive and neglecting or ignoring the negative.
- *Members checking* – The act of taking data and tentative interpretations back to the student or comparison group teacher from whom they were derived and asking them if the results are plausible or the interpretation of the comments were accurate and took place on a regular basis throughout the duration of the research project.
- *Peer examination* – from time to time, the researcher approached colleagues to comment on the findings as they emerged. With the feedback, the research process was refined further by addressing questions of clarification and substantiation for observed patterns/trends. With qualitative analysis, the data were analysed according to the researcher-designed code and evaluation criteria by two analysts (the researcher herself and another teacher) and the inter-rater reliability was sustained at a significantly high value to maximise validity.
- *Researcher bias* – the researcher kept a daily journal to reflect on the research process to clarify/challenge her own assumptions, worldview, and theoretical orientation at the outset of the study.

3.12.2 External Validity

The external validity is concerned with the extent to which the findings of one study can be applied to other situations. There are some difficulties in ensuring generalisability in qualitative research and many researchers have chosen to reframe their understanding of `generalisability' (Eisenhart & Howe, 1992, p. 647; Lincoln and Guba, 1985). It is argued that it is not the researcher's task to provide an index of transferability (or comparability); rather, researchers should provide sufficiently rich data for the readers and the users of the research to determine whether transferability is possible. In this respect, the researcher ensures external validity for the present study by providing a thick and rich description of the data collected and analysed.

3.13 Reliability

Due to the multi-faceted and highly contextual nature of research in education, the logic of repetition of outcome for establishing truth is untenable in the traditional sense. It has been suggested by Lincoln and Guba (1985, p. 288) that "dependability" or "consistency" of results obtained from the data is preferred. The question that needs to be addressed under `reliability' is not whether findings will be found again but whether the results are *consistent with the data collected*. There are several ways to ensure that results are dependable.

3.13.1 The Researcher's Position

It is crucial that the researcher is aware of his or her own assumptions and the theory behind the study, his or her position vis-à-vis the group being studied, and the basis for selecting the students, a description of these students, and the social context which data were selected (LeCompte & Preissle, 1993).

The researcher is aware that `experimenter bias' can be a source of invalidating the analysis process. So, it is critical for the researcher to be aware of the demand

characteristics. That is, the researcher, knowing about the hypothesis and the projected outcome, may possibly provide unintended verbal and non-verbal cues which may influence the performance of the participants in the direction desired. Another source of bias lies in the subjective interpretation of the obtained data. There again, as with the subject bias, it is difficult to assess accurately the experimenter/researcher bias or to find ways of eliminating them. Since this study is conducted in social interaction within the classroom context, it is vital that the researcher is aware of the various sources of experimental error due to uncontrolled, and possibly, in some cases, inherently uncontrolled variables. Thus, the reflective model of journal keeping and constant evaluation are means by which the research has put in place to minimise the experimental bias.

3.13.2 The Participant's Position

The *Hawthorne effect* is characterised as a "demand characteristic" (Burns, 2000, p. 149) whereby a research participant would seek to co-operate with the experiment to be a good subject. To take such a position, the subject attempts to identify the hypothesis of the experiment from the available demand characteristics and acts in a manner that will support the hypothesis. One way to mitigate the Hawthorne effect (or the reactivity of the participant) in this study was that both comparison and experimental groups were informed that they were participants but the designation of `comparison' and `experimental' were not made known to both groups. (Refer to pages 49 - 50 under *3.9.1 Design* and pages 62 - 64 under *3.10 Research Environment* for a description of experimental and comparison group students.)

While the experimental group had the intervention in the use of ethical frameworks, the `comparison' was also given a similar treatment in terms of having common instructional time on `argumentation and reasoning' with the experimental group prior to the commencement of the biotechnology program as well as a simple ethical framework to work on (Appendix 2A). The other means of reducing the Hawthorne Effect was to ensure that the experiment was conducted over a lengthy or sustained period of time to ensure that the experimental effect was significant over time and not simply a manifestation of the Hawthorne Effect.

1. *Triangulation* – This is addressed in terms of using multiple methods of data collection and analysis (using questionnaire survey, informal reasoning model and decision-making code for interpretation). As discussed earlier, triangulation strengthens internal validity and reliability here, as well.

2. *Audit Trail* – the researcher provided a detailed and rich description of the data and how the data were collected, how categories were derived and how decisions were mapped out through models, charts and descriptions throughout the research project/ inquiry. The notes taken from data analysis are documented and provided in the Appendix 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B and 8A.

3.14 Ethical Considerations

The following are details concerning ethical considerations of informed consent, withdrawal rights and anonymity. In the light of the use of audio recordings in class and during interviews, consideration was also given to the appropriate use of the audio data collected.

3.14.1 Informed Consent

One year prior to the implementation of the project, the school leadership, namely, the principal and the senior leadership team was contacted in writing about the possibility of conducting the project at the college. A formal outline of the study and the research plan was then made available to the college leadership. Permission was granted by the school leadership to run the pilot project that year and the research project the following year.

The comparison group teacher who was to take part in the study was also contacted and a letter of agreement was also established with him. In the letter, he was also assured that anonymity would be assumed in his participation of this study. He will assume the fictitious initials of D.R. whenever mentioned in the present study.

Information letters to parents/guardians (refer to Appendix 9) were sent for both classes to inform them of the purpose of the study and to ask their permission for their child to be involved in the study. The students themselves were also asked to give their consent to participate in the study. So, permission was sought and granted from the Principal, teacher, parents or guardians and students to be involved in the study. for the term of ten weeks by completing all required work as a participant (the interview and the course of study that included class activities, pre and post-questionnaire and journal writing) [Refer to Appendix 10]. If the parents did not want their child to participate in the study, the teacher would not involve the students in the activity or completion of the written task, questionnaire, interview or journal writing.

At the outset, one student in the experimental class wanted to opt out of the study as the parent had some reservations as to how this may impact on the child's learning (such as additional pressure). The parents arranged for an interview with me for clarification, and after some explanation, the parents were reasonably pleased with the research and gave consent for the child to participate. We had another student from the comparison group who opted out of the research and the parent did not wish to provide any comments on his reason for doing so.

3.14.2 Withdrawal Rights

The participating teacher and the students were informed that they were able to withdraw from the study at any time. In the comparison group, no one chose to withdraw from the study once the consent was given. In the experimental group, two students left halfway through the course; one due to a change of subject combination and the other for home schooling (reasons which are not related to the research process). One student joined the class halfway through the course as a foreign exchange student.

3.14.3 Anonymity

The participants were informed through a written letter of what data would be collected and analysed as well as the potential use of the audio recordings. Participants were assured that anonymity and confidentiality would be maintained in the documentation of the data, the research dissertation and any publications from the research.

Both the participating teachers (myself and D.R.) were given control over the audiotaping to ensure that they and their students would not be stifled by the process of recording (especially if an "unpopular" opinion is voiced) or any derogatory remarks made concerning anyone that might inadvertently be recorded.

3.15 Chapter Summary

The purpose of the present chapter was to describe the research design used to address the research questions. This chapter began with a statement of the three research questions and a delineation of the reasons for the use of mixed methods as a methodological approach. Such a methodology was characterised by a pragmatic worldview, a constructivist epistemology and an interpretivism theoretical framework. The methodology was action-research based using triangulation and the teacher as the action researcher. The research utilised both quantitative and qualitative data involving multiple forms of data collection and analysis.

The experimental protocol is provided with a description of the mixed methods design where data were collected from a pre-program questionnaire involving both comparison and experimental groups, both taught by different but equally experienced teachers. The composition of the questionnaire and its rationale as well as the choice of ethical frameworks and its rationale were also provided. The stages of data collection and data analyses were presented chronologically within the program period of 10 weeks. The sources include pre- and post-program questionnaires, classroom observation, interviews with students (audio-digitally recorded) and teacher, journal notes, questionnaire data and concurrent data analysis.

A detailed description of the research environment comprised the college profile, students' profile, teachers' profile as well as a model of teaching and learning science/ ethics. This was followed by a description of the program structure and a tabulated form of the teaching strategies and a week-by-week structure of the entire program.

Both qualitative and quantitative methods are designed to ensure both internal and external validity were addressed. The internal validity criteria was met by representative sampling, prolonged engagement and persistent observations in the field, triangulation of methods, triangulation of sources, members checking, peer examination and measures to minimise researcher's bias. To ensure external validity and reliability, a detailed and thorough description of data was collected and analysed, and the position of the researcher and the participants were given much consideration when using multiple methods of data collection and analysis and providing a detailed and comprehensive audit trail. The chapter concluded with ethical considerations that include informed consent, withdrawal rights and anonymity.

This chapter is followed by Chapter 4 which presents the qualitative and quantitative data and findings corresponding to each research question. A summary of the research findings is provided at the end of each sectional response to the three research questions followed by a chapter summary at the end.

CHAPTER 4

DATA ANALYSES AND FINDINGS

4.1 Introduction

Chapter 4 encapsulates the data analyses and findings of the present research and primarily sought to determine the effectiveness of the current model of teaching socio-scientific issues in developing informal reasoning through the use of a simple framework, the effectiveness of the use of ethical frameworks in increasing students' ability to reason analytically and make decisions about ethical issues and to establish avenues where the use of ethical frameworks can increase the teacher's confidence in teaching socio-scientific issues.

Both quantitative data and qualitative data were collected in this study. The quantitative data were collected from both comparison and experimental groups involving a total of 63 students from two Year 10 biological science classes in an evangelical Christian college in metropolitan Perth. The quantitative data were based on pre- and post-program questionnaires that assessed students' understanding and ethical thinking, attitude and opinions of biotechnology, scientific knowledge and a section on students' religious faith based on the COS survey (Christian Orthodoxy Scale). The quantitative data were conducted with the aim of comparing any changes, if any, of the comparison and experimental group in terms of their ethical reasoning, attitude and outlook of biotechnology in the course of the program. The differences in pre and post intervention of the use of frameworks in the students' attitudes and perceptions of ethical reasoning were also analysed.

This chapter addresses the three research questions outlined in Section 1.4. The qualitative and quantitative data used to answer the three research questions were analysed. For research questions 1 and 2, the data were generated from the pre- and post-program questionnaires Part E `The Four Scenarios', class activity `My Sister's Keeper', student journals, student interviews, researcher's observation and teacher's reflective journal writing. These data provided varied perspectives of the learning

activities from the teachers and the students. Data generation and interpretation took place in a cyclical fashion. Interviews with the comparison teacher took place on a weekly basis, and the researcher/experimental teacher took notes in experimental classes, and in some cases, in the comparison classes (as researcher was limited by other teaching commitments and administrative responsibilities during school hours).

In addressing research question 3, qualitative data were obtained from the teacher's interviews, researcher's observations and the teacher's reflective journaling. This was also triangulated with the notes taken from students' journals and students' interviews. A summary of the research findings concludes each sectional response to the three research questions, and is followed by a chapter summary at the end of this chapter.

4.2 Research Question 1 – Qualitative Data and Analysis – Comparison Group

Research Question 1 – How effective is the simple framework in developing students' ability to reason analytically and make decisions about ethical issues?

To assess the effectiveness of the current model of teaching socio-scientific issues, the comparison group was taught a similar biotechnology program for the entire term of 10 weeks (refer to Appendix 1A) using the simple framework template (as given in Appendix 2A). The rationale for the use of the simple framework for the comparison group was provided in Section 3.9.1.2 on pages 54 and 55. The simple framework was to enable the comparison group students to explore the benefits and risks of a number of viewpoints and seeks to establish some kind of justification based on the range of viewpoints.

The comparison group students were given a similar amount of time, about three weeks, to practise the use of the ethical frameworks using similar activities and teaching strategies. The commonality of approach is reinforced through the use of the following teaching strategies also applied in the experimental group along the same timeline; namely, powerpoint presentations, ClickView videos, debates, role-play, small group discussions, place mat activity, concept mapping, writing a booklet

on biotechnology, lab sessions, activities, media article discussions, DVD presentation, online resources, introductory ethics/ argumentation skills lesson, class-generated quiz, use of questionnaires, interviews, assessments and journals. All the teaching strategies used in the program can be found in Table 3.7 on page 67.

The evaluation of the effectiveness of the use of the simple framework in developing informal reasoning and decision making abilities were drawn from the following qualitative data generated from the pre-program and post-program questionnaires Part E `The Four Scenarios' and from the class activity `My Sister's Keeper'.

4.2.1 Qualitative Data and Analysis - `The Four Scenarios'

4.2.1.1 Data Source One

`The Four Scenarios' (Appendix 3) was Part E of the pre- and post-program questionnaire. This questionnaire was given to both comparison and experimental group at the beginning and the end of the program. The Four Scenarios were all gene technology applications, presented with open-ended questions. These scenarios are genetically modified food, genetic screening of embryos, in vitro fertilisation and therapeutic cloning. Students were asked to indicate if they agreed or disagreed with the use and to provide justification (refer to 3.9.1.1 Part E on page 53).

4.2.1.2 Analysis of Data Source One

The Simple Framework as a Good Starting Point to Explore Alternatives

First, based on the students' written responses of the `Four Scenarios', the use of the simple framework such as pros/cons and benefits/risks was found to be useful as it helped students to think about options and alternatives they may not normally think of themselves. Often the responses were a few words or a few sentences but this framework helped to facilitate their thought processes so that in cases, where there was no response in the pre-program questionnaire, there were more students responding in the post-program questionnaire. In 59% of the cases in pre-program

questionnaires and 77% in post- questionnaires, one to two reasons were stated to justify their viewpoint (refer to the student responses in Table 4.1).

Observation A – From `No Response' to a `Simple Response'

The following students' responses were chosen because they indicated `no response' in the pre-program questionnaire but provided some form of response in the post-program questionnaire. The lack of response from one fifth of the comparison group across all four scenarios may be attributed to the fact that some students did not know *what* or *how* to respond at the beginning of the program and were able to respond only after having been taught the content and given some practice in the use of the simple framework or they agreed or disagreed with the technology but did not know *how* to give the reason for their viewpoint. There was *one* student who stated that he did not know enough to agree or disagree with it.

Table 4.1 A Sample of Comparison Group Students' Pre- and Post-program Written Responses on `The Four Scenarios'

Pre-program Response	**Post-program Response**
Scenario 1 Genetically Modified Food - Agree – *No Response* S37	Agree – *`This could make food cheaper, taste better and have better nutritional value.'* S37
Scenario 2 IVF and Genetic Screening - *Don't know what it is!* S38 *No Response*	Disagree – *`Because I don't think it is right to pick the gender of your baby or what it should look like.'*S38
Scenario 3 Reproductive Technologies – *No Response* S51	Agree – *`It allows the infertile couple to have children and live normal lives.'* S51
Scenario 4 Therapeutic Cloning & Stem Cells *No Response* S51	Disagree – *`It is a hard process and can lead to long term (negative) effects.'* S51

Observation B – Statement of one to two reasons

In comparing the students' written responses justifying their viewpoints with one to two reasons, 59% of the students responded in the pre-program questionnaire compared with 77% in the post-program questionnaire across the four scenarios. It may perhaps be inferred that, given the instruction and the practice of the simple

framework, more students were able to respond with some confidence by providing some form of reasoning for their viewpoints.

The following student responses presented in Table 4.2 were selected because their responses of one to two reasons characterised the type of reasoning observed in the comparison group.

Table 4.2 A Sample of Comparison Group Students' Pre- and Post-program Written Responses on `The Four Scenarios' (characterised by one to two reasons)

Pre-program Response	**Post-program Response**
Scenario 1- GM Food	
Disagree – *Even if it can be of great help to people in the sense that it could be healthier and help fight world hunger, GM food might make the earth adjusted to it and people become dependent on it. The earth might not produce any more natural things easily. We might have to use more and more to keep the same quality.*S41	Agree -`*I think that GM food is not that bad because by doing this, we could produce better quality food and more food which would help people. I do reckon though there are dangers involved such as it could upset nature and can produce result that was not intended.*'S41
Scenario 2 – IVF and Genetic Screening	
Disagree *I disagree with the selection of traits as that is some sort of telling God you can improve his creations. If it is a life-threatening disease, I think we can modify the genes.*S46	Agree -`*I agree with the technology (IVF and Genetic Screening) as long as it is used for medical reasons to help people and not for vanity. By medical reasons, I mean it could save people or increase quality of life. But for vanity purpose (such as becoming more attractive with `blue eyes', etc), it is unethical because it puts pressure on a child to become someone he is not. This can also create a bigger gap between the rich and the poor.'* S46
Scenario 3 Reproductive Technologies	
Agree *`This would help infertile couple to have children but they could also adopt a child. I understand that sometimes a parent want to have their very own children.'*S61	Agree *`I agree but it could be a last option the couple think about adopting or surrogacy.'* S61
Scenario 4 Therapeutic cloning and stem cells	
Agree *`It could help save people who need organ transplants.'*S61	Agree *`This is a good way to save lives as they are no risks and other people won't risk dying from donating an organ.'*S61

It may be inferred from the above comparison group students' post-program responses that there was a reasonable level of *increased* awareness of ethical

thinking and the simple framework provided a starting point and some means of justifying their viewpoint with a reason and/or a claim to substantiate a particular stand they chose to take.

4.2.2 Qualitative Data and Analysis - `My Sister's Keeper' Activity

4.2.2.1 Data Source Two

The `My Sister's Keeper' activity was conducted in week 7 of the ten-week program. This activity comprised a DVD presentation (and a written synopsis of the story as shown in Table 4.3 below) based on a fiction written by Jodi Picoult (2004) and an in-class one-hour exercise where both comparison and experimental group students gave their written responses to a series of eight questions designed by the researcher to assess their understanding of the scenario and the reasoning process (refer to Appendix 4 for the class activity questions).

Table 4.3 Synopsis of `My Sister's Keeper'

Anna is not sick but she might as well be. By age thirteen, she has undergone countless surgeries, transfusions, and shots so that her older sister, Kate can somehow fight the leukaemia that has plagued her since childhood. The product of pre-implantation genetic diagnosis, Anna was conceived as a bone marrow match for Kate – a life and a role that she has never questioned… until now. Like most teenagers, Anna is beginning to question who she truly is. But unlike most teenagers, she has always been defined in terms of her sister – and so Anna makes a decision that for most would be unthinkable… a decision that will tear her family apart and have perhaps fatal consequences for the sister she loves. My Sister's Keeper examines what it means to be a good parent, a good sister, a good person. Is it morally correct to do whatever it takes to save a child's life…even if it means infringing upon the rights of another? Is it worth trying to discover who you really are, if that quest makes you like yourself less.

Of the eight questions, students' responses to two particular questions were selected as responses to these most clearly demonstrated (if any) students' reasoning and decision-making processes.

Questions:

- Do you think it is ethical to conceive a child that meets specific requirements? Give reasons for your answer.

- Using the simple/ethical frameworks, explain what decision you would have made if you are Mr and Mrs Fitzgerald (Anna's parents) and how you would necessarily make that decision?

4.2.2.2 Analysis of Data Source Two

In assessing the decision-making skills of the student work samples on `My Sister's Keeper' activity (refer to Appendix 4), the researcher developed a code (see Table 4.4 on page 79) by which incorporated the essential components of sound decision making skills. Sound decision making skills demonstrate a reasonable understanding why a decision has to be made, an understanding of the source of the problem (Ratcliffe, 1997; Ratcliffe & Grace, 2003). This was accompanied by a consideration of a plausible number of options (Eggert & Bolgeholz, 2006; Jimenez-Aleixandre, 2002; Zohar & Nemet, 2002, Zoller, 1982). The options could refer to, for example, the number and type of ethical frameworks used; which was indicative of an integrated approach in shaping the argumentation process towards decision making. Attention was also given to the consequences of weighing the benefits and risks of a technology or practice employed (Siegel, 2006). The ability to monitor and guide one's own thinking process or *metacognition* (Kolsto, 2006) was determined by the kind of question posed or the type and sequence of reasoning used to build towards a well-informed decision.

The table below is a non-hierarchical array of features that constitute sound decision making in dealing with socio-scientific issues in the classroom activities. Based on the literature review of key features in a decision making process on pages 18 - 21 of the present study, the list of codes was developed by the researcher as a means of identifying the progress (if any) of the comparison group in their use of the simple framework.

Table 4.4 List of Codes on the Features of Sound Decision-Making

Code	Features of Sound Decision-Making
A	Understanding why decision is to be made
B	Integrating of two or more ethical frameworks
C	Identifying benefits and risks in the consequences
D	Establishing sound evidence (scientific knowledge, intuition, values)
E	Thinking through the thinking process (meta-cognition)
F	Attitude (openness, engagement, motivation, etc.)

The simple framework indicates a somewhat limited extent of usefulness in developing reasoning and decision making abilities

The sample of students' responses to the class activity `My Sister's Keeper' selected presents a snapshot of the type(s) of reasoning and the nature of decision-making approach of the comparison group. Essentially, the simple framework serves as a good initiation point, raises a reasonable level of ethical awareness and provides some form of facilitation towards sound decision making but does not go far enough to expand ethical thinking and build sufficient ground for justification in decision-making.

Of the 32 students in the comparison group, the following students' responses provided some indicators of the type or development of decision-making abilities. It is noted one third of the students (10 of 32) explained briefly in terms of rights of individuals (child or parent), about one-sixth (5 of 32) emphasized the importance of a care ethic, one eighth (4 of 32) stated that the `saviour sibling' was an unnatural way to resolve the issue while the remaining one third of the class looked to factors of consequences and divine purpose. The data collected from the comparison group on the `My Sister's Keeper' activity can be located in Appendix 4A. The letters in bold and brackets indicate the code given in the Table 4.4 above.

Student S35

Response to Question 1

It really <u>depends on the circumstances</u> of the situation. If someone wants to <u>design their</u> <u>baby, just for appearance</u>, etc., <u>I think it is wrong</u>.

It may be inferred from the student response above that she understood that there were several factors to consider but did not list them or point out how different circumstances may alter or shape the decision made. Here, the student understood that with socio-scientific issues, there is no *one* right answer but the need to decide on one which is the best within a given set of constraints (Zoller, 1982). She was aware of the subjectivity of the issue but failed to make more explicit the guiding values or current knowledge relevant to the issue by not providing a justification for her viewpoint.

The comment `*I think is wrong'* reflects how the student's social and cultural perspectives (cosmetic versus therapeutic intervention) affect the way she viewed the enterprise of biotechnology here. This indicates some form of intuitive reasoning here. However, she did not provide a rationalistic basis for his viewpoint. She did not address the purpose of the problem here – the question of the validity of such an act - even if it is to save a life. **(A)**

Response to Question 2

I would probably choose to try and have a saviour sibling (Anna) though I think I would not have gone as far as the parents did. I would feel what it is like to possibly lose your daughter, <u>and I would probably try and save her</u>, but <u>if it was too hard and too much for her, I would let her go</u>.

This student was able to make a decision here to have the `saviour sibling' to address the problem but established the extent to which the intervention should proceed. Emotive and intuitive reasoning are used as the student empathised with the experience of loss and yet acknowledged the rights of the suffering individual to reasonable quality of life to `let her go'. The decision was not made purely on emotion and there are indications that the student was able to explore and evaluate the alternatives of keeping and releasing the loved one. **(B, C)**

Student S37

Response to Question 1

No, as the child was not made out of love but to basically do what her parents want her to, and she has no control over her decisions.

In his adamant `no' to the question, the student brought to surface the deontological argument of `creation of life as a product of love and not for the purpose of functionality or convenience.' Student was able to speak for the right of the unborn child `destined' to live a purpose determined by the parents. The child becomes an object of `manipulation' to fulfil undoubtedly a higher purpose of saving her sister. While there was no explicit mention of ethical framework here, it is noted here that the student considered the perspective of both the parent and the child; namely (i) balancing the rights of both parties and deciding that the unborn child's voice needs to be heard and his/her rights to be acknowledged as well as (ii) address the issue of fairness as the child/saviour sibling are entitled to life and quality of life respectively. **(A, B)**

Response to Question 2

It would be a really hard decision to make even if you put the situation in God's hands, it would be very hard to see your child die. I would try everything to save my child, but I would not make a designer baby as that is not why you have a child.

This student demonstrated emotive and intuitive reasoning here. A care-based, empathised response is observed: `it would be a really hard decision even if...' While God was acknowledged as a source of divine power and help, the student did not use divine injunctive as part of his argument. He simply stated his personal (*moral*) reason for not having a saviour sibling was the sanctity of one's life purpose cannot be manipulated by anyone [including the parent]. While none of the ethical frameworks appeared to be explicitly used, his attitude to life and moral values **(D, F)** seemed to have some influence over his reasoning process.

In his journal entry, the student observed that there were quite a number of responses based on Christian moral values in the class discussion. It is interesting to note that

having Christian values in class discussion does not necessarily lead to a prevalent integration of these values in the written responses.

Student S54

Response to Question 1

I think it isn't really ethical but it sometimes comes to the only choice when a life is at stake. The reason why I don't think it is really ethical because it is just taking a person's life away just for another person, unless the person will be able to save multiple people?

Student S54 responded by stating that an unethical act may become inevitable when one has to resort to it to save a life. **(D, F)** This student understood why a decision has to be made **(A)** and saw `saviour sibling' as the *only* option but did not see it as ethical because it is one life for another (more precisely, one at the expense of the other). Intuitive and rationalistic reasoning are used here. Interestingly, she extended her argument further by using the utilitarian approach[C]. *Does an unethical act become more justifiable because more lives can be saved through the sacrifice of one life?* Student S54 responded to a question with another without somewhat resolving the dilemma here. She has taken her argument into alternative framework of thinking but simply leaves it there.

Interestingly, at the interviews, this student commented that she has seen the importance of making decisions by considering the perspectives of different people **(B).** She appreciated that many factors come into play in a decision making process. This was also confirmed in her journal entry. Perhaps, students need a more deliberate, scaffolding approach to lead them from this point of acknowledgement and recognition.

The observation that the student considered the `saviour sibling' concept as the *only* solution indicates that she has not taken into consideration her scientific knowledge of organ transplant and the treatment of leukaemia. If she had grounded her reasoning based on scientific knowledge of alternative treatment (e.g. bone marrow transplant by a suitable donor), she need not have placed herself in this conundrum.

Response to Question 2

The decision I would have made would search for the right person that would help with Kate's treatment as soon as she was born.

In the second response, she brought her scientific knowledge of leukaemia treatment into the equation **(C, D).** Yes, the possibility of treatment by seeking a suitable donor would be ideal. It is noteworthy that this student only mentioned a `right person'; she was not very specific as to what help may be rendered: medical expertise, correct medical prescription, suitable organs/donor etc. I was anticipating a right `donor' instead of just a `person'. The sense of time factor has been raised here – and it is a valid point of argument in establishing timely and sound treatment (benefits and consequence). Rationalistic and intuitive reasoning were used although there is lack of substantiation to justify the decision.

Student S56

Response to Question 1

No, you are destroying lives even if you think you are saving another.

Student S56 understood why a decision has to be made **(A)** but highlighted the very irony in the proposed decision. It was an act that `healed' one and `killed' another [or others] simultaneously. This student employed rationalistic, intuitive and moral reasoning all in one statement. However, he did not offer alternative options (using scientific knowledge of gene technology) that may serve as viable reasons for not resorting to such an extreme measure.

It is noteworthy that here the written response was brief. Sometimes, the written response may not always truly reflect all the reasoning processes used. At the interview with S56, he suggested more hands-on and discussion-oriented activities. He raised the point about being tired of reading and writing responses. S56 was a sporty and athletic student and his learning style was one that is clearly kinaesthetic (confirmed with his health/physical education teacher).

Response to Question 2

If I were Anna's parents, I would go to God for help and ask for healing of Kate. When you put your trust in God, he will never put you to shame or let you down.

Student S56 recognised the power of divine intervention and placed his hope in another source of power that he recognised was sure and secure **(D, F**). Here, the moral and religious conviction of the student determined his one and ultimate response – a commitment to the wholly other; faith overtook reasoning in this instance.

The sample of students' responses to the class activity `My Sister's Keeper' presents a snapshot of the type(s) of reasoning and the nature of decision-making approach of the comparison group. Essentially, the simple framework serves as a good initiation point, raises a reasonable level of ethical awareness and provides some form of facilitation towards sound decision making but does not go far enough to expand ethical thinking and build sufficient ground for justification in decision-making.

4.2.3 Students' Learning and Teachers' Perspectives

4.2.3.1 Students' Learning (from students' journals and interviews with students)

Data were generated from students' journals of the comparison group at the end of the program. Students were encouraged to reflect on their learning activities and made a journal entry on a weekly basis. Based on the students' journals, students commented on the types of learning activities that were meaningful and engaging to them; primarily the debates and group discussions generated considerable interest.

On the use of the simple frameworks, the majority of the students (19 out of 32) expressed interest in *some* aspects of its use; primarily in the various perspectives it offers and the clarity it presents when articulating the viewpoint.

Student S48 `*I find it interesting that there are* ***so many different choices and consequences*** *to one thing. What would scientists usually do with such problems?*'

Student S50 `*I learnt about all the* ***different issues and viewpoints*** *surrounding certain aspects of biotechnology which included surrogacy and donor organ transplants. I found the viewpoints especially the* ***ethical and religious viewpoints interesting****. It made me think twice about my viewpoint and whether I was thinking the right way. My conscience sometimes told me what I was thinking wasn't* ***necessarily ethically right****.'*

Student S53 `*I would like to see some real ethical cases which have been resolved. I believe seeing* ***others' opinions would help us express better our viewpoints****. I found the* ***debate and group work interesting****. We have dealt with some ethical issues through group discussions, and also look at Christian viewpoints and others* ***moral points of view****.'*

Students' journal entries also indicated a level of appreciation for a safe and supportive learning environment created by the teacher. Students also expressed explicitly areas of biotechnology they would like to explore. There was an increased level of engagement with the subject of biotechnology. Students expressed interest in finding out specific topics such as genetic modification, human cloning, genetic engineering, stem cells, selective breeding, surrogacy and organ transplants.

In addition, data were also generated from interviews with students of the comparison group. In Week 9 of the term, all students were interviewed in groups. Five groups of students (2 – 3 per group) were interviewed by the researcher. Each session lasted about 15 minutes based on a set of interview questions listed in Table 3.5 on page 59. Each session was digitally recorded and notes were written from the recordings.

All the groups interviewed rated the hands-on activities of DNA profiling as most enjoyable and engaging, and would like to see more hands-on/interactive activities in the program. The interactive nature of group discussions also enhanced student's learning. The following comments are some indications of how the interactive and authentic nature of these activities helped in the reasoning and decision making process of students.

Student S28`*We enjoyed the discussion and the sharing of ideas, and we should do* ***more*** *activities involving* ***scenario****s.'*

Student S12`*The* ***controversial*** *issues open a whole new realm of seeing things. Like with the GM Food, we* ***weigh both benefits and risks****, and we look at problem solving too.'*

Student S24 `*In conflict situations, we learnt that resolution can take place through* ***talking it through*** *and reasoning it through…'*

Student S30 `*It is helpful that* ***personal views of others*** *are considered.'*

Student S7`*The scenarios are really engaging because it has* ***to do with real life****.* ***Debating*** *was good, and the* ***group discussion*** *too.'*

Student S29 `*I found debating and* ***working on different opinions*** *of surrogacy and transplants interesting. It helps me* ***see how everyone viewed*** *things…. I also learnt* ***how to have group discussions.*** *I enjoyed the group discussion and finding out everyone's opinion*'.

Student S8 `*I have found the debate very interesting and just how everyone had a different opinion. I would like to* ***debate on ethical issues****.'*

From the students' journals and interviews, it can be inferred that students valued the use of the simple framework in providing the means for considering a *range* of perspectives in developing and articulating a viewpoint. Students also perceived the *interactive* and *authentic* nature of learning activities as contributing towards their level of engagement with the subject of biotechnology – primarily use real-life scenarios, debates and group discussions.

Although the simple framework was used in class, very few students were conscious of how they were used as a *thinking* tool. The meta-cognition level of understanding how they learn what they have learnt was not quite evident (from the student interviews that followed) until they were prompted about the use of pros and cons or the benefits and the risks.

In an interview with a group of three students from the comparison group towards the end of the term, the following took place.

Interviewer's Question: Was the use of the framework helpful? Explain why.

Student's Response: I can't remember…

Another Student's Response: Not sure…

Third student was silent.

Interviewer's Question: There were some questions that you were asked for each case study… such as what is good or bad about the issue?

Student's Response: Ah.. yes! We weigh the benefits and the risks – that was helpful.

This was noted from the interview (as cited above) and their written responses in class activity analyses showed they had utilised the simple framework only to a *limited* extent. A majority of students were not explicit about its use in their journal entries. This is a point of difference with the experimental group (a point that will be highlighted later in this chapter from the experimental students' verbal and written contributions).

4.2.3.2 Teacher's Perspectives of Learning (interview with teacher of the comparison group)

From the interviews conducted with the teacher of the comparison group on a weekly basis during the ten-week program, the simple framework in delineating the pros and cons was quite useful as it helped the students to think about *options and alternatives* they may not normally think of themselves. He noted that the practice of the simple framework, to a reasonable extent, facilitated student's verbal responses in class discussions. Although the written responses remained brief and often a couple of sentences, students seemed to have gained more breadth and depth of understanding of the issues involved from the classroom discussions. In particular, he noted the increased level of interest and engagement with the subject as more probing questions were asked. He also attributed the increased level of interest to the variety of teaching strategies used such as debates and role-playing. He has found the whole process quite challenging but worthwhile as students are navigated to some extent in dealing with difficult issues.

4.2.4 Christian Values and Students' Responses

Although the comparison group used the simple framework on pros/cons and benefits/risks (with no explicit reference to Christian ethical frameworks), it is noted that Christian values/ beliefs were articulated quite strongly here.

With regards to the `Four Scenarios' pre- and post-questionnaire, there were a significant number of responses (about one third of the class) articulated from a Christian perspective. A majority of students (37.5%; 12 of 32) went along the lines of gene technologies being against God's will because it is against nature (or the divine order of things). Others (remaining two-thirds) were less sure and opted for a more moderate approach. An example of a student's response to one of the `Four Scenarios' is as follows:

S41 *`I think IVF is unnatural but it is sort of acceptable because the embryo is naturally forming. But changing the embryo is like playing God. It will result in a society where everyone looks the same according to a `perfect' standard defined by society.'*

Eighteen of the 32 students made some form of reference to God in their responses to the activity of `My Sister's Keeper'. This may be attributed to the strong Christian ethos of the college and most of the students (> 90%) come from predominantly evangelical Christian family backgrounds. An example of a student's response to the `My Sister's Keeper' as follows:

Student S53 *`I believe the `saviour sibling' act is wrong. I believe it is breaking natural selection, and going against God's will. As tempting and promising as it could sound, it could have huge effects on the child's life (emotional and physical*).

Generally, there was a lack of justification or warrant/claim. With the comparison group, the issue of fairness and rights were popular arguments although in most cases, there was little substantiation. Ambiguity is noted in some cases (7 students). The use of emotive language was quite striking in a few cases (3 students). Thus, with the comparison group using the simple framework, there was distinctively use of Christian values in shaping and influencing the students' responses.

4.2.5 Summary of Findings

Based on the data collected from the comparison group's pre- and post-program questionnaires (refer to Appendix 3A), student responses to the class activity on `My Sister's Keeper (refer to Appendix 4A), students' journals (Appendix 5A), students' interviews (Appendix 6A) and teacher's responses to evaluation questions (Appendix 7), the following research findings are stated.

(i) From the interviews and the journal entries, more than half of the comparison group students [53 %] attested to the workability of the simple ethical framework. It helped them to `find out other people's opinions' (from the student interviews) or `look at issues from many viewpoints – the bad, the *okay* and the good ones'. Such an array of viewpoints have actually aroused the curiosity of several students and prompted them to ask questions and explore further the nature of science in biotechnology. This brought about an increased level of engagement with science; hence the relevance of science in their daily life. Such a positive connection was also noted in improved outcomes (assessment results) for some particularly disadvantaged students in this class (specifically S41, S42 and S35).

(ii) From the students' written responses to the data sources, it was observed that the use of the simple framework helped students to *begin* the process of *considering o*ther options but did not *substantially* improve the level of reasoning or quality of reasoning when comparing pre- and post-program responses. While it was acknowledged by the students during interviews and from students' journal entries on the usefulness of the simple framework, analysis of the students' written responses from the data sources has not demonstrated a reasonably satisfactory increased level and/or quality of reasoning. While the number of students who gained confidence from `no response' to `justified responses' increased by about 18%, the quality of responses between pre- and post- remained relatively similar in that provision of one to two reasons are the common responses to substantiate a view point.

(iii) Given the use of the current model of the simple framework using pros/cons and benefits/risks, the teacher teaching the comparison group observed from class room discussions and activities, such as debates and role play, that was slight improvement in the thinking skills (rationalistic and intuitive reasoning) and ability to articulate one or two perspectives of a difficult issue. It must also be emphasised that this was aided by the use of a whole range of teaching strategies that helped engage the students throughout the term.

(iv) Although the use of the simple framework presented a visual guide to facilitate students' thinking and reasoning of the socio-scientific issue, it requires some reading and writing. This learning style did not appeal to all students. A number of students expressed in their interviews that they preferred to talk, discuss and air their views rather than activities that requires reading a media article and writing their response according to the template. Thus, it was observed that there were different learning styles and teaching strategies that could be used with introducing the simple framework. There is value in articulating one's viewpoint and using verbal means of communication in justification. An appreciation for students' different learning style and the appropriate use of variety and type of teaching strategies that accompany the introduction of the simple framework may enhance its usefulness.

In summary, an evaluation of the use of the simple framework and the extent to which the simple framework has enhanced the student's overall ability to reason and make decisions on ethical issues (based on the qualitative analyses) seemed to point towards increased engagement with science but not necessarily increased effectiveness in the reasoning and decision-making abilities.

4.3 Research Question 2 - Qualitative Analysis - Experimental Group and Quantitative Analysis of Experimental and Comparison Groups

Research Question 2 – In what way does the use of the five ethical frameworks affect students' abilities to reason analytically and make decisions about ethical issues?

To assess the effectiveness of the use of the five ethical frameworks in developing students' ability to reason analytically and decision-making abilities about ethical issues, the experimental group was taught a similar biotechnology program for the entire term of 10 weeks (refer to Appendix 1A) using the five ethical frameworks (template as given in Appendix 2B).

The rationale for the use of the five ethical frameworks for the experimental group was provided in Section 2.4.3.4 and 2.4.3.4.1 on pages 30-34. As a whole, the five ethical frameworks are based on three primary ethical building blocks; primarily deontology (from Greek `*dei*' – must or duty), virtue (Greek `*virtus*' – skill, strength and excellence) and teleology (Greek `*telos*' – end, purpose or goal). Due emphases are given to *commands, character* and *consequences* or *principles, person and purposes* (including the fifth ethical framework). In the context of many and varied competing ethical perspectives, the five ethical frameworks provide a process for making ethical judgements as well as avenues to rationally and relationally justify them. Students can reason and articulate their ethical framework clearly so that they are equipped to make ethical decisions as well as challenge the flaws, if any, in other ethical frameworks that may confront them in the future.

The experimental group of students were given the same amount of time, about three weeks, to practise the use of the five ethical frameworks using the same activities and teaching strategies. The commonality of approach is reinforced through the use of the following teaching strategies also applied in the experimental group along the same timeline; namely, powerpoint presentations, ClickView videos, debates, role-play, small group discussions, place mat activity, concept mapping, writing a booklet on biotechnology, lab sessions, activities, media article discussions, DVD presentation, online resources, introductory ethics/ argumentation skills lesson, class-

generated quiz, use of questionnaires, interviews, assessments and journals. All the teaching strategies used can be found in Table 3.7 on pages 67.

The evaluation of the effectiveness of the use of the five ethical frameworks in developing informal reasoning and decision making abilities were drawn from the following qualitative data generated from the pre- and post- questionnaires Part E Four Scenarios and from the class activity `My Sister's Keeper'.

4.3.1 Qualitative Data Source and Analysis -` The Four Scenarios'

4.3.1.1 Data Source One

`The Four Scenarios' (Appendix 3) was Part E of the pre- and post-program questionnaire. This questionnaire was given to both the comparison and experimental groups at the beginning and the end of the program. The Four Scenarios were all gene technology applications, presented with open-ended questions. These scenarios are genetically modified food, genetic screening of embryos, *in vitro* fertilisation and therapeutic cloning. Students were asked to indicate if they agreed or disagreed with the use and to provide justification (refer to 3.9.1.1 Part E on pages 53).

4.3.1.2 Analysis of Data Source One

4.3.1.2.1 Identifying the Patterns of Informal Reasoning

Based on the written responses to the open-ended questions set in four different scenarios in Part E of the questionnaire, quantitative analysis was conducted to identify the patterns of informal reasoning and the role of morality in the decision making process. This is an adaptation of the model used by Sadler and Zeidler (2005a). Their research was based on evidence demonstrated in the form of rationalist, emotive and intuitive informal reasoning.

1. Rationalistic informal reasoning described reason-based considerations.
2. Emotive informal reasoning described care-based considerations.
3. Intuitive reasoning described considerations based on immediate reactions to the context of a scenario.
4. Moral informal reasoning described considerations based on one's values and belief systems.

The researcher has added the moral reasoning to the three forms of informal reasoning in the research as students in both comparison and experimental groups have been observed to state their values and beliefs in the pre-questionnaire, even though they were not explicitly taught or made known at the beginning of the term. Also, students may rely on a combination of these reasoning patterns as they worked to resolve individual socio-scientific scenarios. From the students' responses to the `Four Scenarios' and the `My Sister's Keeper' activity, there have been traces of evidence that students are making some attempts at integrating multiple reasoning patterns (refer to Table 4.8 on page 104 and Table 4.10 on page 108). The researcher has coded the combinations of reasoning approaches as shown in Table 4.5 below.

Table 4.5 Code for Different Combination of Reasoning Approaches

Code	**Reasoning Represents**
R	Rationalistic only
E	Emotive only
I	Intuitive only
RM (M)	Rationalistic and Moral
EM (M)	Emotive and Moral
IM (M)	Intuitive and Moral
No Response	Null response

The framework of informal reasoning can be visually conceptualised in the form of a Venn diagram as shown in Figure 4.1. Each circle represents one of the approaches of informal reasoning (i.e. rationalistic, emotive and intuitive) with the moral reasoning represented by a shaded equilateral triangle enclosing an non-shaded circle, denoting a complement set of moral reasoning.

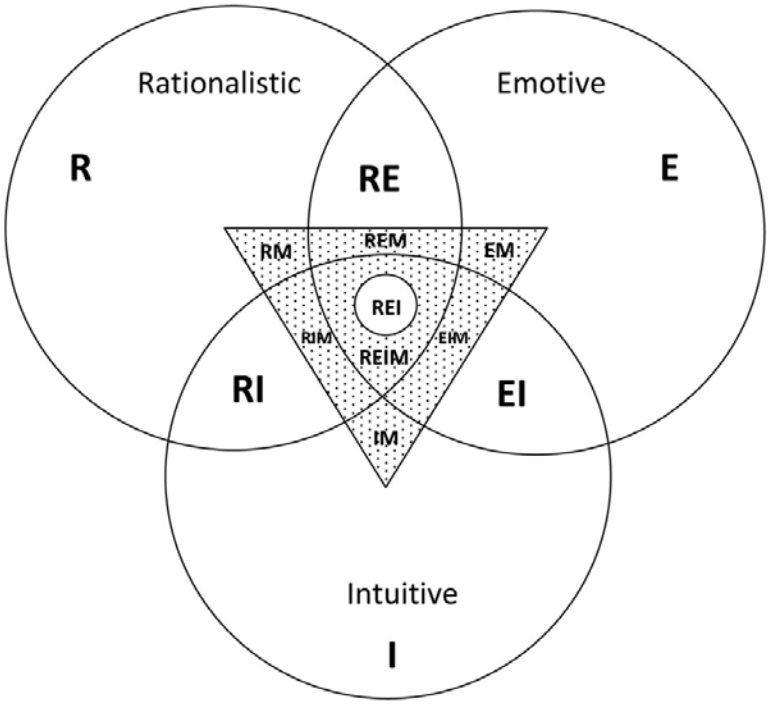


Figure 4.1 Display of the Emergent Patterns of Integrated Informal Reasoning

In analysing each student questionnaire responses from both comparison and experimental groups, the **rationalistic** reasoning are underlined, **emotive** reasoning are in italics, **intuitive** reasoning are in bold and **moral** reasoning are followed by [M]. The code used was explained and followed by an example. The code was used by two teachers who were familiar with Sadler's system of categorising informal reasoning to analyse independently the student work and after initial resolution with a third party, the inter-rater reliability was 91%. Where there were any differences, both teachers resolved by a consensus method based on the preferred rationale negotiated with a third party. Due to the small sample size, the figures for each scenario were all collated to determine how various reasoning types were used.

Table 4.6 Student Responses and Uses of Informal Reasoning Approaches

Rational	Students used rationalistic thought processes to guide their decision making in at least three out of four scenarios presented to them. They made rationalistic calculations based on a variety of factors, such as patient rights, parental responsibilities, the availability of other treatment options, side effects and future applications. **Rationalistic – 3 examples** On Genetically Modified Food - `Agree – It helps fight world hunger and malnutrition. S39 On Genetically Modified Food - Disagree – It would create an even larger gap between the rich and the poor. We do not know all of the dangers of genetic modification. S46 On Therapeutic cloning - Agree Many people are dying, waiting for organs and from the rejection of new organs. Therapeutic cloning would solve the problem. S53
Emotive	Students developed this reasoning from a care perspective in which empathy and concern for the well-being of others guided decisions or courses of action. Students frequently articulated ideas and positions that reflected concern for individuals that would potentially be impacted by their decisions. Considerations were made from a relational perspective. **Emotive – 3 Examples** On Genetic Screening - `Agree to some extent – *I agree with using it to get rid of genetic disease but I don't agree with using it to make designer babies. It is one of my worst fears to have a baby who inherit my condition*.' S24 On IVF and Genetic Screening' – Disagree – *This way of making a child is very unnatural and not at all how God planned it. It is like you are taking over God's role which is wrong*. S25 On Cloning of humans – Disagree - *If I couldn't have a baby with my wife, I would adopt because that's how it is and there are many children out there who need parents.* S13
Intuitive	Students based their informal reasoning on an immediate reaction to the context of a particular scenario. This is not often a `gut-level' reaction that could not necessarily be explained in rational terms. Intuitive feelings may not be rational but because they contribute to the resolution of socio-scientific issue, they may be considered a type of informal reasoning. **Intuitive – 3 Examples** On Genetically Modified Food – Disagree – **For thousands of years, we have survived without GM crops. I don't think GM foods could solve world hunger as this can only be treated by getting the food to places that need it in the first place.** S17

	On Therapeutic Cloning: `Agree**- It is for the better of everyone**.' S20 On IVF and Genetic Screening – Disagree to some extent – **Every child is God's creation and if we are to choose features and intelligence, it is no longer the work of God. I would not pick any child's features and talents. I would like him to be entirely made by God.** S27
Moral	Students based their informal reasoning on a set of beliefs or values or a set of morals they have due to personal convictions, religious or cultural factors. **Moral and Intuitive (MI)** On IVF and Genetic Screening: `Strongly Disagree **– It is against my own beliefs and values. (M)** S31  **Moral and Rational (MR)**  On IVF and Genetic Screening – Disagree – **I think that changing humans to fit our image instead of God's is `playing God'(M)** <u>and can have many risks and dangers. God made us perfect the way we are –whether we have Down Syndrome, black eyes or bald. He loves us the way we are. Changing ourselves to fit human image could affect our relationship with God. It could also have long term effects. S23</u> **Moral and Emotive (ME)** About IVF and Genetic Screening – Disagree *If someone wants to change their baby genes, would God's already have that planned and therefore plan for the baby to be like that?* **It is wrong to try to change God's order (M).** S20

4.3.1.2.2 Collation of Informal Reasoning Approaches for `The Four Scenarios'

A collation of informal reasoning forms for the four scenarios was made to analyse the different informal reasoning forms in the comparison and experimental groups to identify any similarities or differences (if any) between the two groups.

The Four Scenarios are provided in Table 4.7 on the following page.

Table 4.7 The Four Scenarios

1 Genetically Modified Food	**Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are drought and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.** Agree/ Disagree Outline as many reasons for your selection.
2 IVF and Genetic Screening Techniques	**Using *in vitro* fertilisation and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future, it may even be possible to select for other traits such as eye colour or intelligence.** To what extent do you agree or disagree with this technology? Outline as many reasons for your selection.
3 Reproductive technologies	**Many otherwise healthy couples are unable to bear children. Modern reproductive technologies, like fertility drugs and *in vitro* fertilisation, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a fetus and eventually be born as a baby.** Agree/ Disagree Outline as many reasons for your selection.
4 Therapeutic cloning and Stem cells	**In therapeutic cloning, cloning a cloned embryo is created and the stem cells removed. The stem cells are stimulated to grow into specific types of tissues and even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning**

	would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it. Agree/ Disagree Outline as many reasons for your selection.

Table 4.8 is a sample of students' responses taken from both the comparison and experimental groups to illustrate how the various reasoning forms are coded in their responses.

Table 4.8 Examples of Coded Student Samples Reflecting More Than One Form of Reasoning Approach.

Control Group – Student Response (Pre)
On Scenario 1 - Genetically Modified Food Coded: R,I Disagree Even though it can be of great help to people in the sense, it could be healthier and might fight world hunger and make food of better quality. **GM food might make the earth adjusted to it and people become dependent on it. The earth might not produce any more natural stuff as easily. We might have to use more and more to keep the same quality.** S41

Control Group – Student Response (Pre)
On Scenario 3 – Reproductive technologies and cloning Coded: E,M Disagree *Everyone is supposed to be different and* **creating a baby genetically identical to yourself is not natural and against God's will**.(**M)** S41

Experimental Group – Student Response (Post)
On Scenario 2- IVF and Genetic Screening Coded: I,R,M Agree to some extent **I think it could be okay to use for a couple who cannot have children, but only for detecting it has a disease or not. But if the embryo didn't have a disease, it could be okay.** For couples who are barren, it may be okay as long as it is not used to select traits such as intelligence, etc.(M) because the process is unfair to those who can't afford it. And it could potentially harm the baby with genetic screening. A major issue is *that it may result in the termination of pregnancies if the baby is found to have the disease* – **which is no good**. **(M**) S11

Collation of Informal Reasoning Approaches for Three Scenarios Selected

The analysis was based on the collation of reasoning types from the first three scenarios (scenario 1 – 3). Scenario 4 on `Therapeutic Cloning and Stem Cells' was not a viable scenario to infer from as a number of students did not fully understand the difference between therapeutic cloning and the use of stem cells in cloning. Subsequent interviews and written responses from class activities highlighted the nature of this misconception in cloning; primarily stem cells from *self* or non-*self* sources.

Table 4.9 Collation of Informal Reasoning Approaches

Reasoning Type	Comparison Pre [32]	Comparison Post [32]	Experimental Pre [39]	Experimental Post [29]	Comparison Percentage		Experimental Percentage	
					Pre	Post	Pre	Post
Rational R	22	22	25	45	18%	17%	19%	37%
Intuitive I	28	44	48	26	23%	33%	37%	21%
Emotive E	7	11	7	6	6%	8%	5%	5%
Moral M	28	36	40	35	23%	27%	31%	29%
No Response NR	39	19	10	10	31%	14%	8%	8%

4.3.1.2.3 Patterns of Informal Reasoning Findings

(1) In the collated list of the three scenarios (scenario 1 – 3), the types of reasoning approaches utilised by both groups were somewhat similar for all except for the *rationalistic* reasoning which saw an *increase* from 19% to 37% and a *decrease* from 37% to 21% in *intuitive* reasoning with the experimental group.

This may be indicative that the use of ethical frameworks in the experimental group had enabled students to move beyond emotive and intuitive response to develop a more logical or reflective approach; hence a greater use of the rationalistic reasoning type. It was, however, not a substantial difference to

allow a conclusive statement. It would appear that moral reasoning and the use of religious values had remained at fairly similar levels. This was not surprising given that the introduction of socio-scientific issues does not change moral or religious convictions but provide a means by which a viewpoint may be better expressed.

(2) The comparison group pre-questionnaire test showed that there was a greater number of students who opted for no response (31%) compared to the experimental group (8%). This observation was made in due consideration that the pre-questionnaire test was given at the beginning of the course. The lack of response may be attributed to uncertainty expressed with a new topic, lack of familiarity with concepts not taught yet and perhaps a lack of motivation for the topic/ subject. The `no response' number was particularly high for Scenario 4 on `therapeutic cloning and stem cells' in both groups as the topic is quite conceptual and the `wordiness' of the question may have put off some students from responding. This was a point of clarification at the interview. It was also for this reason scenario 4 is not included in the collated list of reasoning types for analysis.

(3) Research from Sadler and Zeidler (2005b) shows that `individuals who exhibited intuitive reasoning often use emotive and rationalistic reasoning to subsequently support their initial reaction. This research appears to point out that whilst this observation is true, this usually occurs *only when* students have a firm understanding of the scientific concepts of the gene technology (in particular with scenario 1 on `Gene Modified Food'). Where there was uncertainty or lack of clarity on the scientific knowledge or concepts (for example in scenario 2 or 4), students used the intuitive reasoning but lacked the rationalistic basis for substantiating their view point.

Nevertheless, the majority of students for both groups consistently exhibited patterns of integrating some form of rationalistic informal reasoning in every scenario, suggesting that, of the four reasoning patterns designated, rationalism was the least context dependent.

(4) It was observed that scenario 2 on `IVF and Genetic Screening' featured a high percentage based on moral reasoning (comparison was 79.5% and experimental was 70%). This meant that certain context call for moral values or reasoning to be expressed more explicitly in justifying their viewpoints. Significantly less reasoning on moral grounds was observed with scenario 1 on `Genetically Modified Food'. This indicated that the context of the socio-scientific issue influenced the type of reasoning used. Scenario 2 dealt with IVF issue – a subject that has been rigorously explored both in the content teaching of genetics and is controversial with regards to the use of stem cells after the IVF procedure (refer to Table 4.10 on page 108).

Essentially, the data suggested greater context dependence for moral, emotive and intuitive reasoning. The incidence of intuitive/moral reasoning across the scenarios 1, 2 and 3 for both comparison and experimental group ranged from 51% to 65%. The frequency of emotive reasoning and moral reasoning remained relatively high in scenario 2 on `IVF and Genetic Screening' and Scenario 3 on `Reproductive Technologies'. These patterns suggested that emotive and moral reasoning can vary according to the contextual issue. That is, reproductive technology as a socio-scientific issue was more likely to elicit emotive and moral reasoning than others.

It was also observed that intuitive reasoning was more prevalent in socio-scientific issue that calls for more individualistic decisions to be made. Scenario 2 and 3 on `reproductive technology' featured substantially high use of intuitive reasoning. The fact that intuitive reasoning typically determined an individual's ultimate decision suggests that intuitive reasoning was a significant factor in the resolution of some socio-scientific issues.

(5) Across the first three scenarios, it was noted that between the pre and post, predominantly for the experimental group, there was a shift from using one or two reasoning towards using more (two or more). This reflected a greater complexity in their reasoning patterns and an ability to integrate a number of different reasoning types. [As explained above, scenario 4 is an anomaly due

to a number of students lacking the understanding of the scientific concepts of therapeutic cloning.]

(6) Interestingly, when comparing the use of number of reasoning types among the post of comparison and experimental, more students from the experimental group were using two or more reasoning types compared to the comparison group.

Table 4.10 Comparison of *the Number of Reasoning Patterns* in the Post Tests of Comparison and Experimental Groups

Use of Reasoning Patterns	Scenario 1		Scenario 2		Scenario 3	
	Comp	Exp	Comp	Exp	Comp	Exp
1	10	0	4	0	6	2
2	12	17	7	10	10	9
3	4	9	13	14	6	12
4	-	-	-	3	1	1
No response	2	2	4	1	5	4

The increase in number of students using two or more reasoning types may be attributed to the use of ethical frameworks that encouraged students to utilise multiple options/choice framework to evaluate and to build up the argumentation process for a decision to be made**.** Or it may also be explained that students are learning to explore socio-scientific issue from various perspectives and use of ethical frameworks helped students to achieve a greater flexibility in the perspective-taking and hence influence the increased sophistication in their reasoning approach. However, the sample size is rather small and this limitation must be given due consideration and caution has to be made not to universalise this.

4.3.2 Qualitative Data and Analysis `My Sister's Keeper'

4.3.2.1 Data Source Two

The experimental group completed `My Sister's Keeper' activity in week 7 of the ten-week program exactly as the comparison group did. This activity comprised a DVD presentation (also given a written synopsis of the story, refer to Table 4.3 on page 83) based on a fiction written by Jodi Picoult (2004) and an in-class one-hour exercise where both comparison and experimental group students gave their written responses to a series of eight questions designed by the researcher to assess their understanding of the scenario and the reasoning process (refer to Appendix 4 for the activity questions).

Of the eight questions, students' responses to two particular questions were selected as responses to these most clearly demonstrated (if any) students' reasoning and decision-making processes.

Questions:

1. Do you think it is ethical to conceive a child that meets specific requirements? Give reasons for your answer.

2. Using the simple/ ethical frameworks, explain what decision you would have made if you are Mr and Mrs Fitzgerald (Anna's parents) and how you would necessarily make that decision?

4.3.2.2 Analysis of Data Source Two

In assessing the decision-making skills of the student work samples on `My Sister's Keeper' (refer to Appendix 4A), the researcher developed a code (see Table 4.4 on page 85) by which incorporated the essential components of sound decision making skills. The literature review governing the principles of sound decision making was provided earlier in pages 18 – 21 of Chapter 2.

The table below is a non-hierarchical array of features that constitute sound decision making in dealing with socio-scientific issues in the classroom activities. Based on the literature review of key features in a decision making process on page 84, the list of codes (refer to Table 4.4 on page 85) was developed by the researcher as a means of identifying the progress (if any) of the experimental group in the use of the five ethical frameworks.

Observation A – On the use of the number and type of ethical frameworks

While only a few students did not make direct reference to the ethical frameworks in the experimental class, the references to rights, virtue and character as well as making choices were implicit in their responses. Of the five ethical frameworks, balancing rights, maximising benefits (utilitarian) frameworks and Christian values, were used substantially more than the rest. Having established that, the number of students using two and/ or three was significant (about 70% of the class).

The main reason for their argument was that the parents have the right to keep their child alive as long as is possible, and the suffering child Kate, has the right to live. This was followed by discussion on whether Kate has the right to end her own life, or the parents have the right to bring the rights of one child over and above the other sibling. Anna also has the right to her own body and thus she can make decisions for herself about whether to give up her kidney for Kate. The view that it would not be right to make one child suffer for the sake of another was quite clearly expressed here. The virtue framework was used to ensure fairness to each child is also discussed.

It was also noted the use of scientific knowledge was also implicit in the responses – a number of students suggested getting a suitable organ donor and discussed and reasoned on the basis of the negative effects of pre-implantation genetic diagnosis and excessive surgeries on the donor child.

The above observations are inferred from the following students' written responses in the class activity.

`*It ruins human nature to produce a baby with a* ***specific genotype****. As soon as it happens, a human is no longer human. It is* ***a scientific experiment****.*' Student S53

`What makes us human special or different is the ***amount of genetic diversity*** *between all of us.'* Student S43

*`If I were Anna's parents, I would obviously spend money on the sick child, but genetically engineering a child should be avoided because it denies the child's uniqueness (****their genetic make-up is changed for a specific purpose****), and there could be many complications like those (****reduced quality of life, restricted career opportunities with one kidney,*** *etc.) in the movie.'* Student S11

`I do not think the reason for living should be reduced to just fulfilling a function – ***providing spare parts for the other****.'* Student S12

In the class's written responses as a whole, students demonstrated the ability to use their scientific knowledge of pre-implantation genetic diagnosis and screening and organ transplants to make a rational decision. While some relied on emotions and intuition, to a certain extent, reasoning still takes the logical flow in explaining how the rights of each individual ought to be considered. Objectivity is demonstrated as different parties – the role and the responsibility of the parent, the donor child, the recipient child, the judge and the lawyer are given due consideration. The arguments are generally valid as the crux of the dilemma is often identified and the reasons for resolving the dilemma are systematically set forth.

Some samples of the student responses from the experimental group are provided in Table 4.11 on page 112. The following students' responses are selected as they demonstrate clearly the use of each of the five ethical frameworks; in most cases, students stated them explicitly (as headings) while others reasoned implicitly within a particular framework without mentioning it at all.

Table 4.11 Sample of Students' Responses Demonstrating Use of Each Five Ethical Frameworks

Balancing rights *– Everyone has the right to live and it is concerning a child, then the parents have the duty to take care of their child and ensure they have the best life possible.*
But every unborn child has the right to develop naturally and without the interference of new genes in the unborn child's life. S11
If I were Anna's parent(s), I would obviously spend money on the sick child, but genetically engineering a child should be avoided because it denies the child's uniqueness and there could be complicated involved, as the story unfolds in the movie. S11
I believe that the child that is genetically engineered has the right to decide to donate her body parts or not. The recipient child has the right to decide whether she wants to receive the organ. S19
It would not be right to make another child suffer for the sake of another, especially if the child does not want to. It is unfair to force a child to suffer, if he/she refuses. S21[from a care perspective]
Maximising benefits *– If the designer (genetically engineered) child was able to save the life of her sister and survive, the benefits would be enormous. It is worth the effort as two lives continue living instead of one. S17*
Making decisions for yourself – *I would have given more choice to Kate (the recipient child) as she might have been ready to die before Anna's conception (saviour sibling). Kate would have to live with a large burden of guilt by having a sister made solely to donate to her without choice. I would make a decision based on Kate's well-being as it is her life in the balance. S2*
Virtues – *As the parents, we should not genetically engineer a child just to help another child. The sick child is not going to live as long as most healthy people anyway; rather than prolong her suffering, we should just let her go. S19*
I would try to find a donor to give my child what she needed. There are many people who donate. I would use the `leading a virtuous life' ethical framework and try to do as much as I could to help the child. But I would not go as far as making a designer baby to give parts away. S8
Christian values – *If a child with the disease was dying, God would have a reason for it. The parents should pray and ask God for strength and wisdom. The parents should not have a `designer child'. S23*
Everyone is made and designed by God for different purposes and to `design' a person eliminates part of the God-given uniqueness. S11[uniqueness of each individual bearing God's image and God's special design]

Those using the Christian framework reasoned from the perspective of care, uniqueness of each individual and God's special design and purpose. Specific references to the unborn child bearing God's image and scripture injunction to love were also made.

While there are strengths in using the above framework, there is also a concern and/ or limitation that having the five ethical frameworks may just `lock' the students into a certain framework and not explore beyond the five given. Further interviews with the student actually indicate that, for some students, this concern may be unfounded

as there was explicit request to move beyond the frameworks (students' response expressed incorporating other frameworks) as well as explore different contexts (students' response to seek other fields of applications.)

Observation B: On the Nature of the Decision-Making Process

In assessing the decision-making skills of the student work samples on `My Sister's Keeper' from the experimental group, the researcher developed a code by which incorporate the essential components of sound decision making skills. Sound decision-making skills demonstrate an understanding why a decision has to be made, an understanding of the goal and the source of the problem. This was accompanied by a consideration of a plausible number of options (e.g. number of ethical frameworks used) which is indicative of an integrated approach in shaping the argumentation process towards decision making. Attention was also given the consequences by weighing the benefits and risks of a technology or practice employed. A question was also asked if there is an attitude of dogmatism or openness about the issue at hand. The ability to monitor and guide one's own thinking process (meta-cognition) will be determined by the kind of question posed or the type and sequence of reasoning used to build towards a well-informed decision (refer to Table 4.4 List of Codes on page 85).

Based on these codes, the student work was analysed by two teachers independently. Initial inter-rater consistency ranged from 60% to 80%; however most of the discrepancies were quickly resolved and ascribed to simple misinterpretations. Following this initial negotiation phase, inter-rater consistency exceeded 90%. Given the relatively high tendency for rater error, two reviewers independently coded all responses and rating discrepancies were mediated by a third reviewer.

The following sample of four students' written responses were selected as they presented a snapshot of the kind of responses from the experimental group that indicate the extent and the level of use of features of sound decision making abilities according to the Table 4.4 provided on page 85. The letter in **bracket and bold** indicates the code as used in the Table.

Student S2

Response to Question 1:

No, I don't think it is ethical to conceive a child that meets specific requirements if these requirements hinder the child's life (clarifying on interview- if it affects the quality of life). (Student S2)

The response reflects an understanding of the implications involved in being a `saviour sibling'. In the interview, student S2 noted that the gene technology is useful provided it does not infringe on a person's right (an implicit reference to the framework on rights and autonomy). Student S2 mentioned the importance of choice for an individual. The freedom of choice must be given to a child to decide if he or she wants to donate his/her organ/body parts. **(B)**

Response to Question 2:

I would have given more choice or more say to Kate (the organ recipient) as she might have been ready to die before Anna's conception. Kate would have to live with a large burden of guilt (empathy expressed here) by having a sister made solely to donate her organs/ body parts without her choice.

I would make a decision based on Kate (student meant giving more weight to Kate's consideration) *as it is her life in the balance*. (clarified at the interview) (Student S2)

In empathy with the suffering of Kate and honouring her wish to die (that is every bit her right as it is her parents' right - to want her to stay alive), student S2 stood with Kate when everyone seemed to stand with the choice that surviving at all cost was the better way to go. Student S2 saw her suffering, her guilt, her helplessness and thought her `voice' has to be heard and her wish respected.

In making this decision, student S2 understood why the decision has to be made **(A)** as he recognised this to be a life and death issue and subject to time. A decision could have been made before Anna's conception. An awareness of timing of decision was discerned here.

There was no explicit mention of what type of ethical frameworks were used here. But the response shows that the student integrates at least three ethical frameworks here – balancing rights, making decision for oneself and virtue (fairness and justice). In his journal, student S2 noted that `I was able to use what I had learnt about ethical framework to help support my decisions and viewpoints on the subject of embryo use.' **(B)** At the interview, student S2 commented that `ethics is a good way of introducing the subject. I find this engaging and connected to science. We need to learn to think the way we think.' [There is an element of meta-cognition here **(E)**].

Student S2 also appreciated the breadth and scope of the issue. Student added these comments in the exercise: `*The moral dilemmas here include the issue of death (Kate was ready to die but her mother wanted her to stay alive); rights to body (when is it far too much to ask for body parts, who can choose?); issue of age/ choice (how does maturing affect a person's ability to make crucial decisions or to limit them?) and issue of parenthood (how much power should parents have over their children?).*

The student was engaged with the subject and the discussion of ethics **(F)**. At the interview, the student suggested that different scenarios could be used to help practise making ethical decisions like this.

Student S11

The following student's response provided another example of how two different ethical frameworks are used and highlighted different perspectives of viewing the issue before making a decision.

Response to Question 1:

I don't think it is ethical to conceive a child that meets specific requirements because it is not fair to the child if <u>they have only been conceived for a specific purpose.</u> Every child has a <u>right to develop normally</u> →they have a <u>right to their own body</u> → and it isn't fair to the child if their genetic make-up is changed for a <u>specific purpose</u>. (Student S11)

Student S11 understood that a decision has to be made to save a sister (that is the source of the dilemma) **(A)** but questioned the fairness of having one making the sacrifice for another. She stressed that each child has equal rights and one should not

be viewed as more valuable that the other. Student S11 used the ethical framework of balancing rights yet recognises the virtue and value of justice and fairness on the part of the parents.**(B)** Student S11 also recognised that there were two different rights here – rights to normal development of body, right to their own body and implicitly, right to how the body was used (noted from the word `specific purpose'.) Student S11 commented at the interview how the frameworks `*make you think deeper and think of different viewpoints, Anna, her parents, the lawyer, etc.'*

In a separate journal entry, she noted**:** ` *The ethical frameworks provide an interesting view of looking at situations involving biotechnology. They help to justify decisions and help to understand the dilemmas involved.'*

This student also based her decision on her understanding of the practical use of pre-implantation diagnostic technology (scientific knowledge of benefits and risks of technology)**. (D)**

Response to Question 2: (The following response is set up exactly to what is written with the capital letter BUT underlined.)

Balancing Rights – Everybody has the right to live and if it is concerning a child, then the parents have the duty to take care of their child and ensure that they have the best life possible

BUT every unborn child has the right to develop naturally and without the interference of new genes in the child's life.

If I was Anna's parents, I would obviously spend money on the sick child but genetically engineering a child should be avoided because it denies the child's uniqueness and there could be many complications involved, like what we see in the movie. (Student S11)

Student S11 made an explicit reference to one ethical framework on `Balancing Rights' yet qualified her statement by referring to the right of every unborn child to natural development. (**B**) Her beliefs and values undergird her decision – to do what was right superseded all expectation for life, health and survival here. Student S11 employed rationalistic, intuitive and moral reasoning approaches here. She identified with the benefits (yes – to provide treatment for the child (**C**)) but resorting to

genetic engineering was an extreme measure as it was denied a basic human right of the unborn child. **(D)**

This student appreciated the larger perspective of the issue when she added the following on the moral dilemmas in this cased: *The way that emancipation case affected the family relationship – the relationships between the family members did get quite `rusty' at times because of Anna's decision and it hurt everyone involved.* It was demonstrated that student S11 was well and truly engaged with the subject as she went on to describe how such issues compound family crises etc. There was a lively discussion ensuing this point. (**F)**

The following student's response highlighted the awareness of ethical thinking and that it was not always possible to have one straightforward answer for the controversial socio-scientific issue. Student questioned the usefulness of the five ethical frameworks where one too many choices may complicate rather than clarify the issue.

Student S12

Response to Question 1:

I personally do not think it is ethical though I can see the <u>motivation</u> behind it by watching My Sister's Keeper in which this occurs in order to help Kate the child with leukaemia alive. I do not think it is ethical as <u>it disregards the child's welfare</u> and only takes into account your own as it is not the child's choice but your own. (Student S12)

She (Anna) should be able to make her own choice. <u>The reason for living should not be reduced to just fulfilling a function</u> – providing spare parts for the other. (Student S12)

Student S12 identified the source of the dilemma and understood the decision that needed to be made. **(A)** This student recognised that, for a life to be sustained, someone must be willing to offer and the quality of life of that person must not suffer as a result of that support given. This student also provided the reason based on individual's right to choose or make a decision to help.

Response to Question 2:

I believe if I were in the position of the parents, I would have tried to keep my child alive at all costs as they have a right to live. I might have even done the same thing the Fitzgeralds did though it is hard to say if you are not in that position. But I think even if I did have a child for that reason of saving another, I would have made sure that they never felt like spare parts for the other. (Student S12)

Although there was no mention of ethical frameworks, student S12 understood the consequence of keeping the sick child alive (maximising benefits (c), empathise with the parents (virtue and values) and uses intuitive reasoning to make a decision. **(B, D)** She considered the possibility of `saviour sibling' but qualified that one child should not feel that she had been `used' for the sake of the other. She was aware of the moral dilemma but utilised a cautionary approach here. Student S12 stood by her conviction that ` *a child should not be forced to undergo procedures to keep the other child alive which disregards the donor child's rights*.'

The student commented in her journal entry (Ethical Framework 17 Aug) *that `using ethical framework in any case study, I think there is no right or wrong answer and so many different answers that coming to a conclusion can be difficult. So I don't think using ethical framework was useful as it seemed to give me more possible answers to choose from then just my own ethics and point of view*. At the interview on 17 Aug, student S12 also commented that `*ethical framework seems to provide more options than one can cope with'*.

It appears from the above observation and the journal entry that this particular student did not see the use of ethical frameworks in all scenarios as always being helpful. In this case, it seems to generate alternatives that may confuse rather than clarify.

At the interview, (S13, S10, S26) some students responded to S12's comment that the number of frameworks used were reasonable. Another student S11 added `*Don't we sometimes use the ethical framework to some extent without even realising that we use them?*' The point raised here was not *just how many* ethical frameworks are being used at one time (2 or 3 or more) but *how* these frameworks are being used subconsciously to support an argument or reasoning process and in later applications

with our students, these frameworks are almost *internalised o*r meta- cognitively used to support their argumentation. **(E)**

The following student demonstrated the use of the fifth ethical framework and integrated with two other ethical frameworks in developing her reasoning and hence presenting a rather cogent argument for her decision. This student's response was chosen to illustrate a characteristic biblical response in the use of the ethical frameworks.

Student S28

Response to Question 1:

I do not think it is ethically right to conceive a baby that meets its parents' requirements. A baby is a gift of God. It is designed in God's image. It is not for imperfect humans to `select' a baby's genes. From the Christian ethical perspective, I feel that it is wrong. It could be compared to being discriminative of a person because of the skin colour. So, I feel, in the same way, people who conceive a child to meet a certain criteria is being discriminative. (Student S28)

This student used her biblical understanding of nature of human and purpose to provide the moral basis for her viewpoint. She spoke intuitively and rationally from her Christian values to justify that the act of gene technology defied divine pattern for creation and live. She also compared the act of intervention as one of discrimination (so the rights and legalistic aspects were also implied here). While she stood firmly by the fifth Christian moral framework, she also integrated her understanding of rights in her reasoning approach (balancing of rights and issue of fairness and justice). **(B)**

Response to Question 2: (The following response is set up exactly to what is written by the student with the capital letters and underlined heading).

<u>USING A CHRISTIAN ETHICAL FRAMEWORK</u>

In the Bible, it says that we should love one another as ourselves. If Mr and Mrs Fitzgerald love their child Kate, they would do anything for her. If I were the parents, I would definitely ask God what to do. While I wait for God's reply, I would try to make my daughter's life as happy and pain free as possible. (Student S28)

Student S28 understood that the source of the moral dilemma **(A)** and integrated her Christian worldview/ values **(D)** by exercising care and empathy (with the parents) **(B, C)** as well as ensuring a humane life existence, graced by the power of God. While emotive and intuitive reasoning approaches were noteworthy here, it can perhaps be explained that underlying beliefs and values could influence (not necessarily `over-ride') decisions made in socio-scientific issues that can capitulate towards the *convenient* use of gene technology over life. This has implications for the role of moral reasoning and religious values in argumentation process and which will be discussed in the next chapter on pages 176 to 179.

In triangulating the above observation with her post-questionnaire case study, student S28 commented that `*genetic screening has the potential to diagnose genetic conditions in a baby. This would help in the emotional and physical preparations for this baby. However, as with all technology, there come some people who will misuse it. This is why I think technology should be used only to a certain degree.* I have inserted this comment that she made at the end of the term to show that the attitude of this student to biotechnology has generally been quite positive but her cautionary approach, as regulated by her Christian values and convictions is noteworthy here.

At the end of the term, in her journal entry, student S28 noted: ` *The course has definitely helped me develop my reasoning skills and allowed me to understand some of the ethical issues which people face as a result of biotechnology.*

4.3.3 Students' Learning (from Journals and Interviews with Students)

4.3.3.1 Students' Journals

As part of the ten-week program, students were taught to reflect on the lessons for the week and write a short journal based on three questions: what they have learnt, what they found interesting and what more they would like to find out. The weekly journal exercise not only provided a written record for their personal growth, it was also intended to build the confidence of the students when they looked back in retrospect and considered how far and how well they have ventured in their learning journey.

The following sample of students' written journal entries was selected because they provided a profile of the four types of responses on the usefulness of the ethical frameworks in enabling them to deal with the socio-scientific issues. Reasons offered by students who have found the five ethical frameworks useful include: anchorage points for decisions made, a system to guide one's thinking process, a basis to present one's views or a basis for justifying one's view. Those who did not find it useful, had difficulty understanding how the ethical frameworks can be used and found the number of frameworks used perhaps one too many (or a little too complex) to navigate one's thinking process.

There are three types of students' journal responses, categorised as type A, B and C.

Type A – Those who described how they found the use of ethical frameworks useful (28 students)

The ethical frameworks were useful in our discussions about the different cases ***because it showed me what I need to think about when making an ethical decision****. I also found the exercise that goes it with it helpful as it showed me* ***what frameworks are****. I can* ***base my decisions*** *on these frameworks when it comes to ethical issues. It also shows me* ***what others might base*** *their decisions on.* Student S13

Ethical frameworks have taught me how to make ethical decisions in ***an orderly way****. I realised that using ethical frameworks does not give you the answer but* ***guides you to make your own*** *decision.* Student S26

Learning about ethical frameworks was really helpful today because I now know how to make decisions about the many issues we are faced with today or may face in

the near future. The ***frameworks provided a basis on which I can hold my views*** *and also* ***a basis for reasoning*** *with decision I make about the ethical issues brought up.* Student S20

After learning about reasoning and ethics, deductive & inductive reasoning, I have come to value the usefulness of ethical frameworks. It is ***the right number of frameworks*** *– enough to help me make a decision. If there was less, it wouldn't be helpful, and it there were more, it would be too confusing and takes too long.* Student S21

I think the ethical frameworks are easy to follow and they cover practically ***all areas for decision making****. It is* ***relevant for the issues*** *we discussed. I think the ethical framework on virtue and Christian beliefs/values are important frameworks to consider. The exercise today was rather easy but effective.* Student S27

Ethical frameworks are helpful, I think, in making decisions, ***because behind every decision, we used reasons to justify them. S****o using ethical frameworks, would come naturally to most people, because don't we use ethical frameworks in all decisions we make even if we don't recognise it?* Student S11

We use ethics in everyday life, and I did not know that. With the ethical frameworks, ***I learn how to give or state my point of view.*** *Next time, I would have to plot or offer my opinion, I can use ethical framework as a `tool' to develop my point into a more understandable or relevant one. (English as Second Language student)* Student S29

Using ethical frameworks in any case study, I think there is no right or wrong answer and so many different answers that coming to conclusion can be difficult. So I ***don't think*** *using ethical frameworks was useful as* ***it seemed to give me even more possible answers to choose from than just my own ethics and point of view****.* Student S12

Type B – Those who did not understand how to use the ethical frameworks in some cases and hence not quite useful (3 students)

The ethical frameworks are really interesting and represent the more popular ways of thinking. I ***don't quite understand how to use them*** *for some issues, like the second case study, for example.* Student S23

Type C – Those who found it overwhelming at times. (1 student included in Type C)

There was so much crammed in today and ***I couldn't process it all in my brain****.* Student S26

The analysis of the responses from the journal entries were further supported by observation made from the `*Use of Ethical Frameworks in Biotechnology Questionnaire'* (Appendix 8) distributed at the end of term in Week 10, **all** agreed that on the usefulness of the ethical frameworks in identifying important issues in biotechnology, understanding the implications involved in the use and misuse of biotechnology and helping one to decide how one can best use biotechnology for the benefit of humans, animals and plants. One student was unsure as to how ethical frameworks can help one recognise the moral effects of biotechnology on humans, animals and plants and two students were unsure how it can provide good guidelines in dealing with difficult issues in biotechnology (out of a class of 31 students). In sum, not all students have found the use of ethical frameworks from the journal entries always helpful. It is noted 3 out of 31 students did not always find them helpful.

A list of comments written by students on this questionnaire may be viewed in Appendix 8A.

4.3.3.2 Interviews with students

Interviews were conducted with seven groups of students (number ranging from 2 to 3) from Week 7 to Week 9 of the course. Each interview took about 15 minutes and a list of questions was used as guide but time was also given to allow students to pose questions, if any. The list of interview questions can be found in Table 3.5 on page 59.

The activities that students found very enjoyable were role playing, debate, case studies and incursions. While four of the five groups commented on the usefulness of the ethical framework, one student S2, however, preferred to just write or state his opinion as he felt the constraint of keeping to a structure. The framework seemed to `straitjacket' his thoughts. Another student added that it was useful to write your views according to categories. He suggested that perhaps more than five ethical frameworks can be used and spread them into more varieties or different contexts. This was an interesting suggestion made when students were asked if there were a way to improve the frameworks.

Another interesting point raised was the introduction of the ethics component earlier in the course and suggestion was made to incorporate this with other aspects such as ecology. It was fairly intense in one course – in one term. Students expressed their appreciation that science learning was not just hard core facts and there are other issues to consider (as part of the learning process). Students began to appreciate and understand the nature of science through the biotechnology course.

The issue of relevance in a science curriculum was raised, and one group pointed out the usefulness of the media (newspaper article). Using the Claire Murray case to talk about organ transplants and drugs issue was relevant and engaging. It was interesting because *`it is good to think about what you think you have been told'* (Student S2). Also, on the point of relevance, a question was posed: *`In what way has this approach [referring to the use of ethical frameworks on different scenarios] helped you appreciate the study of science better?*' One student responded: *`It teaches how biotechnology is used in daily life today; better appreciation for the applications of science.'* (Student S11)

On the usefulness of the five ethical frameworks, a comment was made by a student whose English was his second language. *`Ethical frameworks actually changed my way of thinking; it helps me with other subjects such as English essay writing*.' (Student S29). Thus, it would appear that the ethical frameworks actually helped him find a way to voice his ideas, a structure through which he can express himself coherently.

In summary, with the implementation of ethical frameworks, the majority of the experimental group students expressed how the five ethical frameworks provided a basis on which they can align their views with and served as a tool to provide a reason for why they make the decisions they do.

4.3.4 Quantitative Data and Analysis - Experimental and Comparison Groups

Two groups of Year 10 Biological Science students, the comparison and experimental groups, were given pre-program and post-program questionnaires to complete respectively, at the beginning and at the end of the ten week program (refer to Appendix 1 for the Program Overview). There was one comparison group of 32 students and one experimental group of 31 students, both taught by their subject teachers. Both groups were given 60 minutes to complete the questionnaire.

Quantitative data were collected based on pre-program and post-program questionnaires that assessed the students' understanding and opinions of biotechnology and a section regarding the students' religious faith. The questionnaires for the pre-program and post-program were similar. The quantitative questions used a Likert (`strongly agree' to `strongly disagree') scale or a five point scale type response choices. For a copy of the pre-program and post-program questionnaire, please refer to Appendix 1B.

Quantitative analysis was conducted with the aim of comparing any changes, if any, of the comparison and experimental group in terms of their ethical reasoning, attitude and outlook of biotechnology in the course of the program.

Differences in pre and post intervention of the use of frameworks in the students' attitudes and perceptions of ethical reasoning were analysed. The sample included 63 students from the two participating groups. Profiles based on the student average item mean scores for the questions were generated.

To evaluate the program in terms of changes between pre- and post- questionnaire responses, mean scores for each question were computed, and the significance of pre- and post-questionnaire differences in students' perceptions were analysed using an independent t-test. Section A is a list of 18 statements in Part A of the questionnaire. These statements reflect different perceptions and attitudes about the benefits and risks of biotechnology, and the students responded to these statements on a Likert scale (`strongly agree' to `strongly disagree'). Students were also given opportunities to justify their responses. Responses to these statements are indicative, to some extent, of students' progression in ethical reasoning (Jones, et al., 2007) and

serve to evaluate students' perception of the breadth of outlook on biotechnology capabilities, ability to perceive the connection between scientific knowledge and ethical thinking and acceptance of ethical frameworks and its usefulness. The first column enumerates each of the 18 statements used, and the coding of A1a, 1b and 1c as a cluster refers to one particular perception and/or attitude evaluated. The 9 clusters (A1 – A9) indicates that altogether, there are nine attributes (perception, outlook or attitude towards biotechnology) being evaluated.

Table 4.12 shows the scale item means, pre-test and post-test differences, standard deviations and t-values. The purpose of the analysis was to establish whether there are significant differences in perceptions of students after the intervention.

Table 4.12 Item Mean and Standard Deviation for Significant Differences in Students' Perceptions

Item	Statement	Mean		Standard Deviation		t
		Pre	Post	Pre	Post	
1	A1a	2.85	3.28	0.98	1.11	3.13**
2	A1b	3.27	3.29	0.97	0.95	0.11
3	A1c	3.85	3.73	0.74	0.76	1.06
4	A2a	3.82	3.71	0.91	0.95	0.73
5	A2b	2.49	2.64	0.84	0.83	1.24
6	A2c	3.60	3.42	0.86	0.78	1.39
7	A3a	3.82	3.87	0.92	0.75	0.44
8	A3b	3.62	3.62	0.82	0.75	0.00
9	A4a	3.56	3.45	0.99	0.95	0.71
10	A4b	3.92	3.91	0.68	0.93	0.12
11	A4c	3.78	3.75	1.18	1.03	0.24
12	A5a	2.61	3.07	1.06	1.06	3.17**
13	A7a	2.65	2.85	0.94	1.04	1.52
14	A8a	4.25	4.27	0.73	0.71	0.18
15	A8b	3.70	3.75	0.94	0.93	0.42
16	A8c	4.01	4.09	0.80	0.70	0.68
17	A9a	3.69	4.14	0.74	0.67	5.09***
18	A9b	3.85	4.01	0.87	0.93	1.38

Based on the Table 4.12 shown above, it is noted that item 1, 12 and 17 indicated significant differences. The following Table 4.13 on page 128 highlights the significant differences of the three items (1, 12 and 17).

Analysis A – An Analysis of the Differences in Students' Perceptions of Biotechnology

Table 4.13 Item Mean and Standard Deviation for Significant Differences in Students' Perceptions (highlighting Item 1, 12 and 17)

Item	Item Mean		Item SD		Difference
	Pre	Post	Pre	Post	t
1	2.85	3.28	0.98	1.11	3.12**
12	2.61	3.07	1.06	1.07	3.17**
17	3.69	4.15	0.74	0.68	5.09***

***p< 0.001, **p<0.01 n= 58

The evaluation of the students' attitude and reasoning about biotechnology is based on the students' responses to the following three statements.

Item 1 – Problems resulting from science and biotechnology hardly ever affect me.
Item 12 – As long as biotechnology can solve problems now, it should be fully used.
Item 17 – The use of ethical frameworks is a good strategy to better understand and deal with science and biotechnology issues.

Table 4.14 on page 129 provides a list of indicators as a measure of the progression of ethical reasoning based on the students' attitude and ethical thinking about biotechnology. While the table provides a means of tracing the progression of the student's ethical thinking, it should not be read rigidly. It is not the case that individuals progress uniformly from left to right, nor would it be unexpected that some students may be situated at the left in some cases; and in others towards the right. It needs to be highlighted that a student's position on this spectrum may be affected by the community around them, their motivation and a range of factors. It is not an absolute indication but it provides some form of indication. It is, therefore, reasonable to assume that with some good instruction on ethical reasoning, individuals could move from left to right of the Table 4.14. For example, with item 1, the student sees biotechnology as not affecting him or her at all (for example, eating or abstaining from genetically modified (GM) food) in terms of no effect on oneself to one's peers (how others such as family members and classmates feel about it) to others in one's country (how a country's economy may be impacted by being no

longer GM free) to people globally (how it can solve or alleviate world hunger issues). In this way, the Table 4.14 provides a measure of one's perspective on biotechnology and its attendant ethical issues.

Table 4.14 Student Attitude and Ethical Thinking in Relation to Progression of Ethical Reasoning

Section A: Student attitude and ethical reasoning	**Use of indicators of progression in ethical reasoning** (Jones, McKim, Reiss, 2010, p.15) Novice → Advanced
1: Problems resulting from biotechnology hardly affect me.	Personal → Peers → National → Global
12: As long as biotechnology can solve problems now, it should be fully used.	Immediate Consequences → `now' Long-term Consequences
17: The use of ethical framework is a good strategy to better understand and deal with science and biotechnology issues.	1 framework → 2 frameworks → Evaluate usefulness of frameworks in different situations Acceptance of Ethical frameworks → Critiques frameworks Explicitly refer to frameworks → Remember frameworks → Frameworks become internalised

Item 1 - Students' awareness on biotechnology's effects

Based on the statistical significance in item 1, this is indicative of an individual's position on the problem resulting from biotechnology, moving from being neutral to its issues to a concern of its effects and possibly a social awareness of its wider implications. With greater knowledge of biotechnology and the intervention of ethical framework to address the concern/issues/ problems of biotechnology, students appear in the experimental group (from the table of results) to demonstrate a

better appreciation for the effects of biotechnology beyond the individual to the society at large. According to the Table 4.13 (Analysis of A) on page 128, it is noted that the experimental group shows an increasing awareness of its effects and the statistical significance stands at $p < 0.01$.

Such an increased awareness was also noted in the spontaneous class debate and increased engagement demonstrated from ongoing discussion in subsequent lessons and outside of classroom. Such observations are further supported by interviews with students was raised frequently by both comparison and experimental groups and references on stakeholders' interests were frequently made on national and global levels. Based on scale of ethical progression in ethical thinking (Jones et al., 2007), some students moved from purely *self-centred* perspective (where biotechnology has no effects on oneself) to *one* where there is an expressed concern for its impact on the *local* economy and possible long term effects (being no longer GM free) to the *global* issue of world hunger and GM crops being a plausible solution.

Item 12 – Use of Biotechnology

The quantitative data shows that students in the experimental group adopted a more cautionary approach after the program. There was a greater awareness of risks and benefits and hence, a more circumspect or guarded approach to the use of biotechnology. The experimental group has shown statistical significance of $p < 0.01$. Refer to Table 4.13 on page 128. This is indicative of a progression from considering ethical issues sole in terms of the `now' to the long term.

This observation was supported by a noticeable progression from considering ethical issues (genetically modified food) from terms of the `now' to the `long term' in class discussions and scenario analyses. On the one hand, there were students who had misconceptions of genetically modified food when they took in information at face value but after given time to reconsider the benefits and risks involved, they changed their outlook on the issue and accept its use in view of its long term effects. On the other hand, we have those who valued the benefits but adopted a cautionary approach and opted for better regulation of technology for long term uses.

In summary, students showed a greater caution/ discretion in the problem solving ability of biotechnology. It is plausible that students can now better identify the benefits and risks in the use of biotechnology by considering both temporal and long term effects.

Item 17 – Usefulness of Ethical Frameworks (for experimental group)

The quantitative data shows that students in the experimental group showed an increased appreciation for the use of ethical frameworks as a good strategy to handle science and biotechnology issues. The score was statistically significant at $p < 0.001$. Refer to Table 4.13 on page 128.

The outcome for item 17 was significant in responding to one of the research questions on the extent to which this model of teaching socio-scientific issue enhance the student's ability to reason and make decisions about ethical issues using ethical frameworks. This statistically significant result also supports the observation that there was a progression from only being able to use one ethical framework (e.g. utilitarianism) to using two or three or four to evaluate the usefulness of frameworks for different situations (e.g. considering the frameworks of utilitarianism, rights and virtues when considering the decision to have a `saviour sibling' in the `My Sister's Keeper' activity.)

Certainly, the development of ethical thinking cannot be assumed to be monolithic or inflexible in that it necessarily entails a direction from one end of the spectrum of ethical thinking progression to the other. Having a number of parameters that delineate the progress of ethical thinking over time is a reasonable instrument to allocate *objectively* student's stages of ethical reasoning development (some comparison to Piaget's or Kohlberg's stages of moral development).

Analysis B – An Analysis of the Differences in Ethical Framework Acceptance and Pre- and Post- Knowledge Test

The following Table 4.15 provides the mean, standard deviation and the t-values for the pre- and post- responses of the comparison and the experimental group, highlighting the significant differences, in particular, the two categories - the ethical framework(s) acceptance and the pre- and post-knowledge tests. The ethical framework acceptance outcome was based on the students' responses to the `Use of Ethical Frameworks in Biotechnology Questionnaire' (refer to Appendix 8). The pre- and post-knowledge tests were based on Part B of the questionnaire which comprised 25 questions that assessed students' knowledge and understanding of biotechnology based on topics of genetics and gene technology taught in a Year 10 biotechnology program in the Australian curriculum. Students' knowledge was measured through 25 true-false items (bivariate items).

Table 4.15 Item Mean and Standard Deviation for Significant Differences in Ethical Framework Acceptance and Pre- and Post- Knowledge Test

Question	Test	Mean		S D		t
		Experimental	Comparison	Experimental	Comparison	
Knowledge	Pre	74.34	74.13	9.76	8.95	0.08
	Post	81.06	77.60	6.88	10.58	1.50
Faith, Beliefs and Values	Pre	4.57	4.51	0.31	0.44	0.61
	Post	4.51	4.55	0.54	0.31	0.38
Ethical Frameworks Acceptance	Pre	3.84	3.75	0.46	0.83	0.53
	Post	4.30	3.88	0.55	0.72	2.46**

***** p<0.01 n=58***

Section B1 – Findings on Ethical Framework Acceptance

In the pre-test, it is noted in Table 4.15 above that both comparison and experimental groups on the acceptance of ethical frameworks did not show any statistical significance. The mean score for both groups on the acceptance of ethical frameworks was also not statistically significant. However, in the post-test, the mean score for the experimental group has increased from 3.84 to 4.30, and this was statistically significant at $p < 0.05$. This set of results indicates that there was

significant increase in acceptance of ethical frameworks. This is corroborated with the journal entries where 15 of the 22 submitted (68%) explained how ethical frameworks were useful in making decisions for socio-scientific issues (refer to the Appendix 8 – Use of Ethical Frameworks in Biotechnology Questionnaire and Appendix 8A – List of Students' Comments on the Usefulness of Ethical Frameworks). The number of students who provided positive feedback (explanatory statements) were 15 out of 28 (54%) who completed the questionnaire.

The following Table 4.16 provides the mean, standard deviation, the t-values for the pre- and post-knowledge tests; highlighting the significant difference in the experimental group.

Table 4:16 Item Mean and Standard Deviation for the Pre- and Post- Knowledge Test (with reference to the significant difference for the Experimental Group)

Question	Test	Mean		S D		t
		Pre	Post	Pre	Post	
Knowledge	Experimental	74.84	81.37	9.76	6.78	4.66***
	Comparison	74.34	78.06	9.04	10.45	1.62

*** *p<0.001 n=58*

Section B2 – Findings on the Pre and Post-Knowledge Test

The results from Table 4.15 on page 132 show that the experimental group has a significant improvement in their knowledge test score at the end of the term. For the experimental group, there was a significant increase in the mean score from 74.84 to 81.37. This may be attributed to the use of ethical frameworks which have enhanced student's engagement and increased student's discernment of the reliability of the source of knowledge (where clarification and misconception of scientific concepts are addressed) and integration of a variety of reasoning approaches (will be elaborated in the next chapter).

Analysis C – An Analysis of the Differences in Students' Opinions and Concerns on Different Aspects of Biotechnology

The following Table 4.17 provides the mean, standard deviation for significant differences and alpha reliability based on 40 statements given in Part C of the questionnaire where students responded using a five-point Likert scale to determine their opinions and concerns on different aspects of biotechnology (also refer to page 52). This section asked students about their cognitive and affective and behavioural evaluation about biotechnology. The affective evaluation was represented by questions concerning negative and positive feelings and emotions towards different aspects of biotechnology.

Table 4.17 Mean, Standard Deviation for Significant Differences and Alpha Reliability for Attitude towards Biotechnology

Scale	No of Items	Test	Mean	S D	Difference t	Alpha Reliability
Positively Constructed	13	Pre	2.95	0.46	3.22**	0.71
		Post	3.16	0.46		
Negatively Constructed	17	Pre	3.18	0.52	1.56	0.83
		Post	3.10	0.54		
Concern	4	Pre	2.65	0.85	2.54*	0.64
		Post	2.41	0.78		
Behaviour	4	Pre	2.62	0.97	0.25	0.80
		Post	2.65	0.95		

**$p<0.01$, *$p<0.05$

From the table of results, the mean score for **the positively worded items** has increased from 2.95 to 3.16. This indicates that students' attitude to biotechnology has become positive. There is an increased appreciation towards the use of biotechnology. The statistical significance stands at 0.01. The Alpha Reliability is 0.71 which shows a high degree of reliability.

The mean score of the **concern i**tems has decreased from 2.65 to 2.41 which shows that students are less affected or concerned. This notable decrease in concern or `affectability' may be attributed to students' growing confidence in handling biotechnology issues. The Cronbach alpha value is 0.64 which shows that the test is reliable and can be accepted. The statistical significance stands at $p<0.05$.

There is a slight behaviour change towards being more positive as the mean score rose from 2.62 to 2.65. The Alpha Reliability value at 0.80 points to a high degree of reliability for the test.

In summary, based on the outcomes in Section C, it is noted that the change in outlook of biotechnology towards greater acceptance of the benefits of the technology can be attributed to an improved and a more accurate understanding of the scientific knowledge of biotechnological concepts used particularly in the area of genetically modified food, reproductive technologies (IVF) and genetic screening. There is also a more positive attitude developed towards the use of biotechnology as well as enhanced motivation and engagement with biotechnology as a subject.

4.3.5 Summary of Findings

Based on the quantitative analysis (and together with some aspects of qualitative data obtained from journal entries/ interviews/ feedback questionnaires, class activities), the results for ethical reasoning and attitude can be summarised as follows:

1. In terms of the development of ethical thinking, students in the experimental group using the five ethical frameworks demonstrated some progress in perception and appreciation of the socio-scientific issue from an unaffected position to one of concern and capable of making informed judgment from a personal perspective (and social, for some).

2. In terms of development of ethical reasoning, the experimental group students using the five ethical frameworks demonstrated a more deliberate or intentional approach in considering both the immediate and long-term consequences of the decisions to be made based on scientific knowledge, supported by some form of justification.

3. In terms of growth in the complexity of argumentation used in ethical thinking, students in experimental group moved from using one ethical framework to two, three or even four to justify the decision they made. The increase in scope and complexity of the response was reflected in the ability to evaluate each framework, drawing on the benefits, risks and consequences

of each in order to build a well-informed decision for each socio-scientific issue. The increased complexity of argumentation was also reflected in the students' abilities to consider from a range of perspectives as facilitated by the different ethical frameworks. It enabled students to `look at issues through different lenses' (France, Mora & Bay, 2012, p. 819; Halverson, Siegel and Freyermuth, 2009) and to consider alternative viewpoints (Lewis & Leach, 2006).

4. Students in experimental group expressed both verbally in interviews and in reasonably elaborate written form in their journal entries their acceptance of the five ethical frameworks and the reason(s) for their acceptance of their usefulness; primarily attributing to their instrumental role in anchoring one's viewpoint, facilitating the reasoning process and articulating the reasons for decisions made.

5. Students who have been taught the five ethical frameworks also demonstrated a significant improvement in the post knowledge test score based on Part B of the questionnaire (from the quantitative analysis).

6. Students from both comparison and experimental groups also demonstrated a change in outlook to a more positive one on some socio-scientific issues (particularly, genetically modified food, reproductive technology and genetic screening). This may be attributed to enhanced motivation, engagement with the issue as well as a greater and more accurate scientific knowledge base established.

4.3.6 Data analyses related to faith and values context

4.3.6.1 Religious Convictions and Faith In Relation To Ethical/Moral Reasoning

Section D of the survey indicated that both the comparison and experimental groups were homogenous in the religious commitment and practice of faith. They represented a spectrum of fifteen-year-old students in an evangelical Christian college from a middle class to upper middle class socio-economic backgrounds in the metropolitan city of Perth.

The ethics of Christians as representative by these denominations of churches (predominantly Protestant) referred to ways that Christians located their talk of right and wrong, good and bad, obligation and value in the context of Christian faith, practice and theology. Essentially, `Christian ethics' refers to the study of morality in the context of Christian life and theology (Messner, 2006).

The Christian perspective of bioethics views that a pluralistic secular world needs the moral sustenance that a transcendent God brings to it. It is this Creator God who makes human beings both valuable and responsible. Pure secularity can degenerate into `whatever is happening ought to happen' or `whatever we can do we should do' (Rae & Cox, 1999, p.318). It has no in-built devices or outside perspective by which to judge itself. This is an increasingly serious concern with the biotechnological area of genetic engineering and reproductive technologies, for example.

The following are some broad outlines of a Christian response to bioethics.

First, Christians are called to empathise with the deep and hidden pain of childless couples, of families devastated by genetic illness or of individuals facing degenerative conditions. While the reality of such pains and the quest for solutions drive the research and development in the new biotechnology, the Christian community needs to fulfil the role as vanguard of practical caring for the disabled, the marginalised and the dying (Stott, 2006, p.441). Second, the Christian community is called to challenge the reductionist mindset which is beginning to pervade the modern society and the healthcare system (Meilaender, 2005, p.20). At a social level, there is a need to challenge the economic and political power base which new genetic manipulation and biotechnology is creating and demand for democratic accountability, democracy and justice in the actions of those who control

the technology. Third, there is an urgent need to develop a more profound understanding of what it means to be a human being, created in God's image, corrupted by evil, yet affirmed and redeemed by the Christ event – the incarnation, death and resurrection of Jesus of Nazareth (Rae, 2009, pp.38-41). The Christian worldview encompasses wonder, respect, empathy and protection for the weak and vulnerable in society. It is a worldview which respects the givenness of our humanity, supporting and encouraging restorative therapies while resisting the abusive possibilities of enhancement biotechnology. It is a worldview which respects the physical structure of our bodies while pointing to a greater reality, a deeper healing, and a hope which transcends the grave.

Undergirding the range of bioethics positions among Christians, is the approach that a needed transcendent perspective can protect us from the worst of our natures and our world, while explaining and encouraging the best.

An analysis of the students' responses showed that how one makes a decision may only be partly conscious and could have been shaped by many factors from the Christian background; for example, one's upbringing, faith commitment, past experience and reflection. In comparing the pre and post questionnaire responses for both comparison and experimental groups on the use of faith statements or reference to God, there are traditionally four distinct categories that students look to for some kind of moral insight, guidance and authority; namely Scripture, tradition, reason and experience (Hays, 1997). In the Christian tradition, these four sources have been used in many different ways and combinations. Most have held that Scripture alone has authority in relation to Christian faith and morality and other sources used, such as tradition, reason and experience, are to be weighed against Scripture although in some cases, Scripture, tradition and reason can be seen to be working in a kind of creative tension with one another (Messer, 2006, p.8)

Refer to **Part D of the Pre- and Post- Program Questionnaire** – **Religious Beliefs, Faith & Practice** in Appendix 1B; also refer to description of Part D on pages 53.

By **Scripture,** Christians mean the writings collected together in the Hebrew (Old Testament) and the New Testament – the rich mixture of writings of various kinds, written over many centuries in many different settings. To regard the Scripture as a source of moral authority, Christians understand and interpret these writings in their

own contexts (such as history, saga, poetry, law, biography, instruction or warning). Christians look to the Bible for guidance at the levels of rules, principles, paradigms and symbolic world and how relevant these are to the Christian community.

By **tradition,** this has been defined as `the Church's time-honoured practices of worship, service and critical reflection' (Hays, 1997, p. 203). Christians look to tradition as it provides a source of collective experience and shared memory on which Christians and Christian communities can draw in their living and acting.

By **reason,** this is to say that human powers of thought, understanding and argument can give us insight into what is good and right, and thus reason can be considered as a source of authority.

By **experience,** it refers to the kind of moral deliberation that makes some use of one's own or others' experience but to describe experience specifically as a source of moral authority can meant a variety of different things. It can refer to the role of the individual's conscience in moral decision-making and action. It can mean an inner conviction in the hearts and minds of believers and Christian communities about God's will and guidance.

The following Table 4.18 provides a sample of students' responses indicative of how scripture, tradition, reason and experience are drawn upon to substantiate their reasoning for a particular viewpoint. These responses are obtained from Part E of the questionnaire.

Table 4.18 Students' Responses Based on Scripture, Tradition, Reason and Experience.

Scripture	*S27* ***God has created everyone in his own image****, and who are we to alter his creations?* (Genesis 1:27)
	S 4 – Changing a baby's genes/physical appearance is forgetting **God created man in his own image**.
Tradition	*S1 - Selecting the gender of a child is wrong except the only good thing is treating a disease. You should love the child the way it is born,* ***because it is God's plan.***
	S17 ***God's will.*** *The baby should be left as God intended it to be.*
Reason	*First, I feel that a* ***child is a gift from God.*** *Changing their looks would be like receiving a special present from someone and then saying you will change it because you do not like it.*
Experience	*S46 This is not* ***the way God wanted us*** *to have children. We should instead pray for miracle and not try to be God.*

In summary, `scripture and tradition' provide a context from which students operate to make sense of the world and how the world ought to operate, especially when facing a moral dilemma. Their responses may arise from their interpretation of Scripture – namely, the inherent goodness of God's created order from the beginning, the human identity as bearing the divine image, and the sanctity of life. They may also arise from the understanding of tradition where practices of faith and obedience require submission to the will of God, prayer and exercise of faith that is essentially hopeful expectation of ultimate good of all things purposed by God.

Such an understanding may also arise from the institutional stand (teachings of the church) or authority on an issue, or the students' perception of who God, his nature and his character (whether he is omniscient - `all-knowing'; include God's sovereign will and man's free will), how he rules the world (such as having a special plan and purpose for all). Such an understanding may arise from students' experience of how they consider God works in their lives – in absolute control, with grace, truth, sensitivity, care and compassion or with miraculous interventions, for example, in the case of infertility or a disabled child.

To consider `reason' as a source of authority is to say that human powers of thought, understanding and argument can give one insight into what is good and right.

Students have reasoned from the belief that humans, having been created by God in His image, are given minds that are able to grasp something of the moral structure of the created world. This is found in the natural law tradition, and can also be aided by divine revelation.

On `experience' as the fourth source, it is quite natural to expect that any kind of moral deliberation may be drawn from one's personal experience or others' experience, but to describe experience specifically as a source of moral authority can mean a variety of different things. It can refer to the role of the individual's conscience in moral decision making and action; for example, some students are quick to point out any intervention `in vitro' is unnatural and thus unacceptable. Or it can refer to an inner conviction in the hearts and minds of a community of people who share similar understanding about divine will, guidance and way of life.

4.3.6.2 Lines of Reasoning – Process

First, both qualitative and quantitative analyses of the comparison and experimental groups' responses to the Four Scenarios (narrowed down to three as the fourth one reflected some misconceptions in understanding therapeutic cloning) demonstrated the following features:

Both comparison and experimental groups have no differences in terms of the frequency of reference to God or the use of Scripture in their reasoning or decision making process. This is understandable as the intervention in the use of ethical framework in this study did not affect religious convictions or faith development although whether an increase in scientific knowledge in gene technology may influence their post decision is a point to consider.

Second, if the socio-scientific issue did not feature strongly in its moral content or presented an issue of a less personal nature, for example, such as the issue on genetically modified food, there were fewer students making explicit reference to their personal beliefs in God when reasoning and making decisions. Take for example scenario 1 on genetically modified food, there was no significant difference between pre- and post- responses with 25% of students making reference to God and/or Scripture in their reasoning. This was relatively low compared with 50% of

students in Scenario 2 which looks at IVF and genetic screening technology, and 62% of students in Scenario 3 which looked at reproductive technologies and cloning. Thus, the form of moral reasoning is context dependent.

Sample of students' responses which made reference to God are as follows:

> *`GM food may harm people and alter the creation of God.' Student S34*
>
> *`I am against GM because as a Christian, I believe that God created all things in a certain way and I do not think He wants us to change his creations. I think it is also insulting to God as it generally sends out the message that we think we can `improve' his creation...We do not know all the dangers of genetic modification. It is playing God and it is unethical.' Student S46*

Third, the nature of the reasoning processes from all three scenarios also demonstrated some differences. With Scenario 1 on GM food, 19% changed their minds from disagreeing in the pre- questionnaire to agreeing in the post-questionnaire, that is, they embraced the positive aspects of the technology at the end of the course. With an improved understanding of how genetic modification works and given scientific knowledge in the area, optimism for the technology was increased. By the end of the course, 56% of the students were positive about the benefits of GM and agreed to its use.

The following student disagreed in the pre-questionnaire and responded in agreement for the use of biotechnology (with some caution) in the post-questionnaire as follows:

Student's response:

> *`I think GM food is not that bad because by doing this, we could produce better quality food and more food which would help people. I do reckon that there may be dangers involved such as it could upset nature and can produce a result that was not intended.' Student S41*
>
> With Scenario 2 on IVF and Genetic Screening Techniques, 48% of the class remained steadfast on their disagreement to the technology (from pre and

post) and 80% of the students who disagreed refer to the fact that such an act was altering God's creation and playing God. Overall, we are referring to about 68% of students who made some form of reference to God and their faith, in making the decision whether to disagree entirely or agree to a certain extent. Reasoning on the basis of faith and their scientific understanding was observed to explain or justify the limits they agreed to the technology with about 28% of the class.

Student's response:
S28 I agree with its use of genetic screening to search for genetic diseases but totally disagree with the use of this technology to manipulate a child's eye colour or intelligence.

With Scenario 3 on reproductive technologies, 61% of the class disagreed on the use of the technology with 45% of those who disagreed, made reference to God or their faith in their reasoning, and the remaining on the basis of its immoral nature. About 10% of the class changed their attitude towards the technology at the end of the course, working on their improved understanding of the scientific concepts behind reproductive technologies. Essentially, having scientific knowledge did little to move or persuade the majority from changing their opinion on reproductive technologies. Most students in this category adopt an intuitive and emotive reasoning with some justification.

Students' responses:
`We should never clone humans. It is not morally right at all. Science is advancing too fast for our own good.' Student S18
`Cloning is wrong. Again, it is altering the way God intended the pregnancy and reproduction to be. In the bible, there were quite a few barren women. Like they did, maybe couples should have faith and pray for a child. Cloning is unnatural, if the couple is not of the Christian faith, maybe, they should consider adoption.' Student S17

Table 4.19 presents some of the students' written responses and lines of reasoning to the four scenarios in Part E of the questionnaire. It provides some indications as to how references to God are used in their reasoning as well as, in some cases, how scientific knowledge is used in bringing about a change of conviction.

Table 4.19 Students' Written Responses and Lines of Reasoning

	Scenario 1
Against God's created order Not natural Alter God's creation	*`Although changing the genes may look promising, what research has been done on how it may benefit or harm human health. God made the plant that way and we are doing nothing but messing with his creation by modifying the genes.'S11*
	Scenario 2
Playing God	*`God made you as you are and with a purpose. Stick to it.* ***Playing God*** *is wrong use of technology.' Student S36*
Displacing God	*`This way of making a child is very unnatural and not at all how God planned it. It is like you are* ***taking over God's role*** *which is wrong.' Student S25* *`I disagree with the selection of traits as it is a sort of telling God that you can improve his creations.' S46*
God's plan and God's will	*`I don't think people should be able to select the gender of a child, let alone eye colour or intelligence. It is unethical, unnatural. It may be going against plans that God has for your life and your children.' Student S21*
Man made in God's image (Genesis 1:27)	***`God has created everyone in his own image****, and who are we to alter his creations? (Genesis1)' Student S27*
Biblical view of life Status of embryo	*` **Status of embryo** – An embryo is actually a baby. If you change it, you are messing with a real human being, not just a blob (a piece of human tissue). It is unnatural.' Student S15*
Affects relationship with God	***`Affects our relationship with God****. Changing ourselves to fit our ideal human image could affect our relationship with God. It could have long term effects.' Student S23*
	Scenario 3
Uniqueness of God's creation	*`Everyone is supposed to be different and creating a baby genetically identical to yourself is not natural and against God's will.' Student S41* *`Uniqueness of God's creation – Cloning is a false form of creation and there can only ever be one unique version of yourself that is created by God' Student S16*
God's role in creation	

	` God is the only one who knows your body. I think that it is wrong and they should just adopt a child instead.' Student S1
	`Cloning is wrong. God would not be pleased because he created man and woman to have babies. And by cloning, it is a sort of saying to God that man can do a better job than him.' Student S4
Praying	
	`This is not the way God wanted us to have children. We should instead pray for miracle and not try to be God.' Student S46
Nature of God	
	` I don't agree with this as it is going against God's word. It is unnatural and immoral.' Student S53
God's will	
	` God has till provided natural ways to have children such as adoption.' Student S55
Use of scientific knowledge and expressed change of conviction	*Scenario 1* *` I now see and agree why GM food can be good. Like crops that are GM could grow in regions of severe drought, such as Africa. However, just because they may greatly help in the fight against world hunger and malnutrition does not mean it is ethically right. I think the way God created plants is the best way to keep them that way. The question to ask is whether changing God's creation to aid another human being is agreeable. To this, I say, to some extent, that is agreeable. Changing plants it fine as long as it helps others. However, this could lead to ethical problems concerning other aspects of GM food.'* *Scenario 2* *`I agree that genetic screening for the sole purpose of searching genetic disease is okay. However, I believe the eye colour and gender difference should not be meddled with.* *First, I feel that a child is a gift from God. Changing their looks would be like receiving a special present from someone and then saying you will change it because you do not like it.* *Second, genetic screening has the potential to diagnose genetic conditions in a baby. This would help in the emotional and physical preparations for this baby. However, as with all technology, there come some people who will misuse it. This is why I think technology should be used only to a certain degree.' Student S28*

4.3.6.3 Summary of Lines of Reasoning on Genetically Modified Food, Human Cloning & Reproductive Technologies Scenarios from the Faith Perspective

(1) In general, students' arguments stemmed from concerns about harmful consequences and in this respect, usually did this from a care-based and compassionate approach.

(2) Even if safe, cloning threatens the worth and dignity of human beings. Students argued from a faith perspective that the main objection to reproductive cloning was that it was seen as a way of taking excessive control of human procreation and identity.

(3) In the subject of IVF, lines of reasoning flowed along the theme of introducing a large measure of technological control into procreation in the hands of humanity.

Technological control of procreation and identity was seen as problematic in at least two ways. First, it marks a shift of relationships with our fellow beings. If we try to control human procreation technologically, we are in danger of coming to regard them as less than fellow humans who command our respect, and more as products or commodities we can own and control. Secondly, some Christians see this as an attempt to make ourselves like God, the Creator, forgetting we are not gods, but God's creatures.

(4) Many aspects of medicine and technology could, in a Christian view, be seen as cultivating the Garden of Eden – a part of our human calling by God to make something of the world and become better stewards of it. It may be argued against in this view as reproductive cloning could be, like building the Tower of Babel, making us becoming like God by means of our own skill and cleverness which brings us to alienate ourselves from God.

(5) The student responses revealed fundamentally an approach of looking to Scripture/ Bible for guidance at the levels of rules, principles, paradigms and symbolic world and at how relevant they are to the Christian community.

They also referred to bible narratives (stories of believers in their God encounter/experiences) to understand the dilemma they face and how to best resolve them.

4.4 Research Question 3 - Qualitative Data and Analysis

Research Question 3: *In what ways does the use of ethical frameworks influence the teachers' approach in teaching socio-scientific issues?*

As in all scientific investigations, it is imperative that the comparison and experimental classes, the subject teachers, the curricula and the teaching are consistent in all the variables/ factors except for the one variable under study – the implementation of the ethical frameworks. In this respect, the teaching philosophy and the core beliefs of both teachers ought to share a reasonable level of commonality for the entire study to be fair and valid.

Aforementioned in the preceding chapter, I have listed the shared core beliefs in the Table 4.20 as follows. Before the commencement of the teaching unit, this set of core beliefs was compiled after a discussion took place between the teachers of the comparison and experimental groups. It was initiated because the researcher recognised the importance of having a common understanding of the definitive teaching unit, the rationale for socio-scientific education, the type of expectations on the learning environment and the number/type of teaching strategies. This provided a sound basis for a consistent comparative analysis of the data obtained from each group, having established the common ground from which the research would take place.

Table 4.20 Profile of Comparison and Experimental Group Teachers

Profile for Comparison and Experimental Teachers
Shared Core Beliefs
1. We both agreed that controversial socio-scientific issues are important aspects of science education.
2. We both agreed that ethics and values are necessarily involved in socio-scientific issues discussions and instructional activities.
3. We both agreed on the specific topics to be covered as socio-scientific issues in classes.
4. Our rationale for our focus on socio-scientific instructions is as follows:
(i) Modern democratic societies demand an informed public capable of making decisions on controversial, value-laden issues. Many of these issues are based on science and technology, and it is the responsibility of science teachers to help prepare students to think critically, weigh scientific evidence and negotiate complex ethical terrains. Responsible citizenship require active participation which itself requires a form of scientific literacy that involves the thoughtful negotiation of SSI.
(ii) Socio-scientific issues serve as an effective means of connecting science to students' everyday lives. Dealing with controversial science topics in the classroom can stimulate interest among students and help them establish relevance for what they are learning.

4.4.1 Teachers' Perspective and Reflection

As part of reflective teaching and learning, there are four themes that have emerged in the course of my role as the action researcher- experimental group teacher. These four themes are as follows:

i. How a teacher's expresses one's own values
ii. How a teacher creates the collaborative classroom atmosphere (learning environment
iii. How a teacher manages the ethical reasoning process (or creates the thinking climate)
iv. Teacher's confidence in teaching socio-scientific issues

These reflections are written based on interviews with the teacher of the comparison group including verbal feedbacks on a regular basis throughout the data collection period. This section is also written based on a teacher's journal diary that I recorded on a daily basis during the course of the entire research.

4.4.1.1 Findings from the Teacher of the Comparison Group – D.R.

i. How a teacher expresses one's own values

One of the issues that soon became apparent is that many areas of biotechnology have a direct impact on social and moral issues. It is impractical to attempt to teach this subject with only a scientific perspective and students like to delve into controversial issues as it makes the subject a lot more interesting. The framework allows the teacher to make various connections in a logical and objective manner. It is also very helpful in developing and understanding the reasoning behind various viewpoints.

"As a Christian, I have my own convictions about certain issues that are based on the teachings of the Bible but I try to be objective and provide both sides of the various issues. I have always been interested in challenging students to think seriously about the important moral and spiritual issues. Education without these challenges would be superficial to me."

The teacher considers that the framework definitely helps students and the teacher to process the information in a non-threatening and objective manner. It relies more on reasons than emotions or opinions. He finds it quite satisfying to see a class begin to delve into new territory and work through some of the consequences of various choices. The framework in many ways is providing a life skill.

ii. How a teacher creates the collaborative classroom atmosphere (learning environment)

The teacher believes group work is essential in teaching socio-scientific issues. To create the collaborative classroom atmosphere, one needs to be aware of some of the group dynamics within the class. It is good that the research is conducted in Term 3 as that provided some time and space for me to be acquainted with the students and their learning styles and for them to be familiar with some of my teaching strategies.

Concerning some factors that may have affected learning in this class, it is evident that the class was not streamed from the wide range of abilities discerned. There was a core of fairly vocal boys that could at times be disruptive. They were split up when the class was divided into eight groups. When forming the groups, one person was appointed as a leader, usually one of the more vocal boys and a range of 2 other

students, both male and female. Forming the groups had the biggest impact on the learning environment as they sat in that group for the remainder of the term. It was also a large class of 32 students. Collaborative activity was observed to proceed rather smoothly for the rest of the semester.

iii. How a teacher manages the ethical reasoning process (or creates the thinking climate)

Using a variety of teaching strategies definitely helped the students to think more deeply and from a range of different perspectives. The variety helped to develop interest and brings a certain freshness into the classroom teaching dynamic. Students were challenged to think outside their normal comfort zones in terms of positions they might normally hold and think more critically about controversial issues such as stem cell research or the application of IVF. Students began to look for reasons to support their positions and also thought about and discussed the emotional and moral dimensions involved.

Some of the teaching strategies were more challenging than others; debating forces some of them to take a position they may not normally take and to find reasons to support that position. One thing that occurred which was very interesting was that a group of dominant boys were not engaging fully in the debate process but one of the new boys (KM) not a part of the group was quite a dynamic and persuasive speaker and it was obvious that he had thought through the arguments carefully. His example made quite an impression on this other group and actually inspired them to lift their game and their attitude and begin to follow his example. Such a positive peer pressure became more evident in the latter part of the program.

Using group work was particularly helpful as it helped to break down peer groups and provides a platform for student to interact and exchange ideas with people they would normally not interact with. Students benefitted as they learned to get along with people including difficult people and learning to listen to other peoples' points of view were life skills that helped to equip them for working with people outside the normal school environment.

Role playing was very good from the perspective of getting them to think about what an issue looks like from different perspectives, to get into someone else's shoes.

The variety of teaching strategies used was very helpful in triggering new thinking and communication skills. At the beginning, for many of them, their ability to analyse and handle ethical issues in biotechnology was somewhat limited but these improved gradually. The effectiveness scored was 8 or 9 /10.

iv. Teacher's confidence in teaching socio-scientific issues

To ascertain the degree of teacher's confidence in teaching socio-scientific issues, the comparison teacher was asked to rate himself on a scale of 1 – 10 (1 = least and 10 = most) the five attributes as set in the Table 4.21.

Table 4.21 Comparison Teacher's Self-Evaluation

1	Knowledge of ethical reasoning process - 3 to 8 (beginning to end of term)
2	Confidence in using teaching strategies – 6 to 8 (this developed as we went along, debating and role playing need more work though)
3	Understanding of small group dynamics – 6 to 8 (having assigned roles within groups helped)
4	Understanding how students process information 7 to 8 (still feel there is more to learn in this area)
5	Awareness of the important contribution that teaching controversial issues makes to science education – 8 to 9 (have previously known the value of this as there are certain topics in the biology course (sex and evolution) that I have found to create a lot of interest and they provide an excellent platform to discuss moral and ethical issues.

From the comparison teacher's self-evaluation, he has experienced some measure of personal growth in terms of knowledge of ethical reasoning process which also gave him the confidence in using the teaching strategies such as debating and role-playing which places a greater demand on students' argumentation and reasoning skills. This is also accompanied by an appreciable increase in understanding of small group dynamics, recognised to be a significant factor in the collaborative learning of socio-scientific education.

4.4.1.2 Findings from the Teacher of the Experimental Group - Researcher

i. How a teacher expresses one's own values

First, in implementing the ethical framework as part of the biotechnology course, I am very conscious about how the teacher (as the influencer or playing the dominant role in the teaching process) expresses his or her values to the class. In addressing ethics in the context of socio-scientific issues, it is vital that the teacher avoids expressing one's own values and ethics without careful thought and deliberation as to how this is being done. This approach is justifiable in that teachers do not wish to unduly influence students with their own views as they may be perceived as attempting to promote a personal viewpoint. However, as Hodson (2003) described, values play a significant role in all aspects of education including curricula, pedagogies and assessments, and avoiding `values' "mistakes the very purpose of the science component of education for citizenship" (p. 654). Teachers cannot avoid expressing their values: the question is whether they choose to have their values revealed explicitly (but not confrontationally nor dogmatically) or implicitly. Regardless of the teachers' orientations or intents, classrooms can never be value-free environments; however, it is certainly important to strive for value-fair environments (Loving, Lowry & Martin, 2003).

It is well to acknowledge that a value-fair environment is important. But it would be naïve to advocate value-free instruction, especially in conceptualising socio-scientific issues as curricula. Any attempt to provide both sides of an argument or an issue is oversimplification. `The tendency for participants to stress the importance of covering both sides of a socio-scientific issue indicated an under-representation of the complexity inherent to most socio-scientific issues (Oulton, Dillon & Grace, 2004). The problem lies not in sharing multiple perspectives, but rather if it is possible, to provide equal coverage for two sides. Due to the multifarious nature of socio-scientific issues and their involvement on so numerous `sides', equal coverage to two opposing sides is not always necessary and frequently impossible.

As the experimental group teacher, I highlight the complexity of the socio-scientific issue and make an intentional effort not to be compelled to a conjectured `balanced' point of view. I made it clear to my students that at some point in our class presentation, I will present a Christian perspective to biotechnology and it covers a

range of stances towards biotechnology, in particular gene technology. In the delivering the presentation, I will highlight the various stances and the rationale behind each stance. This is consistent with my teaching philosophy that we all teach from a particular worldview, whether we are fully conscious of it or not. I present from a Christian worldview because that is part of my value and belief systems. Students respect this type of presentation because they know they are not `cornered' or `swayed' through a discussion of issues into taking a viewpoint that the teacher is seen or perceived to adopt. On a platform of a worldview (in this case, highly congruent with the ethos of the college), students can choose to accept or not because they know it stems from an undergirding philosophy that is greater than an idea, an opinion or just a passing thought.

Students are challenged to think beyond just taking a viewpoint; they began to see its connection within a far greater framework and the consistency and rationale that flows with it. The feedback from my students, both verbal and written (in journals) indicated that this approach was reasonable and well-received. I am aware that not all students in my class come from Christian backgrounds or are necessarily Bible-believing or practising Christians (also confirmed by the faith surveys conducted).

It is interesting to see that while this presentation is appreciated; it has no significant impact on the pre- and post-questionnaires as those who are reasoning on the basis of their Christian values, had not changed their positions or compromised in any way their stances on the socio-scientific issues discussed; and others who use the other ethical frameworks from the start had not made a sudden adjustment to include a Christian-based reasoning. This is an important observation because values may shape the way we think, the way we reason and how we present our viewpoint but they cannot be altered in a socio-scientific curricula; but they may be made more explicit as one is made more conscious of how they affect our reasoning process.

ii. How a teacher creates the collaborative classroom atmosphere

Research has shown that the classroom atmosphere plays a vital role in determining the amount of learning that takes place in a classroom. ` For successful pursuit of action-oriented rational decision-making process, teachers' pedagogies should include an open and supportive atmosphere in their classrooms, providing students with opportunities to explore, examine, and consider different possible alternatives

for resolutions when confronted with problems and asked also relevant higher order cognitive skills questions (Zoller,1999). Classrooms are conceived as `communities of learners' or `intentional learning environment' drawn from the situated cognitive approach (Brown et al. (1993)). The authors linked this idea to Bourdieu's (1972) notion of communities of practice and to Lave and Wenger's (1991) perspective of learning as increasing participation in `communities of practice', situated in certain activity, context and culture. Lave and Wenger's approach highlighted the kind of social engagements that provide the proper context for learning to take place. This emphasis on social interaction as an essential component for both cognitive development and learning are based on the work of the Russian cultural-historical theorist such as Vygotsky (1981).

The significance of such an emphasis is underscored in a current investigation by Berland and Lee (2010). While studying the influence of first-hand data on students' argumentation, preliminary results suggest that middle school students are more likely to engage with and incorporate challenging evidence when it is evidence they can *see* rather than being something that is *reported* to them. This study highlights the importance of the learning environment and its influence on the students' argumentation.

With the experimental group, I have slowly built rapport with my students over the first semester, familiarising myself with the students' learning styles and exploring the different small group dynamics during class activities such as lab sessions and discussions. Developing a good relationship with the students as well as understanding how different characters within the class work together, helps in ensuring that small groups function effectively. Consideration of other factors such as the pacing of the lesson and the nature and type of activity (determining the number within each group) also work towards creating a collaborative classroom atmosphere which becomes conducive for verbal exchange, articulation of opinions and reasons in the act of resolving dilemmas and making decisions in socio-scientific education.

iii. How a teacher manages the ethical reasoning process (or create the thinking climate)

In managing the ethical reasoning process, the teacher sets the classroom atmosphere (aforementioned) and also teaches the students to respect alternative views and undergirding that, an unquestionable respect for each person as co-learning deliberators and equal participant in the discussion. The proper aim of teaching ethics and technology, according to Crosthwaite (2001) is the facilitation of informed debate, both morally and technologically informed, in both scientific and general communities, about issues of ethical significance. And I agree with her that the major part is *respect for***,** and *ability to engage in moral reflection, debate and deliberation*. It is these that should guide both the content and the manner of teaching in this area (2001, p. 100).

In managing the ethical reasoning process, I have introduced the use of five ethical frameworks as tools for ethical deliberation. I have students who expressed concerns that the ethical frameworks are not always easy to use – at least with some case studies. Usually these observations were made after one or two preliminary attempts, and with apparently quite difficult and complex cases. However, with sustained effort, in most attempts, the students arrived at a place where the ethical frameworks had been reasonably successfully used. And where there are differences in ethical frameworks used, and different decisions made, students were encouraged to reflect on the process of deliberation and debate – which is an important part of teaching ethical reasoning – before choosing to agree to disagree on an informed social decision. Managing discussions effectively can be a challenging task and strategies for structuring small groups and whole class setting are valuable in ensuring the process runs smoothly. To ensure effective small group activity, the teacher has to be sensitive to the group dynamics within a particular class and this can only be cultivated over a period of time – which explains why the research was conducted in the second semester. With time, the teacher observed different learning styles and tested different teaching strategies and built good rapport with students.

The biotechnology unit started with a special teaching course by the philosophy and ethics teacher so students were introduced the subject of ethics and ethical thinking. Most students found the connection between ethical thinking/ reasoning and the

socio-scientific knowledge fascinating and it increased the interest and motivation to find out more on the different aspects of the biotechnology as the term unfolds. The planning and organisation of the unit with a solid introduction of the ethical component set a platform to launch students into the ethical thinking process and practice opportunities were provided through carefully paced individual, group and class activities.

Through the use of different teaching and learning strategies, students were given a wide range of opportunities to practise their critical thinking, argumentation and reasoning. The use of ethical frameworks was enforced through various case study analysis, DVD presentations, media articles, personal research, online interactive, etc. This was in line with Sadler (2004, p. 523) which stated that the `most fruitful intervention would be those which encourage personal connections between students and the issues discussed, explicitly address the value justifying claims, and expose the importance of attending to contradictory opinions. If teachers expect their students to engage in sophisticated argumentation, students need ample opportunities to practice justifying claims, attending to counter positions, and dissecting argumentations to increase their awareness of that which constitutes well-reasoned arguments.'

The present study shows that the teacher plays a critical role in the implementing of ethical frameworks in dealing with socio-scientific issues. How the teacher expresses one's values, how the teacher creates the collaborative class room atmosphere and how the teacher manages the ethical reasoning process will determine the level of success in the implementation of this teaching strategy and hence enhance the teacher's confidence in teaching socio-scientific issues and thus propel the socio-scientific curricula in the right direction.

iv. **Teacher's confidence in teaching socio-scientific issues**

The experimental teacher also completed a self-evaluation exercise to ascertain the degree of confidence in teaching socio-scientific issues. The five attributes are identical to those used by the comparison teacher and the rating is also conducted on a scale of 1 – 10 (1 = least and 10 = most) as shown in Table 4.22 on the next page.

Table 4.22 Experimental Teacher's Self-Evaluation

1	Knowledge of ethical reasoning process - 5 to 9 (beginning to end of term)
2	Confidence in using teaching strategies – 6 to 8 (it depends also on the student-teacher relationship; differs from cohort to cohort)
3	Understanding of small group dynamics – 6 to 8
4	Understanding how students process information- 5 to 7(an important area to improve)
5	Awareness of the important contribution that teaching controversial issues makes to science education – 9 - 10

As with the comparison teacher, the experimental teacher also experienced a measure of personal growth in the process of teaching socio-scientific issues. In terms of knowledge of ethical reasoning process and confidence in using teaching strategies, there has been a discernible growth curve. It is noteworthy that, with the increase in knowledge of ethical reasoning process, the experimental teacher recognised its close relationship with understanding how students process information. Such an observation underlines the importance between science literacy and the ethical reasoning development.

4.4.2 Summary of Analysis

The present study from the teachers' perspective and reflections shows that such an open and supportive atmosphere conducive for our socio-science curricula implementation took place due to two important key factors.

First, the teacher understands the class well, or to be precise, the learning style of each student well, to place students in small groups where the dynamics within each group is a positive and constructive one. This explains why the biotechnology unit was introduced in term 3 as the relationship building between the staff and students took place throughout the first semester. The composition of each group determines the level of collaboration and productive work carried out. Small group dynamics are a key factor in ensuring that socio-scientific curricula are effectively implemented.

Sampson and Clark (2009) in their study on the impact of collaboration during scientific argumentation indicated that collaboration was beneficial for individual learning. The triads, on average, produced arguments that were of higher quality. The finding suggests that collaboration improves what students learn from and about scientific argumentation when students engage in a task that requires the evaluation of alternative explanations for a discrepant event and then the generation of an argument that provides and justifies an explanation for the phenomenon/ issue under investigation.

Understanding the group dynamics and the group formation process was a key feature prior to the implementation of the ethical frameworks. In overall enhancing the efficacy of our approach, teachers as science educators need to help students learn how to interact with other students, and this is accomplished by teaching out students how to listen to one another and respect other viewpoints, even if it is totally opposing to theirs.

Second, students' learning of the use of the ethical frameworks was supported by diverse instructional means, such as having students work individually, in pairs/ and in groups of threes for a substantial amount of time in most lessons, making the lessons not teacher centred, but student-centred. The student-centred approach is not a new concept (Zohar & Nemet, 2002) but it ensures that the students' learning is rich in social construction of knowledge (Duit & Treagust, 1998).

How is this relevant to a teacher's confidence in teaching ethical frameworks?

The following Table 4.23 provides a comparison of the rating between the two teachers in terms of their confidence in teaching socio-scientific issues

Table 4.23 Comparison of Teachers' Self Evaluations

Rating (out of 10)	Comparison Teacher	Experimental Teacher
Knowledge of ethical reasoning process	3 - 8	5 - 9
Confidence in using teaching strategies	6 - 8	6 - 8
Understanding of small group dynamics	6 - 8	6 - 8
Understanding of how students process information	7 - 8	5 - 7
Awareness of the important contributions that teaching controversial issues makes to science education	8 - 9	9 - 10

From Table 4.23, it is noted that both comparison and experimental teacher experienced increased confidence in teaching socio-scientific issues. Both teachers used ethical framework(s); the comparison teacher used a simple framework while the experimental teacher used the five ethical frameworks. Both teachers recognised that their knowledge of the ethical reasoning process and confidence in using teaching strategies had been more developed. This improvement was also accompanied by an increased understanding of the small group dynamics, how students process information and a greater awareness of the value of teaching socio-scientific issues.

The relevance of the teacher's confidence in teaching ethical frameworks are articulated as follows:

First, the teacher's confidence is strengthened primarily in the relationship he or she has built over a semester's work prior to implementing something new or different. Understanding the students' learning style and having the students adapted to the teacher's teaching style (for the same length of time) are vantage points from which the teacher is working from. The ethical framework is provided also as a form of thinking, reasoning and writing tool to structure and express the thoughts and reasoning patterns and process.

Secondly, the students always enjoy the opportunities when they can have an input in their learning experiences. Having the student participated actively guarantees their preliminary engagement, their sustained focus and hence their total involvement in the learning process. These should foster the teachers' confidence in ensuring that the teaching process is a two-way street, not a monologue or a transmissive model of teaching.

This is congruent with observed research that students who experienced *sustained* opportunities to negotiate scientific content in the context of socio-scientific issues, showed evidence of epistemological improvement, whereas a control group of students who experienced a more traditional science education experience without any focus on socio-scientific issue (minimal students peer interaction) showed no such evidence. This is also supported by the study that shows that student who experienced the socio-scientific driven curriculum, learned more about basic anatomy and physiology concept than their peers in comparison groups (Zeidler, Sadler, Applebaum, Callahan & Amiri, 2005a).

The present study confirms the observation in both comparison and experimental groups where small groups malfunctioned, the results from their case analyses indicated a less rigorous and integrative approach and hence, less satisfying outcomes. Socio-scientific issues become personally relevant when students form and participate in rigorous scientific argumentation (Sadler, 2004). In the experience of both the comparison and experimental teachers, the use of the thinking tools such as frameworks facilitated by a collaborative working atmosphere and complemented by a range of student-centred teaching and learning strategies, have been an enriching and rewarding journey with the students.

In summary, in the use of ethical frameworks or the simple framework, the teachers has certainly inspired renewed confidence in teaching socio-scientific issues and socio-scientific education as a subject can be invigorated with a wider application of this reasoning and thinking tool across a spectrum of different contexts with its associated social, political and moral challenges, leading our students on the way to active and responsible citizenry.

4.5 Summary of Data Analyses and Findings

Summary of Research Findings

The present study has shown that in socio-scientific education, the use of the simple framework (delineating pros and cons/benefits and risks) has some value, but not substantial, in developing the informal reasoning ability (rationalistic, intuitive and emotive reasoning) of students. This was observed in the students' slight increased capacity to understand the issue and integrate one or more forms of informal reasoning in resolving a dilemma although such a rationalistic and intuitive approach are not necessarily substantiated or supported or developed adequately.

The application of socio-scientific issues to different contexts has been engaging to the students due to their relevance to their personal experience and social setting; hence there was also increased motivation towards learning of science. This is noted through improved knowledge test scores at the end of the teaching unit (refer to outcomes in quantitative analysis). Triangulation with notes from interviews with these students and student journal entries also indicated an enhanced level of engagement and interest in science learning.

While scaffolding has been provided in the form of the simple framework, students did not always recognise them as a thinking tool, and the meta-cognition level of consciousness in using this framework is not significant from the written responses in the class activities on different scenarios and pre-program and post-program questionnaires. This phenomenon was further confirmed in the interviews and the observations and inferences made from the quantitative analysis in the present chapter.

The use of the ethical frameworks (both the simple framework and the five ethical frameworks) in supporting argumentation and reasoning process, as research shows, needs to be complemented by a variety of teaching strategies whether the process of

reasoning was `talking through' or `writing out'. As a thinking tool which requires a certain level of literacy (reading a scenario, understanding and writing), the use of frameworks does not always appeal to students with learning styles that requires, perhaps, a more hands-on and kinaesthetic learning approach.

In the analysis of qualitative and quantitative results, it was found that the experimental groups were more integrative in their reasoning patterns and presented a more developed line of reasoning and decision-making process; that is, they identified and assessed the different ethical frameworks, summarised their viewpoints and critically self-evaluated. Alternatively, the comparison group showed that judgements are based more on emotive reasoning and intuition; and concerns with uncertainty featured predominantly in the decision making process. In addition, the student's justification for the decision was less integrative, that is, focused narrowly on one or two points and ignored other dimensions of decision making. It was also recognised that the experimental group performed better in terms of considering a good range of alternatives, sourcing alternative information, clarifying of values and discerning some scientific concepts and principles while demonstrating respect for other viewpoints.

In summary, it was observed that in implementing the ethical frameworks, students were equipped with a structure by which they could consider their values, explore different alternatives, use evidence-based reasoning and make informed and reasoned conclusions about socio-scientific issues. Ethical frameworks help students achieve higher level of cognitive competences in decision making. These frameworks also foster the ability to consider multiple viewpoints and integrate various strands of evidence into an informed, *scientific content* (data)-driven position as well as cultivate important scientific skills and fundamental life skills that students can well utilise.

This present study from both qualitative and quantitative analysis indicated that the use of ethical frameworks had significantly improved students' ability to reflect

critically, reason analytically and make rational decisions about their own ethical values in dealing with socio-scientific issues.

The present study showed that the teacher plays a critical role in the implementing of ethical frameworks in dealing with socio-scientific issues. How the teacher expresses one's values, how the teacher creates the collaborative class room atmosphere and how the teacher manages the ethical reasoning process will determine how effectively the teaching strategy is implemented and to what extent the teacher's confidence is strengthened in handling socio-scientific issues.

Due to the nature of subjectivity in gauging self-confidence, it was difficult to ascertain to what extent both the use of ethical frameworks or the simple framework had fostered that measure of confidence in teachers teaching socio-scientific issues, it was, however, notable that there was a definitive inspiration and renewed confidence in both experimental and comparison teachers in ensuring that the use of ethical frameworks could be a significant teaching strategy in developing reasoning and thinking in socio-scientific education.

4.6 Chapter Summary

Chapter 4 reported the data of the present study and its analyses structured around each research question. It provided a detailed description of each data analysis utilised to answer the three research questions. First, the qualitative data and analyses for both comparison and experimental groups were reported in detail and comparisons made with previous research. This was followed by detailed analyses of student written responses in the pre-program and post-program questionnaires, class activity work samples on `My Sister's Keeper', students' journals and notes taken from interviews with students. Next, quantitative data and analyses were reported, organised in terms of the constructs represented by the questionnaire scales. A summary of findings and analyses included the identification of patterns of informal

reasoning as well as ethical thinking, reasoning, decision making and attitude based on the researcher's code of sound decision making features. Subsequently, an analysis relating faith and values context was provided, given the faith/values situational context of the present study. In the last section, the qualitative data analyses and results were reported from the teachers' perspective and reflections. Chapter 4 concluded with a summary of the research findings in response to the three research questions.

This is followed by Chapter 5 which encapsulates the discussion of findings related to the three research questions and concluded with a summary of the research findings of the present study.

CHAPTER 5

DISCUSSION OF FINDINGS

5.1 Introduction

Chapter 5 continues with a discussion of these findings in relation to the three research questions and highlight findings unique to this study in light of the relevant literature.

The rationale for structuring the discussion of findings according to each research question is due to the difference in focus of each research question. Research questions 1 and 2 are *student-centred* with the emphasis on the *learning* perspective. The difference in the pedagogical tool used (one simple framework or five ethical frameworks) necessitates a separate discussion for each research question. The third research question is focussed on the use of the pedagogical tool from the *teaching* perspective. Such an approach is also utilised in Chapter 6 to delineate the findings according to each research question.

The discussion of findings of research question 1 is centred on the usefulness of the simple framework from the learning perspective while the teaching perspective is discussed later in conjunction with the third research question.

The discussion of findings of research question 2 is focussed on five key aspects of socio-scientific education; namely, the nature of science, the case-based approach, argumentation and informal reasoning, attitudinal change and faith/values framework in relation to ethical reasoning.

The discussion of findings of research question 3 is presented in the context of the class room discourse and the teaching perspective is emphasised.

The chapter is concluded with a summary of the research findings of the present study.

5.2 Discussion and Research Findings

5.2.1 Discussion of Findings of Research Question 1

Research Question 1

How effective is the simple framework in developing students' ability to reason analytically and make decisions about ethical issues?

This discussion of findings for Research Question 1 is approached from both a learning and a teaching perspective. It attributes some value to the use of the simple framework in engaging students and a slightly improved learning outcome for the comparison group students.

From the Learning perspective

The use of a simple framework helps students to think about options and alternatives they normally would not think of themselves. Students learn to explore from a variety of viewpoints. Research findings indicated that there was some slight development in the way students integrated their knowledge by connecting it to the context and identifying the issue from multiple perspectives. Eastwood et al. (2011) acknowledged that there are different developmental frameworks for college students and adults, including the Reflective Judgment Model (King & Kitchener, 1994), Perry's Scheme of Intellectual and Ethical Development (1979), and the Epistemological Reflection Model (Magolda, 1992) and proposed that there are early, middle and highest level of development in situated learning where students make sense of a new concept in the context of its application and discipline. The early stages are characterised by conceptions of knowledge as absolute and derived from authority, understanding of reality as directly observable, and difficulty in recognising complexity or different perspectives. The middle stages are characterised by perception of complexity, uncertainty and multiple perspectives, although reasoning may be inconsistent and decisions or commitment may be hindered by complexity. At the highest levels of development, knowledge is seen as complex, uncertain and a product of inquiry. Individuals apply consistent criteria to form

evidence-based decisions and recognise and incorporate multiple perspectives in their reasoning.

The present study showed that, given a simple framework, students made some slight progress, though not always consistent, towards the middle stages of the model suggested by Malgolda (1992). They identified a range of perspectives, and a shift from authority-based knowledge to a somewhat tentative-personal/evidence-based position can be discerned. Certainly, as noted, the use of a simple framework was not the only contributing factor. The classroom environment, including opportunities for reasoning (Zeidler et al., 2009) with relevant, authentic contexts, role modelling by teachers and peers all played a part towards influencing the students' development.

There is modest improvement in the students' use of rationalistic and thinking reasoning approaches. Students began exploring the use of more than one form of informal reasoning. Although rationalistic informal reasoning was the most commonly used approach, it was found that where there was uncertainty or lack of clarity of the scientific knowledge or concepts, students were inclined to use intuitive reasoning instead. While it was observed that students exhibited a slight increased capacity to understand the issue and integrate one or more forms of informal reasoning in resolving dilemma, the rationalistic and intuitive approach are not necessarily substantiated or supported or developed adequately.

This research finding also concurs with researchers in recent studies that have found that students use emotive and intuitive reasoning along with rationalistic reasoning in socio-scientific issues (Sadler and Zeidler, 2005a). Study showed that students used emotive and intuitive reasoning more than other reasoning types in socio-scientific arguments, as was also noted in the research by Fleming (1986). Furthermore, student emotive reasoning was found to be reliant on the context selected than their rationalist and intuitive reasoning. Present study showed that by providing the ethical frameworks, students actually relied less on their emotions or mere intuition as they were provided with alternatives to consider and thus sought for a greater measure of objectivity in their response.

It is noted that using the framework as a writing activity was not a learning style that appealed to all. Some students preferred to use the framework to `*talk it out*' rather than just `*think and write it through'*. Such an observation from the present research suggested a perspective on argumentation and decision making process that was based on the premise that argument and reasoning encompassed both individual and social meaning, and that this dual meaning comprised an inner chain of reasoned discourse (individual) and a dispute or debate between people holding contrasting positions (social) (Jimenez-Aleixandre & Erduran, 2008). The internal and social aspects are connected in that social dialogue offered a way of externalising internal thinking strategies embedded in argumentation and reasoning (Kuhn, 1993). In this respect, classroom discourses in the form of small group discussions can promote students' argumentation skills (Bennett et al., 2010), and from the present study, it appeared that discussing the issue in small groups was preferred by some students as a means of facilitating and articulating their position. By engaging collaboratively in argumentation activities that make reasoning public, students could gain collective experience of constructing, justifying and evaluating arguments and evaluating outcomes. However, the value of these activities can only be fully harnessed through a curriculum that is explicit about the argumentation process through `task structuring and modelling' according to Jimenez-Aleixandre and Erduran (2008) and Osborne et al. (2004). This aspect of making the argumentation more explicit was addressed through the provision of specific instruction on argumentation at the course commencement (refer to program on page 69) and through the use of the ethical frameworks that is addressed in the response to the second research question.

The present study demonstrated some modest improvement in engaging students and a slightly improved learning outcome through the use of the simple framework in the comparison group. It appeared that the use of socio-scientific issues that were firmly located in contexts familiar to the students increased the level of engagement of students and fostered a stronger sense of relevance. Motivation for learning increased and learning outcomes could be elevated. So, the present research aligned with Aikenhead's (2006) initiative to corroborate important issues pertaining to the use of everyday contexts and the relevance of students' experiences of school science. The present research findings also concurred with previous research that socio-scientific issues in classrooms provided contexts that connect school science to real-life issues

thereby making science more relevant and interesting (Albe, 2008; Harris & Ratcliffe, 2005). The engagement noted seemed to be related *both* to the *type of context* of the socio-scientific issue as well as the *design of the learning experiences.* Students explored the socio-scientific issues using a variety of learning experiences in which they were stimulated, motivated, supported and challenged. The use of debates, role-play, group discussions, case studies, media interaction and technology application all contributed towards an engaging inquiry process. As to the context of socio-scientific issues, there were students who expressed their preference for more biological contextual issues (e.g. agricultural and ecological) whilst others preferred the human biological contexts (e.g. human genetics and health sciences).

5.2.2 Discussion of Findings for Research Question 2

Research Question 2

In what way does the use of the five ethical frameworks affect students' abilities to reason analytically and make decisions about ethical issues?

This discussion of findings for Research Question 2 is approached from a learning perspective which includes an understanding of the nature of science, the case-based approach and argumentation as an informal reasoning approach. The effectiveness of the use of the five ethical frameworks was evaluated on the basis of the type of multiple reasoning patterns, ethical reasoning process, range of perspective-taking, level of engagement and attitudinal change. Consideration was also given to use of faith/values framework in relation to ethical reasoning.

From the Learning perspective

5.2.2.1 Nature of Science

The present study suggested that there was recognisably a more distinct evaluative use of scientific knowledge by students to substantiate their viewpoints. This was observed by the substantiation of viewpoints by justification using scientific evidence and providing more alternative perspectives. As highlighted in Chapter 2 of the present study, Zeidler et al. (2002) have raised concerns that students were not

able to differentiate between data, unfounded opinions and predictions, and related research also confirmed that students preferred to depend on personal relevance over evaluative decisions based on serious considerations of presented evidence. The use of socio-scientific issues and the practice of decision-making in the present study enabled students to critically evaluate evidence and claims, make the connection between the scientific knowledge gained and the issue at hand by understanding its relevance to a particular scenario through a systematic process of clarifying, reasoning, arguing and finally articulating an adopted view point. Students also developed an enhanced appreciation for alternative and different perspectives in looking at an issue and they learned to take measured consideration of other aspects such as ethical, financial, legal, social and political when studying socio-scientific issues. The present study highlighted the importance of developing transferable reasoning skills through a well-structured task orientation which was central to the promoting of the use of socio-scientific issues in the science curricula.

The experimental group who demonstrated a greater improved learning outcome in the pre- and post-program knowledge test and this improved learning outcome was based on statistically significant results obtained from the quantitative analysis. There were several possible but not mutually exclusive explanations for this improvement in knowledge. According to Zohar and Nemet (2002), students engaged biological concepts by higher-order cognitive operations that enabled them not only to remember these concepts but also to actively build mental representations, new relationships and personal understandings. Addressing genetic concepts from the perspective of moral dilemmas derived from social issues created "anchored instruction" for students in that socio-scientific issues offered an anchor for learning that generated interest and connected to students' out of school life experiences (Bruer, 1993). Finally, student learning was aided by a range of instructional means, such as having students work individually, in pairs, and/or in small groups and the employment of various teaching strategies such as debates, role playing, classroom activities that are not teacher-centred, as noted from data analysed, students' journals, teachers and students' interviews.

5.2.2.2 Case-based Approach

Students have provided indications that they viewed the ethical framework as a meta-cognition/thinking tool as well allowing them to better appreciate the nature of science and its cross-curricular applications. The ethical frameworks provided a basis to align their views and served also as a basis to provide reasons for the decision making. Evidence from the students' written work demonstrated that the frameworks provided a kind of scaffold to integrate new knowledge. The ethical frameworks more frequently used were balancing rights (justice), maximising benefits (utilitarian) as well as Christian values. In terms of developing ethical thinking, students using the five ethical frameworks demonstrated significant progression in perception and appreciation of socio-scientific reasoning from unaffected position to concern and informed judgement (refer to pages 135 and 136 of this study.

In relation to the discussion in Chapter 2 (pages 18 - 22) on the importance of using protocols when implementing case-based issues in science classrooms, the organisation frameworks by Berland and Reiser (2009), Keefer (2003), Kolsto (2000), McNeill and Krajcik (2007) and Pedretti (2003) were outlined briefly to highlight the importance of hands-on and minds-on science. These frameworks can be used to support whole class discussions and provide scaffolding in the written form of individual student work.

In this respect, the use of frameworks, and for the present study, the ethical component has been emphasised. Students in the experimental group had expressed meta-cognitive awareness in their responses in both written forms and verbally at the interviews. Meta-cognitive awareness (Kuhn 2005; Kuhn et al., 1995) is the ability to bracket one's own prior theory and view alternatives. Interestingly, whilst the comparison group appeared to prefer `talking it through' than `writing it through' (note the preceding discussion in response to Research Question 1), observations of the experimental group seemed to suggest that meta-cognition can be implicitly fostered by means of writing activities. Past research (Klein, 2000; Prain & Hand, 1996; Rivard, 1994) have analysed the role of writing in learning science although little has been directed to scientific reasoning. The present study with ethical frameworks, provided some positive outcomes and suggested the plausible benefits

of writing on scientific reasoning when students work individually (also noted in Garcia-Mila & Anderson, 2007). In adopting Vygotsky's (1981) socio-cultural approach on construction of knowledge by means of negotiation and peer collaboration, there is a place for both internal (via writing) and external (via talking) dialogic forms of learning. The present study appeared to reinforce the emphasis on the use of ethical frameworks as a means of providing an epistemological and dialogical environment for socio-scientific education in a science classroom.

The present research findings also concurred with the suggestion raised by (Ben-David & Orion, 2012; Jimenez-Aleixandre, 2008) in designing argumentation learning environments, it is important to involve students in *reflection* and *meta-cognitive thinking*, encouraging them to compare their ideas and positions with alternative ones, or to evaluate the change in them and the causes behind the change. This position was further supported by Garcia-Mila and Anderson (2008) when they claimed that developing meta-cognition was a key factor in the co-ordination of theory and evidence. They also pointed to the effectiveness of combining *practice* with *reflection*. This meta-cognition awareness was noted in the written response of the experimental students and raised as a point of interest during the student interviews. Students expressed the desire to know more on this aspect of science education. Students' verbalisation of the metacognitive experience helped to increase teacher's awareness of students' learning processes and difficulties which in turns enabled teachers to address this need by redirecting and refining instructions to students

5.2.2.3 Argumentation – Informal Reasoning

The ten-week course presented in this study was designed according to the recommendations found in the literature (Kuhn, 1991; Voss & Means, 1991) which comprises two key elements: firstly, explicit instruction about the formal structure of an argument (two-hour lesson by a Philosophy and Ethics teacher) for both comparison and experimental groups and secondly, the generation of multiple opportunities for students to engage in argumentation and to take part in discussions and case analyses that require deliberate use of arguments and justifications. Results from the present study suggested that making instruction about argumentation

explicit and providing a framework enabled students to be more conscious about the generalised principles involved in reasoning and enhanced their meta-cognitive awareness and thinking. Essentially, the use of the ethical frameworks enhanced argumentation and reasoning by helping students to bring `pre-existing skills into the realm of classroom discourse' (Zohar & Nemet, 2002).

Previous research in assessment of socio-scientific competence in reasoning and decision making has suggested different criterion among decision makers (Bogeholz & Barkmann, 2005; Eggert & Bogelhoz, 2009; Hong & Chang, 2004; Jimenez-Aleixandre, 2002; Kolsto, 2006; Lee, H. et al., 2012, Sadler & Zeidler, 2005a,b; Seethaler & Linn, 2004; Wilson & Sloane, 2000). Several tendencies noted in these research studies include reliance on personal experiences, the influence of emotive factors, the primacy of social considerations, and moral and ethical calculations. The present study recognised that identifying the different reasoning patterns can be a valuable tool in determining the level of complexity in the decision-making process and therefore contributed towards a way of evaluating decision making competence. In this respect, Sadler and Zeidler (2005a) provided an empirical basis for the construction of a model of socio-scientific informal reasoning by characterising patterns of student reasoning. This model was modified in the present study to include the ethical/ moral dimension to bring to focus the use of *ethical* frameworks.

On the informal reasoning approaches, data analysed showed that students weaved greater complexity in their argumentation and there was noted an increase in the use of rationalist reasoning and less intuitive reasoning for students using the ethical frameworks. However, this is not indicative that rationalistic reasoning is superior to intuitive reasoning although `intuitive' informal reasoning is usually based on an immediate reaction to the context of a particular scenario. Intuitive informal reasoning is the result of a `gut-level' reaction to feeling that could not necessarily be explained in rational terms. Although intuitive feelings may not be rational, because they contribute to the resolution of socio-scientific issues, they may be considered a type of informal reasoning.

From the collated list of the three scenarios (scenario 1 – 3), the reasoning type for both comparison and experimental groups remained distinctively constant for all except for the rationalistic reasoning which sees a double-fold increase and a slight

drop in intuitive reasoning. As discussed earlier, it may indicate that the use of ethical frameworks in the experimental group may have encouraged students to move beyond an emotive or intuitive response or it may indicate that students with more practice have developed a more logical or reflective approach in employing the rationalistic reasoning type.

Data analysed also suggested that the context of the socio-scientific issue determined the type of reasoning approach used. An intuitive reasoning approach seemed more prevalent with individualistic scenarios (compare `reproductive technology – prenatal screening versus `genetically modified food'). Research from Sadler and Zeidler (2005b) showed that `individuals who exhibited intuitive reasoning often used emotive and rationalistic reasoning to subsequently support their initial reaction. Thus, the manner in which intuitive reasoning was integrated with other modes of reasoning displayed a certain trend. Intuitive reasoning was usually more influential that other reasoning approaches. If the student expressed an immediate reaction to an issue, then he or she was most likely to use this reaction as a guide for his or her ultimate position, regardless of other concerns.

This research suggested that whilst this observation was true, this usually occurred *only when* students have a firm understanding of the scientific concepts of the gene technology (in particular with scenario 1 on `Gene Modified Food'). Where there is uncertainty or lack of clarity on the scientific knowledge or concepts (for example in scenario 2 or 4), students used intuitive reasoning but lack a rationalistic basis for substantiating their view point.

Nevertheless, the majority of students for both comparison and experimental group consistently exhibited patterns of integrating some form of rationalistic informal reasoning in every scenario, suggesting that, of the four reasoning patterns designated, rationalism was the least context dependent.

Data analysed also showed that scenario 2 on `IVF and Genetic Screening' featured a high percentage of moral reasoning. This meant that some contexts may elicit a response where moral values or moral reasoning were expressed more explicitly in justifying their viewpoints. Significantly less reasoning on moral grounds was observed with scenario 1 on `Genetically Modified Food'. This provides further evidence that the context of the socio-scientific issue influenced the type of

reasoning used. Thus, the present study appeared to confirm previous studies where the quality and level of moral reasoning expressed are often dependent on socio-scientific issue contexts (Sadler & Zeidler, 2005b; Topcu, Sadler & Yilmaz-Tuzun, 2010; Lee, H. et al. 2012).

From the data analysed across the first three scenarios, it was noted that between the pre- and post- questionnaire responses for both comparison and experimental groups, there was a shift from using one or two reasonings towards using two or more. This reflected a greater complexity in their reasoning patterns and an ability to integrate a number of different reasoning types. Of significance was the difference in the number of reasoning types among the post of comparison and experimental groups. There was a notable increase in the number of students in the experimental group using two or more reasoning types compared to the comparison group. Detailed analyses showed that sometimes one pattern of reasoning supported another, and in other cases, two or more patterns emerged, indicating divergent influences. This pattern lent support to earlier conclusions regarding students' perceptions of socio-scientific issue complexity(Halverson, Siegel & Freyermuth, 2009; Pedretti, 1999; Yang & Anderson, 2003) . The display of multiple reasoning patterns was due at least in part to the recognition of various perspectives that can shape and influence positions taken in response to the different socio-scientific scenarios. With due consideration to the intervention experienced by the experimental group, the increase in the number of students using two or more reasoning types may be attributed to the use of five ethical frameworks that encouraged students to utilise a multiple options/choice framework to evaluate and to guide the argumentation process for a decision to be made**.**

In other words, students were learning to explore socio-scientific issues from various perspectives and the use of ethical frameworks helped students to achieve a greater flexibility in the perspective-taking and hence influenced the increased level of sophistication in their reasoning process. However, the sample size was rather small and this limitation must be given due consideration.

5.2.2.4 Attitudinal Change

There was a notable attitude change towards a more positive and greater awareness of the benefits of biotechnology. On the other hand, with the gain in scientific knowledge, there was also greater caution or discretion on the use of biotechnology. This research finding was in line with previous research on effects of student-centred approaches to teaching, among whom, Conner (2004) showed small but positive effects on attitudes in a high school biology class. Previous research has indicated that direct participation in science activities has a positive impact on the attitudes of adolescents and young adults (George & Kaplan, 1998; Klop, 2009). Also, with the gain of new knowledge and a greater appreciation for the dilemma in socio-scientific issues, students were less worried about the effects of biotechnology and learn to build their attitudes upon a broader cognitive foundation, a more measured affective association and showed an improvement in the ability to know what to do or how to act when confronted with it.

5.2.2.5 On Faith/Values Framework in relation to Ethical Reasoning

It is noted from the students' responses that intuitive reasoning can be influenced by religious convictions/religious knowledge. It appeared from the students' responses that faith does, to some extent, affect or influence one's moral reasoning capacity. Faith can provide a basis for reasoning. In some cases, faith can also take precedence over reasoning in opting for a more simplistic acceptance rather than a logical rationalistic step-by-step approach in reconciling differences in facts and reality. Sadler and Zeidler (2005a, p. 130) raised the concern that rationalistic thinking patterns often typify what is generally expected in science classrooms, and educators often strive to ensure the development of rationalistic thinking skills (Tweney, 1991). Sadler and Zeidler's research (2005a) suggested that rationalistic informal reasoning is one of three ways that students might relate to socio-scientific issues. Students may adopt *relational perspectives* based on empathy and care; or in addition, they might be influenced more by their immediate intuitive reactions.

The present study suggests that faith values may also be adopted as a form of moral reasoning. For students to be personally engaged in socio-scientific issues presented

in the classroom, they needed to be given the opportunity to express their personal ideas about the issues or at least need an environment in which their patterns of thought are valued. Cajas (1999) highlighted that one of the rationales offered to support the development and implementation of socio-scientific curricula was the tendency for the material to truly engage students. For this goal to be fulfilled, science educators must be prepared to consider and respect the manners in which students negotiate these issues, even when that includes patterns of reasoning not typically associated with science. If socio-scientific issues were presented from only a rationalistic perspective, which has been normatively accepted as a hallmark of science education (Pool, 1991; Tweney, 1991), many students may be excluded. Effectively, this research argues for the need for intuitive reactions, emotions and value-based concerns to be valued as much as the reason-based ones. In the socio-scientific education, it is thus important to encourage students to explore their own informal reasoning without prescribing a particular mode of reasoning as one that is essentially valued above others in the classroom.

Yet, on the other hand, it was also noted that scientific knowledge can influence or shape the faith/moral reasoning process and affect the decision made. While scientific knowledge enables one to understand how a concept works so that one can make informed ethical judgement on the issue, limits on scientific knowledge can also present ethical dilemmas. For example, having the power to prolong life without sustaining the quality for a `meaningful' life creates the issues we see in euthanasia. Yielding to the power of biotechnology (such as GM food) may not necessarily be good in the long term as scientific effects need to be measured alongside other considerations that are social, political, economical and essentially moral in nature.

The present research findings suggested that it is important to allow for natural patterns of affective expression in resolving socio-scientific issues as well as affirms the place of scientific evidence and knowledge as central to the epistemology of science (McComas et al., 2000). To further facilitate the scope and effectiveness of socio-scientific education, it is important to explore the social aspects of science, status of evidence and its attendant philosophical viewpoints as well as the role of values in science. This research brings to the fore a question of what is fundamentally a socio-scientific decision making process as contrast to that of evaluating the strengths of a scientific theory**.** This research highlights the need to

redefine scientific literacy in terms of possessing normative judgements of scientific evidence and an aptitude capable of articulating emotive considerations and personal values.

5.2.2.6 Critique of Content and Process of Ethical Reasoning From the Faith Perspective

A careful study of the students' responses brings us to a critique of Kohlberg's moral development theory that asserts that the structure of moral thought can be distinguished from content. According to Colby and Kohlberg (1987):

> The concept of structure implies that a consistent logic or form of reasoning can be abstracted from the content of an individual's responses to a variety of situations. It implies that moral development may be defined in terms of the qualitative reorganisation of the individual's pattern of thought rather than in the learning of new content (p. 41).

Thus, the stages of moral reasoning represent qualitatively distinct ways of thinking about right and wrong (structures), not manifestations of underlying core beliefs (content). Therefore, according to Kohlberg, moral stages *cannot* be uniquely identified by directly asking about someone's moral beliefs. Rather, stages must be determined by a sophisticated analysis of the reasoning underlying declared moral choices.

From the present study, we see that unlike moral stages, moral beliefs are acquired through social transmission. When confronted with problems requiring moral thought, students called upon learned beliefs to frame solutions. Sources of moral beliefs which in this study were Christian beliefs, include parents, peers, and social institutions/religious institutions. The focus of this study assumes increased importance in view of the fact that school is one key social institution (among others) where children gain moral knowledge, even, in the science curriculum. It is therefore crucial that we understand how the moral content/religious conviction affects the reasoning process.

It may not be obvious that a person's moral beliefs may have little bearing on the stage of moral reasoning. The present study shows that this conclusion would be

premature. Ideological content may not alter the moral thought directly but could conflict dramatically with some types of moral reasoning. For example, a highly religious student would find it difficult to reconcile a belief in a loving God, with moral reasoning that is self-serving – Kohlberg Stage 2.

Students' Responses

`Selecting the gender of a child is wrong except the only good thing is treating a disease. You should love the child the way it is born, ***because it is God's plan for you. God is loving and his plan for you is perfect.*** *' Student S1*

`God's will. *The baby should be left as God intended it to be.' Student S17*

`I don't think people should be able to select the gender of a child, let alone eye colour or intelligence. It is unethical, unnatural. It may be going against plans that God has for your life and your children.' Student S21

In such a case, the tendency to reason at Stage 2 conflicts with core beliefs that discourage such thinking. The resulting disequilibrium would reduce the tendency to reason at Stage 2. Thus, content, in this case one's religious belief, would influence structure, one's stage of moral reasoning.

In summary, the present study showed that it is not enough to develop ability to reason morally or ethically. A person may be high on moral/ethical reasoning but low in personal conviction based on moral knowledge. Content, fundamental moral material or scientific knowledge/understanding, must be provided so that the person will know that the decision being made is a moral one, that she/he at that moment, is acting as a moral agent.

Thus, a moral curriculum that combines content and process may lead to formation of personal conviction, a sense of moral responsibility. So, in a definitive way, the present study showed that students' moral/ethical reasoning ability accompanied by strong convictions can influence and determine who would act out their beliefs.

5.2.3 Discussion of Findings of Research Question 3

Research Question 3

In what ways does the use of ethical frameworks influence the teachers' approach in teaching socio-scientific issues?

This discussion of findings for Research Question 3 is approached from a teaching perspective which considers how the use of the simple framework and the five ethical frameworks has influenced the teachers' approach in teaching socio-scientific issues. Consideration is also given to the effects on teachers' confidence in the use of teaching strategies and the awareness of the importance of values education in socio-scientific education.

From the Teaching Perspective

5.2.3.1 Classroom Discourse

Reviewed research on teacher's attitudes and classroom practice relative to biotechnology revealed a general tendency for secondary school science teachers to address at least some controversial issues with their classes but the approaches and frequencies varied (Cross & Price, 1996). More biology teachers than their colleagues from other science disciplines were more likely to incorporate controversial issues with consistency. They believed that values (including their own) were necessary aspects of socio-scientific issues discussion. The limitation these teachers experienced was the lack of resources to help them structure quality learning experiences in the context of controversial issues (Lumpe et al., 1998). Other notable patterns highlighted by Bryce and Gray (2004) found that apart from the challenge of understanding the science of biotechnology and time constraints for socio-scientific issues implementation, teachers needed training to develop skills for structuring and leading discussions, and in particular, teachers facilitating discussions of science's ethical and/or religious implications (Levinson, 2004; Loving & Foster, 2000). This study was an attempt to address the latter expressed need that teachers needed resources that would facilitate discussion of science's ethical implications.

This study showed that the use of ethical frameworks has increased the teachers' confidence in teaching socio-scientific issues. Using the ethical frameworks is a means of making explicit to students the different lines of argumentation for a specific socio-scientific issue. The framework provided a scaffolding structure for students to develop their argumentation and reasoning process. In setting out a framework as such, the teacher's familiarity with the reasoning approach using the ethical frameworks, as well as the ability to model questioning, played a crucial role in successfully teaching socio-scientific issues.

For this research, the stance of the teacher in teaching socio-scientific issues remained one of procedural neutral instead of perspective taking. This provided room for students to explore, argue and articulate their viewpoints. Although the teacher did not actively promote a certain ethical position, it was recognised that teaching involved transmission of implicit values. Hodson (2003) highlighted that values play a significant role in all aspects of education including curricula, pedagogies and assessments and avoiding values `mistakes the very purpose of the science component of education for citizenship' (p. 654). Regardless of the teacher's orientations or intents, classrooms can never be value-free environments; however, it was certainly important to strive for value-fair environments (Loving, Lowy & Martin, 2003). In addition, teachers also served as models for responsible behaviour and decision making, and an absolute exclusion of values from discussions of controversial issues may imply that values had no role in responsible citizenship. In this respect, having the five ethical frameworks provide a structure where values embedded in the frameworks provided room for other discussion and consideration in the argumentation process.

From the teacher's perspective, effective teaching in socio-scientific issues using ethical framework can only take place by creating a collaborative classroom environment that is safe and supportive for students' engagement with the controversial issues. Primarily, it is imperative for the teacher to understand the class well, understand the learning style of each student well so as to place students in small groups where the dynamics within each group is a positive and constructive one. Thus, the use of ethical frameworks is not a stand-alone pedagogical learning strategy which teachers can confidently employ in a socio-scientific classroom; it needs to be supported by a variety of teaching strategies and instructional methods

are more student-centred, rather than teacher-directed. This focus on the complementary role of student-centred teaching strategies was also highlighted in the latest research on the use of ethical frameworks in the pluralistic context by Saunders and Rennie (2013).

In the present study, role-play was one of the student-centred teaching strategies successfully utilised to engage students in the argumentative and reasoning process. The role play approach was one where students take on roles that represent different positions and this could stimulate argumentation as student engage with opposing roles. McSharry and Jones (2000) highlighted that it was of interest to see how the teacher would organise and manage the role-play approach, given that it has proved challenging for many teachers. Such an observation was further supported by research conducted by Simon et al. (2006) which indicated that only teachers who were confident in the use of argumentation will include role-play in such activities. The present research argues for the use of ethical frameworks as a pedagogical tool to enable the teacher to facilitate discussion and argumentation in both role-plays and debating activities which are essentially *student-centred* teaching strategies.

5.3 Summary of Research Findings

First, research addressing the first research question demonstrated that the use of a simple framework delineating the pros and consequences and benefits/risks did produce some modest results in developing informal reasoning capacity for the comparison group. There was also observed increased motivation and engagement with the topic due to enhanced relevance to personal situations and societal issues. Although the framework was used intentionally to guide the reasoning process, there was minimal meta-cognition observed and a lack of awareness of utilising this as a thinking tool. The use of the framework in supporting argumentation and reasoning process needed to be complemented by a variety of student-centred teaching strategies.

Second, research in response to the second question suggested that in the implementation of ethical frameworks, students were aided by a schematic structure,

that is the five ethical frameworks. This guided students to important considerations by helping them sort out relevant from irrelevant facts, by prioritizing the conflicting and competing ethical claims of various parties and from variegated perspectives, and by integrating information to arrive at a judgement of what ought to be done. Effectively, the use of ethical frameworks *guides* students' understanding of the socio-scientific issue and helps them to *formulate* the crux of decision-making. Both qualitative and quantitative analysis indicated that the use of ethical frameworks has significantly improved students' ability to reflect critically, reason analytically and make rational decisions about their own ethical values in dealing with socio-scientific issues.

Third, the research has shown that the teacher played a crucial role in implementing the ethical frameworks when handling socio-scientific issues. The use of frameworks instilled modest but definite confidence in teachers, with the five ethical frameworks having a slightly better edge. This study suggested that, from a teacher's perspective, the use of ethical frameworks can be a viable tool in socio-scientific education, and this needed to be complemented by the teacher taking a procedural neutral stance to prevent values being implicitly transmitted, role-modelling the scientific reasoning process through carefully crafted questions, creating a collaborative and caring learning environment and a variety of student-centred teaching strategies such as role plays and debates

This chapter on discussion of findings is followed by the concluding chapter of this study. This chapter presents a summary of the thesis, a list of research findings and summary of research findings. It also outlines contributions of the present research and the limitations of the study. It concludes with a description of the practical limitations of the study and recommendations for future research.

CHAPTER 6

CONCLUSION

6.1 Introduction

Chapter 6 commences with an introduction, a summary of the thesis delineated according to chapters followed by a list of research findings and summary of research findings pertaining to the three research questions. This chapter also outlines contributions of the present research and the limitations of the study with reference to method, design and implementation process. The penultimate section consists of the practical implications of the study and recommendations for future research, followed by the conclusion.

Over the last decade, there has been a confluence of factors and trends in curriculum development, educational theory and practices and changing national policies in the Australian educational scene. Values education has emerged to be a prime focus in writing a school curriculum on some common ground. A student-centred approach to teaching practices has gained wider acceptance. Socio-scientific issues as a vital area of concern in improving active responsible citizenship is increasingly integrated in a number of cross-disciplinary subjects. The Australian National Curriculum (2012) identifies `developing ethical reasoning' and `decision making' as key attributes in educational outcomes. Such a movement necessitates how science educators can constructively and creatively address these rapid changes.

By and large, the socio-scientific research focuses on four main directions: first, relationships between the nature of science conceptualisations and socio-scientific decision making; secondly, the importance of classroom discourses in peer interactions and its impact on reasoning, thirdly, the use of case-based issues in developing scientific literacy and active citizenship and lastly, ways of evaluating information regarding socio-scientific issues, and socio-scientific argumentation in genetic engineering, environmental issues and other public health issues. As highlighted in Chapter 1, recent studies have shown that students' poor

argumentation in the context of socio-scientific education has increasingly become a concern in science education. In relating to this growing concern amidst the current local climate of the national curriculum implementation being in full orbit by 2013, the present study was undertaken to design, implement and evaluate a decision-making ethical framework in which students consider their values about a socio-scientific issue and assess different alternatives as well as to incorporate teaching about common heuristics.

The investigation focussed on the use of a student-centred model in a Year 10 biotechnology class taught over a period of 10 weeks in an inter-denominational evangelical Christian college in Perth, Western Australia. In this study, the focus was on the use of ethical frameworks incorporating Christian values to enable students confronted with controversial dilemmas in socio-scientific issues. To do so, this study aimed to contribute towards a pedagogical strategy that would facilitate students' critical thinking, informal reasoning, argumentation and decision-making skills. This study was unique in that it presented one of the few studies that incorporated Christian/faith values in the ethical frameworks that enabled the researcher to explore the connection, if any, between cognitive learning and the moral reasoning and moral development, and in the wider sense, the link between cognitive learning (scientific literacy) and ethical reasoning.

6.2 Summary of Thesis

Chapter 1 of this thesis commenced with a general introduction to the present study which noted the global and national changing trend in science education towards greater relevance and meaningful engagement with students through the use of socio-scientific issues with a special focus on enhancing students' critical thinking, argumentation and decision-making skills. The background and rationale was next presented with special reference to the imminent full implementation of the Australian Curriculum. The objective of the research and the three research questions were also stated, followed by a recapitulation of the significance of the present research and a section enlisting the definitions of key terms used in this research.

The first half of Chapter 2 began with a survey of the socio-scientific movement and its attendant challenges paved the way for a more in-depth discussion and outlining of implications for the present study. The thematic areas of recent research connected to socio-scientific issues were delineated as follows: the nature of science issues, the classroom discourse issues, case-based issues and evaluating informal reasoning and decision making in socio-scientific issues and overall, the implications for these four areas were also reinstated. The second half of the chapter provided a review of relevant literature related to the use of ethical frameworks in treating socio-scientific issues.

In a separate section, ethical thinking and rationale for the use of ethical frameworks were treated with specific reference to conventional ethical frameworks, the four principles approach, ethical frameworks integrating pluralism as well as ethical frameworks for classroom approach.

Chapter 2 concluded with a special reference to moral and religious values in socio-scientific education and a chapter summary.

Chapter 3 provided a description of the research design, the methods that were used to gather the data and the data analysis techniques that were chosen to address the three research questions. The chapter started with a statement of the three research questions, described the interpretive case-study approach, specified the mixed methods research design, stated the rationale for the particular design, outlined the purpose statement as well as presented a brief description of how the design was implemented and how the data was collected based on the mixed methods triangulation convergence design.

Action research was the research methodology used in the present study. A description of the triangulation in the action research process and the role of the teacher and action researcher were also outlined. Both the internal and external validity were given due consideration in the research process and reliability was established from both the researcher's and the participant's positions. Such a process was further guaranteed by putting in place ethical considerations which include informed consent, withdrawal rights and anonymity measures.

The experimental protocol was defined in terms of its design, method and process of data collection and the qualitative and quantitative data analyses were based on sources comprising the questionnaires, classroom observations, interviews with students, journal writings of students and teachers, questionnaire data and concurrent data analysis.

A description of the research environment including the college profile, the students' profile, the teachers' profile and a learning model of teaching science/ethics were also presented. This chapter closed with an overview of the course structure detailing a list of teaching strategies and a week-by-week outline, completed with an overall chapter summary.

Chapter 4 encased the analyses and findings of the present research and primarily sought to determine the effectiveness of using the simple framework in developing informal reasoning, the effectiveness of the use of five ethical frameworks in increasing students' ability to reason analytically and make decisions about ethical issues and to establish avenues where the use of ethical frameworks can increase the teacher's confidence in teaching socio-scientific issues.

Both quantitative data and qualitative data were collected in this study. The quantitative data collected from both comparison and experimental groups involved a total of 63 students from two Year 10 biological science classes in an evangelical Christian college in metropolitan Perth.

The quantitative data were based on pre-program and post-program questionnaires that assessed students' understanding and ethical thinking, attitude and opinions of biotechnology, scientific knowledge and completed with a section on students' religious faith based on COS survey (Christian Orthodoxy Scale). The quantitative questions utilised a *Likert* scale or a five point scale type response choices. Profiles based on the average item mean scores for the questions were then generated.

The quantitative data were collected with the aim of comparing any changes, if any, of the comparison and experimental group in terms of their ethical reasoning, attitude and outlook of biotechnology in the course of the program. The differences in pre and post intervention of the use of ethical frameworks in the students' attitudes and perceptions of ethical reasoning were also analysed.

To evaluate the programs in terms of changes between pre and post mean scores for each question were computed, and the significance of pre-test and post-test differences in students' perceptions were analysed using an independent T-test on SPSS.

The quantitative data and analyses thus obtained were triangulated with the qualitative data gathered from questionnaires, classroom observations, interviews with students and teacher, journal writings and student work samples. All qualitative data collected were analysed and categories of patterns observed were coded on all factors that would contribute towards our understanding of the effectiveness of the model of using ethical frameworks for students and from teacher's perspective.

Chapter 4 provided the findings for the three research questions at the heart of the present research as outlined in Section 1.4. The qualitative and quantitative data used to answer the three research questions were analysed, and the findings were reported in the respective summaries of analysis and results at the end of each stipulated research question.

Chapter 5 provided an in-depth discussion of the research findings and highlighted threads of continuity with previous research with particular reference to nature of science, case-based approach, argumentation and informal reasoning and classroom discourses. Special reference was also made in relation to faith/values and moral reasoning from the religious perspectives.

6.3 List of Research Findings

Research Question 1

How effective is the simple framework in developing students' ability to reason analytically and make decisions about ethical issues?

Findings for Research Question 1

Learning perspective

1. The use of a simple framework helped student to think about options and alternatives they normally would not think of themselves. Students learned to explore from a variety of viewpoints
2. There was improvement in the students' use of rationalistic and thinking reasoning approaches. Students began to explore the use of more than one form of informal reasoning.
3. It was noted that using the framework as a writing activity was not a learning style that appealed to all. Some students preferred to use the framework to `*talk it out*' rather than just `*think and write it through'*.
4. The current model demonstrated some improvement in engaging students and a slightly improved learning outcome.
5. There was a notable attitude change – more positive and greater awareness of the benefits of biotechnology and with gain in knowledge, also greater caution or discretion on the use of biotechnology

Teaching Perspective

1. The use of a simple framework supported the argumentation and reasoning process but must be supplemented by student centred teaching strategies and a conducive collaborative learning environment.

Research Question 2

In what way does the use of the five ethical frameworks affect students' ability to reason analytically and make decisions about ethical issues?

Findings for Research Question 2

Learning perspective

1. There was recognisably more distinct use of scientific knowledge to substantiate the viewpoints. This was observed by the substantiation of

viewpoints by justification using scientific evidence and providing more alternative perspectives.

2. Students had provided indications that they viewed the ethical frameworks as a meta-cognition/thinking tool as well as better appreciated the nature of science and its cross-curricular applications.
3. The ethical frameworks provided a basis to align their views and served also as a basis to provide reasons for the decision making. Evidence from the students' written work demonstrated how the frameworks provided a kind of scaffold to integrate new knowledge. The provision of the five ethical frameworks for the experimental group showed that the students used it as a starting point to develop competence in argumentation and reasoning. The usefulness of such frameworks was confirmed in the research undertaken by Acar et.al. (2010) who point out that educators should give more space and respect to student values in socio-scientific issues (refer also to Bell and Lederman, 2003; Fleming, 1986; Sadler & Zeidler, 2005a). One way of addressing this deficiency was to provide the values framework for students to even begin to consider, or bring to fore, or make explicit the underlying belief or values that actually shaped their decision making. In this respect, this study confirms the above observation by highlighting the outcome that the ethical framework *more* frequently used were balancing rights, maximising benefits *as well as Christian values*.
4. On the informal reasoning approaches, it was noted students weaved greater complexity in their argumentation and there was increased rationalist reasoning and less intuitive reasoning for students using the ethical frameworks.
5. The context of the socio-scientific issue determines the type of reasoning approach used. An intuitive reasoning approach seemed more prevalent in socio-scientific issue that calls for more individualistic decisions to be made. The socio-scientific issues such as `reproductive technology' and `cloning' featured substantially high use of intuitive reasoning, and to a certain extent, elicit an increased level of emotional and moral reasoning.

6. In terms of developing ethical thinking, students using the five ethical frameworks demonstrated significant progression in perception and appreciation of socio-scientific reasoning from unaffected position to concern and informed judgement.
7. The experimental group demonstrated a greater improved learning outcome in the pre and post knowledge test and this improved learning outcome was based on statistically significant results obtained from the quantitative analysis.

On Faith/Values Framework in relation to Ethical Reasoning

1. It was noted from the students' responses that intuitive reasoning can be influenced by religious convictions/religious knowledge.
2. It appeared from the students' responses that faith did, to some extent, affect or influence one's moral reasoning capacity. Faith can provide a basis for reasoning. In some cases, faith could also take precedence over reasoning in opting for a more simplistic acceptance rather than a logical rationalistic step-by-step approach in reconciling differences in facts and reality.
3. It was also noted that scientific knowledge can influence or shape the faith/ moral reasoning process and affect the decision made. Scientific knowledge enabled students to understand how a concept works so that they could make an informed ethical judgement on the issue. Yet limits on scientific knowledge can also present ethical dilemmas. For example, having the power to prolong life without sustaining the quality for a `meaningful' life creates the issues we see in euthanasia. Yielding the power of biotechnology (such as GM food) may not necessarily be good in the long term as scientific effects needed to be measured alongside other considerations that are social, political, economical and essentially moral in nature.

Research Question 3

In what way does the use of ethical frameworks influence the teachers' approach in teaching socio-scientific issues?

Research Findings to Research Question 3

Teaching Perspective

1. The use of ethical frameworks has increased the teachers' confidence in teaching socio-scientific issues. However, the stance of teacher in teaching socio-scientific issues remained one of procedural neutral instead of perspective taking. This provided room for students to explore, argue and articulate their viewpoints. The teachers' familiarity with reasoning approach as well as the ability to model questioning also played a crucial role in successfully teaching socio-scientific issues.

2. From the teachers' perspective, effective teaching in socio-scientific issues using ethical frameworks can only take place by creating a collaborative classroom environment that was safe and supportive for students' engagement with the controversial issues. Primarily, it was important for the teachers to understand the class well, understand the learning style of each student well so as to place students in small groups where the dynamics within each group was a positive and constructive one.

3. The use of ethical frameworks was not a stand-alone pedagogical learning strategy; it needed to be supported by a variety of teaching strategies and instructional methods that are more student-centred, rather than teacher-directed.

6.4 Summary of Research Findings

First, research addressing the first research question involving the comparison group has shown that there were moderate results in enabling students to develop informal

reasoning capacity. Through practising with the simple framework, in comparing the pros and cons and thus outlining the benefits and risks, students developed a limited measure of competency in reasoning and developing arguments to express their viewpoints. However, students were also noted to be more motivated and engaged with learning science because of the increased relevance to their personal lives and the societal concerns. Although the simple framework was explicitly introduced as a tool to aid the reasoning process, the meta-cognitive awareness of this being instrumental in facilitating the argumentation process was almost non-existent. There was a common assumption by students that this was one approach, and possibly the only approach to resolving dilemmas in socio-scientific issues. The present study also showed that the use of the simple framework in facilitating the reasoning and argumentation process must be accompanied by a range of teaching strategies in its implementation.

Second, research in response to the second question pointed to the usefulness of a schematic structure, that is, the five ethical frameworks, to orientate the thinking process to explore possible alternatives, to prioritize conflicting and competing ethical claims, to examine from different perspectives and to integrate their information by linking from knowledge content and/or claims to well-grounded conclusions. Essentially, the use of ethical frameworks *guides* students' understanding of the socio-scientific issue and helps them to *formulate* the crux of decision-making. Data analysis from both qualitative and quantitative aspects suggested that the use of ethical frameworks has brought about a marked improvement in the students' ability to reflect critically, reason analytically and make rational decisions about their own ethical values in handling socio-scientific issues.

Third, research in response to the third research question underlined the important role of the teacher in implementing the ethical frameworks as a reasoning and argument-developing tool in socio-scientific education. On a modest level, research has shown that using the frameworks for both comparison and experimental groups has instilled in teachers some measure of confidence; with the five ethical frameworks proven more satisfying and effective as a pedagogical tool. This study suggested that, from a teacher's perspective, the use of ethical frameworks could be a viable tool in socio-scientific education, and this needed to be supported by the

teacher taking a procedural neutral stance, role-modelling the scientific reasoning process through carefully crafted questions, creating a collaborative and caring learning environment and a variety of student-centred teaching strategies. Present research also showed that socio-scientific education programs focussing on dialogical and reflective processes (as outlined in the teaching strategies) could help to facilitate socio-scientific reasoning.

6.5 Distinctive Contributions of the Study

1. The present research suggested the use of ethical frameworks as an effective means to explore socio-scientific issues. The implementation of such a pedagogical tool addressed some of the concerns raised (earlier in the introductory chapter) on the need to develop critical thinking strategies and with an emphasis that include both the *affective* and *cognitive* aspects in science learning.

2. The use of ethical frameworks in socio-scientific education as a teaching and learning tool also reinstated the importance of incorporating values in science education and establishes a tangible link between moral considerations and scientific literacy. This concurs with the current perspective that suggests that scientifically literate individuals `should be able to confront, negotiate and make decisions in everyday situations that involve science.'(Sadler, 2011, p.1).

3. The use of ethical frameworks in socio-scientific education has demonstrated an increase in the number of informal reasoning approaches utilised – primarily, intuitive, rationalistic and moral (including faith/values). The integration of two or more informal reasoning approaches through the use of the ethical frameworks was indicative of increased complexity in students' shaping and developing their reasoning and argumentation responses.

4. The use of ethical frameworks in socio-scientific education delineated, in a practical way, how students identified ethical issues and analysed key ethical concepts and principles, thus evoking a greater sense of personal and social responsibility as well as helping them make informed decisions that impact on individuals and society. This addressed the second ethical behaviour learning continuum in reflecting on personal ethics in experiences and decision making (Science as a Human Endeavour strand of the Australian Curriculum in Science, 2012). As such, the use of ethical frameworks presents itself as one of the working tools that can be used to fulfil the outcome of the *Science as a Human Endeavour strand* in implementing the new national science curriculum.

5. The incorporation of faith values in the ethical frameworks confirmed previous research that there was the possibility that *other* concepts besides that of justice and fairness could be the key in determining how one judges what is morally right. The present research indicated that there are different problem-solving strategies in making moral judgements beside stage schemes of justice described by cognitive developmental psychologists and educators. The present study also suggested that allegiance to belief systems and ideologies can sometimes override the influence of one's own sense of fairness in making decisions of moral rightness. This is an important factor to consider in mapping out curriculum for moral education and socio-scientific education.

6. The present research ascribed a high level of importance to the role of the teacher in implementing socio-scientific education. Due to the emphases on both cognitive and affective development of students and the magnitude and complexity of socio-scientific issues, the teacher will need to develop competence in the use of teaching strategies and resources such as ethical frameworks that focus on dialogical and reflective processes to facilitate socio-scientific reasoning,

6.6 Limitations of the Study

Limitations of the Study – Method/ Design/ Implementation Process

1. The small sample size was the primary limitation of this study, rendering it a case study rather than a representative sample. While the findings cannot be generalised, the comparison and experimental represented two similar teams from the same school with mixed composition of students.

2. A limitation inherent in most studies, as in this present study, could be the duration of the intervention program. A term of ten weeks may not be adequate for covering the basic components of a biotechnology course and the added unit on teaching ethical reasoning. The actual running of the program (excluding two weeks for assessments and college activities) was 8 weeks. If the course were to run any longer, it might experience some difficulties in keeping conditions constant between the comparison and the experimental classes. Some leverage has to be given for disruptions due to the school calendar. The ideal duration for a Year 10 Biological Science program on biotechnology unit was recommended to be at least 10 weeks. In classroom practice, with the implementation of Stage 1AB courses in the Western Australian context, the time allocated for the biotechnology unit may be somewhat limited but this did not preclude the incorporation of socio-scientific issues and ethical reasoning component in the curriculum. Due to time pressure imposed by the need to cover the national curriculum, teachers may need to be creative with the use of classroom time in generating involvement of students through student-centred activities (which inherently takes more time to implement).

3. Another limitation may be attributed to differences in frequency of data collection, in particular with the journals. The comparison group teacher encouraged journal writing on a weekly basis (due to nature of the dynamics of the class and his teaching style) and the experimental teacher implemented a daily routine of journal writing (which was also a reflection of the teacher's teaching style and also the students' different learning style). Certainly, one

has to be aware of the Hawthorne effect that comes into play with the experimental group and the teacher as the action researcher. This was taken into careful consideration during the interviews where clarification were often made (within a short time frame of a week) to ensure that the interpretation by the teacher(s) were consistent with what the students were actually conveying in the class and their written responses.

4. The present research designed to promote moral reasoning or ethical reasoning has not always yielded consistent, conclusive results. According to previous research (Rest, 1979), such inconsistent results are not new. This may be attributed to a number of theoretical and methodological problems associated with studying the development of ethical reasoning/moral reasoning. It is very unlikely that the reorganisation of basic cognitive structures can take place instantaneously or even overnight. It takes time to reflect upon various experiences and co-ordinate their many implications before one can arrive at a new way of construing a problem. In addition, ethical reasoning and moral behaviour, as a whole, is an exceedingly complex phenomenon, and no single variable is sufficiently comprehensive to represent this.

   The present research added a new dimension by illuminating the role of religious knowledge in its plausible integration in the moral reasoning process. One way to do this was to incorporate scripture understanding as one of the ethical frameworks and explore its place and frequency of use in the reasoning process. We have noted the high number of references, both implicitly and explicitly to scriptural knowledge and/or understanding in the decision-making process. It was observed that a Christian worldview and Christian values, to an appreciable extent, shaped the attitude of students towards some aspects of biotechnology. This was helpful to the extent that it broadened our understanding as to how values and science education were integral towards a more holistic approach in developing scientific literacy and responsible citizenship.

However, it is inconclusive from the present study to establish a direct link between increased moral reasoning to a more developed content learning (scriptural knowledge/understanding). The limitation inherent in the design of the investigation did not permit a comparison with another class of similar aged students from, for example, a non-religious/different faith background.

6.7 Practical Implications and Recommendations for Further Research

First, research provided evidence that suggested that informal reasoning is related to the context of the socio-scientific scenarios. Even though all of the scenarios involved gene technology, the incidence of emotive and moral and intuitive reasoning seemed to vary among the scenarios. Rationalistic reasoning remained relatively high for all scenarios. So the *context* issue or the scenario is integral to the decision maker's negotiation of socio-scientific issues. This has educational implications concerning the type of socio-scientific issues used for socio-science education. To maximise the value in socio-scientific pedagogy, teachers ought to challenge students with questions that will highlight explicit connections to similar socio-scientific contexts.

In the use of informal reasoning by both comparison and experimental students, it was interesting to note that among all the three informal reasoning forms, the intuitive reasoning prevailed as the more commonly used form of informal reasoning than the rationalistic.

From the researcher's point of view it may be argued that rationalistic reasoning is not necessarily the superior form to other forms of reasoning such as intuitive or emotive because how we think is governed not only by our cognitive development but our emotional capacity to grasp and empathise, and relate to our previous experiences that are culturally conditioned and communally shaped since our childhood. Intuitive reasoning and emotive reasoning inevitably shape decisions which are primarily personal (although may affect immediate family circles) and integrally moral in nature. This may be suggested when comparing students' responses to the scenario on GM food with that of the IVF procedures.

Such an observation was consistent with studies conducted on cognitive style and judgement. One potentially relevant aspect of cognitive style is the extent to which individuals form their judgements intuitively, as opposed to reflection (Frederick, 2005; Haidt, 2001; Stanovich & West, 1998). By intuitive judgements, we mean judgements made with little effort based on automatic processes, and by reflective judgements, we meant judgements in which the judge pauses critically to examine the dictates of her intuition(s), thus allowing for less intuitive or counter-intuitive conclusion. Reflection is typically assumed to be more demanding than intuition, and the two processes have been studied to be competing components in a number of dual-process models (Evans, 2008; Kahneman, 2003).

The creation of alternative ethical frameworks in this research presented one such opportunity for reframing and shaping moral reasoning process. The importance of providing alternative frameworks and multiple perspectives resonates in a number of research studies (Eastwood, et al., 2011; France, Mora & Bay, 2012; Gorman, 1977; McClelland, 2010; Tal & Hochberg, 2003; Sampson, et.al., 2011). This place for rationalistic and/or intuitive approach in moral reasoning will have implications for educational endeavours in creating suitable classroom environments for developing informal reasoning.

To determine how morality works, it may be recommended that one shifts attention towards the study of *intuitive* and *emotional* processes in decision making. In this respect, the present research could be extended further to study the implications of using intuitive and emotional forms of reasoning in relation to moral reasoning and/or ethical reasoning process.

Second, earlier studies on the relationship between religious knowledge and moral reasoning were conducted (Harris, 1981; Nelson, 2004; Rest, 1986). It is not clear from these studies whether cognitive ability is the causal factor in the relationship. It may be inferred that the reason religious knowledge is positively related to post-conventional moral reasoning is because of the common factor of general cognitive ability. So far, the design of these research studies does not provide evidence that teaching biblical content increases moral judgement ability. It is also difficult to narrow the complex and multi-dimensional variables of both religion and morality to

measurable, workable constructs. It would be interesting to compare the present research with a similar case study conducted in a non-religious setting.

The present study was conducted in a Christian college which provided the advantage of ensuring some degree of homogeneity in the faith aspects of our Christian values-based framework. Perhaps, this research can be taken in a further direction by exploring its effectiveness in a school setting with greater diversity in terms of religious values and/or in a more pluralistic context. This would provide interesting insights as to how faith, religiosity and pluralistic values can influence or shape the moral/ethical reasoning process. Such a research direction undertaken may have significant implications for both science education and Christian education.

6.8 Conclusion

Chapter 6 outlined the background to the present study, the objective and the distinctiveness before providing a brief summary of the thesis. This is followed by a summary of the findings of each of the three research questions based on both qualitative and quantitative data. The chapter then detailed the distinctive contributions, the limitations, the practical implications and recommendations for further study.

Overall, the research from the thesis supported and argued for the idea that effective use of ethical frameworks in the ethical reasoning process with socio-scientific issues served to engage students as well as help develop informal reasoning and decision-making skills.

In seeking to develop increasing ethical awareness and ethical reflection in the community of inquiry in socio-scientific education, it is vital that the teacher creates a classroom environment that facilitates collaboration and mutual exchange and respect for different viewpoints. The learning environment is one that is characterised by thoughtful deliberation and informed discussion so that issues are thoroughly explored and debating the issues form a basis for informed social decision making. In addition, encouraging students to reflect meta-cognitively on the

process of debate and the use of ethical frameworks to map out the reasoning/ argumentation process in which they are engaging is also an important part of teaching in socio-scientific education.

As to how best to achieve these stipulated objectives towards greater scientific literacy and citizenship in society, the present study presents but a small part of a gargantuan endeavour to extend an increasingly important science education research agenda. It is hoped that in a small but significant way, this study contributes towards the vision of making socio-scientific education more effective and engaging in dealing with the complexities of the modern, pluralistic and genomic society in this century.

References

Abd-El-Khalick, F., & Lederman, N.G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education*, 22, 665-701.

Abd-El-Khalick, F. (2006). Socio-scientific Issues in pre-college science classrooms. In D.L. Zeidler (Ed.). *The role of moral reasoning and discourse on socio-scientific issues in science education* (pp.41-61). Dordrecht: Springer.

Acar, O., Turkmen, L. & Roychoudhury, A. (2010).Student Difficulties in Socio-scientific Argumentation and Decision-making Research Findings: Crossing the borders of two research lines. *International Journal of Science Education* 32:9, 1191-1206.

Aikenhead, G.S. (1985). Collective decision making in the social context of science. *Science Education* 69, 453-475.

Aikenhead, G.S. (1986) The content of STS education. *STS Research Network Missive*, 2. 13-18.

Aikenhead, G.S. (1994). What is STS science teaching? In J. Solomon & G. Aikenhead (Eds.) *STS Education: International Perspectives in Reform* (pp.47-59). New York: Teachers College Press.

Aikenhead, G.S. (2000). Re-negotiating the culture of school science. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of research*. Buckingham: Open University Press.

Aikenhead, G.S. (2006). *Science education for everyday life: Evidence-based practice*. New York: Teachers' College Press.

Albe, V. (2008). Students' position and considerations of scientific evidence about a controversial socio-scientific issue. *Science & Education*, 17, 805-827.

Allchin, D. (1999). Values in Science: An educational perspective. *Science & Education*, 8, 1-12.

American Association for the Advancement of Science. (1990). *Science for all Americans*. New York: Oxford University Press,

Andrew, J., & Robottom, I. (2001). Science and ethics: some issues for education. *Science Education*, 85, 769-780.

Australian Curriculum, Assessment and Reporting Authority (2012). Australian Curriculum: Science. Retrieved 14 April 2012 from http://.www.australiancurriculum.edu.au/

Ayres, P., Sawyer, W., & Dinham, S. (2004). Effective teaching in the context of a grade 12 high-stakes external examination in New South Wales, Australia. *British Educational Research Journal*, 30 (1), 141-165.

Barab, S.A. , Sadler, T.D., Heiselt, C., Hickey, D.T.. & Zuiker, S. (2007). Relating narrative, inquiry and inscriptions: Supporting consequential play. *Journal of Science Education and Technology*, 16, 59-82.

Baumberger-Henry, M. (2005). Co-operative Learning and case study: Does the combination improve students' perception of problem-solving and decision making skills? *Nurse Education Today*, 25, 238-246.

Beauchamp, T.L. & Childress, J.F. (2001). *Principles of Biomedical Ethics* (5th Ed.). Oxford: Oxford University Press. Also refer to the website for the Four Principles Approach: http://www.ethics-network.org.uk/ethical-issues/ethical frameworks/ Retrieved on 9 Jan 2009.

Bell, R.L. (2004). Perusing Pandora's Box: Exploring the what, when and how of nature of science instruction. In L. Flick & N. Lederman (Eds.), *Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education.* Dordrecht: Kluwer Academic Publishers.

Bell, R.L. & Lederman, N.G. (2003). Understandings of nature of science and decision-making on science and technology based issues. *Science Education*, 87, 352-377.

Bell, R.L., Lederman, N,G. & Abd-El-Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching*, 37, 563-581.

Ben-David, Adi & Orion, N. (2012). Teacher's voices on integrating metacognition into science education. *International Journal of Science Education*, 1 – 33 ifFirst Article. http://dx.doi.org/10.1080/09500693.2012.697208. Accessed on 1 August 2012.

Bennett, J. Hogarth, S., Lubben, F., Campbell, B. & Robinson, A. (2010) Talking Science: The research evidence on the use of small group discussions in science. *International Journal of Science Education*, 32 (1), 69-95.

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Hillsdale, NJ: Lawrence Erlbaum.

Berkowitz, M.W. (1985) The role of discussion in moral education. In M.W. Berkowitz & F. Oser (Eds.) *Moral education: Theory and application* (pp.197-218). Hildale, NJ: Lawrence Erlbaum.

Berkowitz, M.W. (1997). The complete moral person: Anatomy and formation. In J.M. DuBois (Ed.) Moral issues in psychology: *Personalist contributions to selected problems*. New York: University Press of America.

Berkowitz, M.W. (2002). The science of character. In W. Damon (Ed.) *Bringing in a new era in character education* (pp.43-63), Stanford, CA: Hoover Institution Press.

Berland, L.K. & Reiser, B.J. (2009). Making sense of argumentation and explanation. *Science Education* 93, 26-55.

Berland, L.K. & Hammer, D. (2012). Students' framings and their participation in scientific argumentation. In M.S. Khine (Ed*.). Perspectives on Scientific Argumentation: Theory, Practice & Research (*pp.73-93). Dordrecht: Springer.

Berland, L.K. & Lee, V.R. (2010). Anomalous graph data and claim revision during argumentation. *Paper presented at the International Conference of the Learning Sciences*. Chicago, IL.

Berliner, D.C. (1986). In search of the expert pedagogue. *Educational Researcher*. 15 (7), pp.5 – 13.

Bersoff, D.M. (1999). Explaining ethical behaviour among people motivated to act pro-socially. *Journal of Moral Education*, 28, 413-428.

Biotechnology Australia (BTA) (1999). Developing Australia's biotechnology future: A discussion paper. Available online: http://isr.gov.uau/www.dyn/biotech.future/doc

Biotechnology Online School Resource and CD-Rom. Available online: http://www.biotechnologyonline.gov.au

Bingle, W.H. & Gaskell, P.J. (1994). Science literacy for decision making and the social construction of scientific knowledge. *Science Education* 72 (2), 185-201.

Blair, R.J.R. (1997). Affect and the moral-conventional distinction. *Journal of Moral Education*, 26, 187-196.

Boerwinkel, D.J. & Waarlo, A.J. (2009). *Rethinking Science Curricula in the Genomics Era.* Urecht, Netherlands: Urecht University, The Netherlands CD-Beta Press.

Bogeholz, S. & Barkmann, J. (2005). Rational choice and beyond: Handlungorientierende Komptetenzen fur den Umgang mit fakticscher und ethischer Komplexitat. In R.Klee, A, Sandmann, & H. Vogt. (Eds.). *Lehr –und Lernforschung in der Biologiedidaktik (* Vol. 2, p.211-224). Innsbruck, Austria: Studien Verlag.

Bourdieu, P. (1972). Esquisse d'une theorie de la practique. Geneve: Librairie Droz. (English translation: Outline of a theory of practice. Cambridge: Cambridge University Press, 1977).

Breckler, S.J. (1984). Empirical validation of affect, behaviour and cognition as distinct component of attitude. *Journal of Personality and Social Psychology*, 47, 1191-1205.

Brewer, J., & Hunter, A. (1989). *Multimethod research: A synthesis of styles*. Newbury Park, CA: Sage.

Brown, A.L., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J.C. (1993) Distributed expertise in the classroom. In G. Salomon (Ed.), *Distribution cognitions: Psychological and educational considerations* (pp.188-228). Cambridge, MA: Cambridge University Press.

Bruer, J.T. (1993). *Schools for thought*. Cambridge, Mass: The MIT University Press.

Bryce, T. & Gray, D. (2004). Tough acts to follow: The challenge to science teachers presented by biotechnological progress. *International Journal of Science Education* 26, 717-733.

Burns, R. B. (2000). *Introduction to Research Methods*. (4th Ed.). New South Wales, Australia: Longman.

Cajas, F. (1999). Public understanding of science: Using technology to enhance school science in everyday life. *International Journal of Science Education*, 21, 765 – 773.

Cassidy, E. & Kurfman, D. (1977). Decision making as purpose and process. In D. Kurfman (Ed.), *Developing decision making skills* (pp. 1 – 26). Arlington, VA: National Council for the Social Studies.

Cavagnetto, A. Hand, B.M., & Norton-Meier, L. (2010). The nature of elementary science discourse in the context of the science writing heuristic approach. *International Journal of Science Education*, 32(4), 427-449.

Chadwick, R., Kuhse, H., Landman, W.A., Schuklenk & Singer P. (Eds.).(2007). *The Bioethics Reader – Editors' Choice.* Oxford: Blackwell Publishing.

Cherryholmes, C.H. (1992). Notes on pragmaticism and scientific realism. *Educational Researcher*, 14, 13- 17.

Chin, C., & Osborne, J. (2010). Supporting argumentation through students' questions: Case studies in science classrooms. *The Journal of the Learning Sciences*, 19, 230-284.

Christie, R., J. Harvel, & Seidenberg, B. (1958). `Is F-scale irreversible?' *Journal of Abnormal and Social Psychology*, 56, 143-159.

Clark D.B. & Sampson, V. (2007). Personally-seeded discussions to scaffold online argumentation. *International Journal of Science Education*, 29(3), 253-277.

Coburn, W. (1993). Constructivism. Journal of Educational and Psychological Consultation, 4(1),105-112.

Cohen, L., Manion L. & Morrison, K. 7th Ed. (2011). *Research Methods in Education*. London & New York: Routledge Falmer.

Colby, A. & Kohlberg, L. (1987). The measurement of moral judgement: Theoretical foundations and research validation (Vol. 1). Cambridge: Cambridge University Press.

Conner, L. & Gunstone, R. (2004). Conscious knowledge of learning: accessing learning strategies in a final year high school biology class. *International Journal of Science Education*, 26(2), 1427-1444.

Conway, R. (2000). Ethical judgements in genetic engineering: The implications for technology education. *International Journal of Technology and Design Education*, 10, 239-254.

Cooper, P., & Mcintrye, D. (1996). Effective teaching and learning: Teachers' and students' perspectives. Buckingham: Open University Press.

Crawford, B.A. (2000). Embracing the essence inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, 37 (9), 916-937.

Creswell, J.W. & Plano Clark V.L. (2007). *Mixed Methods Research*. Thousand Oaks, California: Sage Publications Inc.

Cross, R.T. & Price, R.F. (1996). Science teachers' social conscience and the role of controversial issues in the teaching of science. Journal of Research in Science Teaching, 33, 319 – 333.

Crosthwaite, J. (2001). Teaching ethics and technology – what is required? *Science & Education*, 10, 97-105.

Crotty, M. (1998). The Foundations of Social Research: Meaning and Perspective in the Research Process. London: Sage Publications.

Curriculum Council of Western Australia (1998). Curriculum Framework for Kindergarten to Year 12 Education in Western Australia. Perth, WA: Curriculum Council of WA.

Davis, E.A. & Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher*, 34 (3), 3 – 14.

Davis, M. (1999). *Ethics and the university*. London: Routledge.

Dawson, V. (2000). *Factors influencing the successful teaching of bioethics in secondary school science.* Paper presented at the 31st annual conference of Australasian Science Education Research Association (ASERA) Fremantle, Western Australia, June 28-30, 2000.

Dawson, V. (2003). Effect of a Forensic DNA testing module on adolescents' ethical decision making abilities. *Australian Science Teachers' Journal* 49(4), 12-17.

Dawson, V. & Venville, G.J. (2009). High school students' informal reasoning and argumentation about biotechnology: an indicator of scientific literacy? *International Journal of Science Education* 31 (11), 1421-1445.

Dawson, V. (2011). A case study of the impact of introducing socio-scientific issues into a reproduction unit in a Catholic Girls' School. In Troy D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press.

Driver, R., Leach, J., Millar R., & Scott, P. (1996). *Young people's images of science*. Philadelphia, PA: Open University Press.

Driver, R., Newton, P. & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84(3), 287-312.

Duit, R. & Treagust, D. (1998). Learning in Science – from behaviourism towards social constructivism and beyond. In B. J. Fraser and K.G. Tobin (Eds.). I*nternational Handbook of Science Education, Part 1*: Kluwer Academic Publishers, Dordrecht.

Eagly, A.H., & Chaiken, S. (1993*). The psychology of attitudes.* New York: Harcourt College Publishers.

Eastwood, J.L., Schlegel, W.M. & Cook, K.L. (2011). Effects of an inter-disciplinary program on students' reasoning with socio-scientific issues and perceptions of their learning experiences. In Troy D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press.

Eggert, S. & Bolgeholz, S. (2006). Gottinger Modell der Bewertungskompetenz-Teikompetenz "Bewerten, Entscheiden und Reflektieren" fur Gestualtungsaufgaben Nachhaltiger Entwicklung. *Zeitschrift fur Didaktik der Naturwissenschaften*, 12, 177-199.

Eggert, S. & Bogeholz, S. (2009). Students' use of decision making strategies with regard to socio-scientific issues: an application of the Rasch partial credit model. *Science Education* 94, 230-258.

Eisenhart, M.A. & Howe, K.R. (1992). Validity in educational research. In M.D. LeCompte, W.L. Milroy and J. Preissle (Eds.). *The Handbook of Qualitative Studies in Education*. New York: Academic Press, 643-680.

Ekborg, M. (2008). Opinion building on a socio-scientific issue. The case of genetically modified plants. *Journal of Biological Education*, 42 (2), 60-65.

Emig, J. (1977). Writing as a mode of learning. *College Composition and Communication*, 28, 122-128.

Endicott, L., Bock, T. & Narvaez, D. (2002). *Learning processes at the intersection of ethical and intercultural education. P*aper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Erduran, S. , Simon, S. & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education* 88 (6), 915-933.

Ertmer, P. & Newby, T. (1993). Behaviourism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, 6(4), 50-72.

Evans, J.H. (2002). Playing God? Human genetic engineering and the rationalisation of public bioethical debate. Chicago: University of Chicago Press.

Evans, J.S. B.T. (2008). Dual-processing accounts of reasoning, judgement, and social cognition. *Annual Review of Psychology*, 59, 255-278. doi:10.1146/annurev.psych.59.103006.093629

Fensham, P.J. (2002). Time to change drivers for scientific literacy. *Can J Sci Math Tech Educ* 1:9-24.

Fensham, P.J. (2009). Real world contexts in PISA Science: Implications for context-based science education. *Journal of Research in Science Teaching*, 46(8), 884-896.

Ford, M. & Lowery, C. (1986). Gender differences in moral reasoning: A comparison of the use of justice and care orientations. *Journal of Personality and Social Psychology*, 50, 777-783.

Fowler, S.R., Zeidler, D.L., & Sadler, T.D. (2009). Moral sensitivity in the context of socio-scientific issues in high school science students. *International Journal of Science Teacher education*, 31(2), 279-296.

Finocchiaro, M.A. (2005). Arguments about arguments. Systematic, critical and historical essays in logical theory. New York: Cambridge University Press.

Fleming, R. (1986). Adolescent reasoning in socio-scientific issues, Part I: Social cognition. *Journal of Research in Science Teaching*, 23, 677-687. Part II: Non-social cognition, 689-698.

France, B. (2007). Location, Location, Location: Positioning Biotechnology Education for the 21st Century. *Studies in Science Education*, 43(1), 88-122.

France, B., Mora, H.A. & Bay, J.L. (2012). Changing Perspectives: Exploring a pedagogy to examine other perspectives about stem cell research. *International Journal of Science Education* 35(5), 803-824.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19, 25 -42. doi: 101257/089533005775196732

Friedman, W., Robinson, A. & Friedman, B. (1987). Sex differences in moral judgements? A test of Gilligan's theory. *Psychology of Women Quarterly*, 11, 37-46.

Garcia-Mila, M. & Anderson, C. (2007). Developmental change in note-taking during scientific inquiry. *International Journal of Science Education*, 29, 1035-1058.

Garcia-Mila, M. & Anderson, C. (2008). Cognitive Foundations of Learning Argumentation. In S. Erduran & M. P. Jimenez-Alexandre (Eds.) *Argumentation in science education: Perspectives from Classroom-Based Research* (pp.29-45). Dordrecht: Springer.

GTEC – Gene Technology Ethics Committee, Australia. Available online: http://www.ogtr.gov.au/ committee/gtec.htm.

GM Act 2000 - Gene Technology Act 2000, Australia. Available online: http://www.comlaw.gov.au

Geddis, A.N. (1991). Improving the quality of science classroom discourse on controversial issues. *Science Education*, 75, 169-183.

George, R. & Kaplan, D. (1998). A structural model of parent and teacher influences of attitudes of eighth graders: Evidence from NELS: 88. *Journal of Research in Science* 82, 93-109.

Gilligan, C. (1982). *In a different voice: Psychological theory and women's development*. Cambridge, MA: Harvard University Press.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*. Canberra, Australia: Department of Education, Training and Youth Affairs.

Gorman, M. (1977). Moral and faith development in seventeen-year-old students. *Religious Education* 72:5, 491-504.

Grace, M.M. & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education*, 24, 1157-1169.

Gray, P. (1999). *Psychology*. (3rd Ed.). New York: Worth Publishers.

Greene, J.C. & Caracelli, V.J. (1997). Advances in Mixed-Method Evaluation: The Challenges and Benefits of Integrating Diverse Paradigms. San Francisco: Jossey-Bass Publishers.

Guba E.G. and Lincoln Y.S. (1989). *Fourth Generation Evaluation*. California: Sage Publications Inc.

Haidt, J. (2001). The emotional dog and its rational tail: A social intuitionist approach to moral judgement. *Psychological Review*, 108, 814-834.

Haker, H. & Beyleveld, D. (2000). *The ethics of genetics in human procreation*. Aldershot, UK: Ashgate.

Hall, S. (1996). Reflexivity in emancipator action research: illustrating the researcher's constitutiveness. In O.Zuber-Skerritt (Ed.) *New Directions in Action Research*. London: Falmer, 26-48.

Hall, A., Reiss, M. & Scott, A. (Eds.) (2002). *Salters-Nuffield Advanced Biology AS Student Book 1*. Pilot Edition. Heinemann: Oxford.

Halliday, M.A.K., & Martin, J.R. (1993). *Writing science: Literacy and discursive power*. Pittsburgh, PA: University of Pittsburgh Press.

Halverson, K.L., Siegel, M.A., & Freyermuth, S.K. (2009). Lenses for framing decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education*, 18(2). 1 – 8.

Hammersley, M. & Atkinson, P. (1983). *Ethnography: Principles in Practice*. London: Routledge.

Harris, A.T. (1981). "A Study of the Relationship between Stages of Moral Development and the Religious Factors of Knowledge. Belief and Practice in Catholic High School Adolescents." *Dissertation Abstracts International 42:* 638A-639A (University Microfilms no. 8116131).

Harris, R., & Ratcliffe, M. (2005). Socio-scientific issues and the quality of exploratory talk – what can be learned from schools involved in a `collapsed day' project? *The Curriculum Journal*, 16, 439 – 453.

Hauerwas, S. (1981). A Community of Character: Towards a Constructive Christian Social Ethic. Notre Dame, IN: University of Notre Dame Press.

Hauerwas, S. (1984) The Peacable Kingdom: A Primer in Christian Ethics. London: SCM Press.

Hays, R.B. (1997). *The Moral Vision of the New Testament*. Edinburgh: T & T Clark.

Hekman, S.J. (1995). *Moral voices, moral selves: Carol Gilligan and feminist moral theory*. University Park, PA: The Pennsylvania State University Press.

Hodgkin, R.A. (1985). *Playing and Exploring – Education through the discovery of order*. London: Methuen.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, 25, 645-670.

Hoffman, M.I. (2000). Empathy and moral development: Implications for caring and justice. Cambridge: Cambridge University Press.

Hogan, K. (1999). Thinking aloud together: A test of an intervention to foster students' collaborative scientific reasoning. *Journal of Research in Science Teaching*, 36 (10), 1085-1109.

Hogan, K. (2002). Small groups' ecological reasoning while making an environmental management decision. *Journal of Research in Science Teaching*, 39, 341-368.

Hogan, K. & Maglienti, M. (2001). Comparing the epistemological underpinnings of students' and scientists' reasoning about conclusions. *Journal of Research in Science Teaching*, 38, 663-687.

Hogge, J., and S.T. Friedman (1967). The scriptural literalism scale: A preliminary report. *Journal of Psychology* 66, 275-279.

Holy Bible. (1994). New King James Version. Nashville: Thomas Nelson Publishers.

Holly, M.L. (2002). 2nd Ed. *Keeping a Professional Journal*. University of New South Wales, Australia: UNSW Press in association with Deakin University Press.

Hong, J.L. & Chang, N.K. (2004). Analysis of Korean high school students decision-making process in solving a problem involving biological knowledge. *Research in Science Education*, 34, 97-111.

Hunt, L., Fairweather, J. & Coyle, F. (2003). Public understandings of biotechnology in New Zealand: factors affecting the acceptability rankings of five selected biotechnologies. Research Report No. 266, December 2003. Christchurch: Agribusiness and Economics Research Unit (AERU), Lincoln University.

Hunsberger, B. (1989). A short version of the Christian Orthodoxy Scale. *Journal for the Scientific Study of Religion* 28:3, 360-365.

Hyden, R.H. & Bulow, P.H. (2003). Who's talking: drawing conclusions from focus groups- some methodological considerations. I*nternational Journal of Social Research Methodology*, 6(5), 305-321.

Jennings, F.L. (1972). A Note on the Reliability of Several Belief Scales. *Journal for the Scientific Study of Religion* 11.2, 157-164.

Jimenez-Aleixandre, M.P., Rodriguez, A.B., & Duschl, R.A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education*, 84, 757-792.

Jimenez-Aleixandre, M.P. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education*, 24 (11), 1171-1190.

Jimenez-Aleixandre, M.. (2008). Designing argumentation learning environments. In S. Erduran & M.P. Jimenez-Aleixandre (Eds.). *Argumentation in science education: Perspectives from classroom-based research* (pp.91-115) Dordrecht, the Netherlands: Springer.

Jimenez-Aleixandre, M.P., & Erduran, S. (2008). Argumentation in science education: an overview. In S. Erduran & M. Jimenez-Alexandre (Eds.) *Argumentation in science education* (pp.3-27). Dordrecht, the Netherlands: Springer.

Johnson, B. & Christensen, L. (2008). *Educational Research: Quantitative, Qualitative and Mixed Approaches.* 3rd Ed. Thousand Oaks, California: Sage Publications Inc.

Johnson, R.B. & Onwuegbuzie, A.J. (2004). Mixed methods research: a research paradigm whose time has come. *Educational Researcher* 33 (7) 14 -26.

Jones, A., McKim, A., Reiss, M., Ryan B., Buntting, C. Saunders, K. et.al. (2007). *Research and development of classroom-based resources for bioethics education in New Zealand.* Hamilton, NZ: Wilf Malcolm Institute of Education Research, School of Education, University of Waikato.

Jones, A., McKim, A. & Reiss, M. (Eds.).(2010). Ethics in the Science and Technology Classroom – A New Approach to Teaching and Learning. Rotterdam: Sense Publishers.

Jorgensen, L.M., & Ryan, S.A. (2004). Relativism, values and morals in the New Zealand Curriculum Framework. *Science & Education*, 13, 223-233.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist*, 58, 697-720. doi:10.1037/0003-66X.58.9.697

Katz, D. & Stotland, E. (1959). A preliminary statement to a theory of attitude structure and change. In S. Koch (Ed.). *Psychology: A Study of a Science* (Vol.3, 423-475). New York: McGraw-Hill.

Kaufer, D. & Geisler, C. (1990). Structuring argumentation in a social constructivist framework: A pedagogy with computer support. *Argumentation* 4 (4), 379-396.

Keefer, M.W. (2002). Designing reflections on practice: Helping teachers apply cognitive learning principles in SFT- inquiry based learning program. *Interchange: A Quarterly Review of Education* 33 (4), 395-417.

Keefer, M.W. (2003). Moral reasoning and case-based approaches to ethical instructions in science. In D.L. Zeidler (Ed.), *The role of moral reasoning on socio-scientific issues and discourse in science education.* Dordrecht: Kluwer Academic Press.

Keefer, M.W., Zietz, C.M., & Resnick, L.B. (2000). Judging the quality of peer-led student dialogue. *Cognition and Instruction*, 18 (1), 55-83.

Kemmis, S (1994). Action Research. In T. Husen & T.N. Postlethwaite (Eds.) *International encyclopaedia of education* (2nd Ed. Pp.42-49). Oxford and New York: Pergamon and Elsevier Science.

Kenyon, L.O., Kuhn, L., & Reiser, B.J. (2006). Student epistemologies of science to guide the practice of argumentation. In S.A. Barab, K.E. Hay, & D.T. Hickey (Eds.), *7th annual international conference of the learning sciences* (pp.321-327) Mahwah, NJ: Lawrence Erlbaum Associates.

Killen, M. Leviton, M. & Cahill, J. (1991). Adolescent reasoning about drug use. *Journal of Adolescent Research* 6, 336-356.

King, M., and R.A. Hunt (1970). *Religion, prejudice and cognitive style*. Unpublished paper.

King, P. M. & Kitchener, K.S. (Eds.). (1994). *Developing reflective judgement: Understanding and promoting intellectual growth and critical thinking in adolescents and adults* (pp.65-84). San Francisco, CA: Jossey-Boss.

Klein, P.D. (2000). Elementary students' strategies for writing –to-learn in science. *Cognition and Instruction,* 18, 317-348.

Klop, T. (2009). Attitudes of secondary school students towards modern biotechnology. Rotterdam: Optima Grafische Communicatie.

Kneupper, C.W. (1981). Argument: a social constructivist perspective. *Journal of the American Forensic Association*, 17(4), 183-189.

Kolsto, S.D. (2000). Consensus Projects: Teaching science for citizenship. *International Journal of Science Education* 6,645-664.

Kolsto, S.D. (2001a). Science Literacy for Citizenship: Tools for dealing with the Science dimension of controversial socio-scientific issues. *Science Education* 85, 291-310.

Kolsto, S.D. (2001b) `To trust or not to trust…' Pupils' way of judging information encountered in a socio-scientific issue. *International Journal of Science Education* 23, 877-901.

Kolsto, S.D. (2006). Patterns in students' argumentation confronted with a risk-focussed socio-scientific issue. *International Journal of Science Education*, 28 (14), 1689-1716.

Kolsto, S.D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., Mestad, I.,Quale, A., Tonning A.S.V., Ulvik, M. (2006). Science students' critical examination of scientific information related to socio-scientific issues. *Science Education* 90, 632-655.

Kolsto, S.D. & Ratcliffe, M. (2008). Social aspects of argumentation. In S. Erduran & M. P. Jimenez-Alexandre (Eds.) *Argumentation in science education: Perspectives from Classroom-Based Research* (pp.117-136). Dordrecht: Springer.

Koenig, H., Parkerson, Jr., G., & Meador, K. (1997). *Religion index for psychiatric research*. American Journal of Psychiatry, 154.

Kortland, K. (1996). An STS case study about students' decision making on waste issue. *Science Education*, 80(6), 673-689.

Korpan, C.A., Bisanz, G.L., Bisanz, J., & Henderson, J.M. (1997). Assessing literacy in science: Evaluation of scientific news briefs. *Science Education*, 81, 515-532.

Kubli, F. (2005). Science Teaching as Dialogue – Bakhtin, Vygotsky and some applications in the classroom. *Science and Education* 14, 501-534.

Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. Science Education, 77:319-337.

Kuhn, D. (2005). Education for thinking. Cambridge, MA: Harvard University Press.

Kuhn. D., Garcia-Mila, M., Kohar, A., & Andersen, C. (1995). Strategies of knowledge acquisition. *Monographs of the Society for Research in Child Development*, 60 (4, Serial No. 245).

Kuhn, D. & Udell, W. (2007). Co-ordinating own and other perspectives in argument. *Thinking and Reasoning*, 13(2), 90 – 104.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

LeCompte, M. & Preissle, J. (1993). *Ethnography and Qualitative Design in Educational Research* (2nd ed.). London: Academic Press.

Lee, H., Chang, H., Choi, K., Kim S-W. & Zeidler, D.L. (2012). Developing character and values for global citizens: analysis of pre-service science teachers' moral reasoning on socio-scientific issues. *International Journal of Science Education* 34 (6), 925-953.

Lee, M. (2007). Developing decision making skills for socio-scientific issues. *Journal of Biological Education* 41 (4), 170-177.

Lemke, J.L. (1990). Talking science: Language, learning and values. Norwood, NJ: Ablex.

Levinson, R. (1994). *Teaching Science*. London: Open University Press.

Levinson, R. (2003, March). *Teaching bioethics in science: Crossing a bridge too far?* Paper presented at the Annual Meeting of the National Association of Research in Science Teaching, Philadelphia, PA.

Levinson, R. (2004). Teaching bioethics in science: Crossing a bridge too far? *Canadian Journal of Science, Mathematics and Technological Education*, 4, 353-370.

Levinson, R. & Reiss, M. (Eds.) (2003). *Key Issues in bioethics: A guide for teachers*. London: Wellcome Trust. www.wellcome.ac.uk

Levinson, R. (2006). Towards a theoretical framework for teaching controversial socio-scientific issues. *International Journal of Science Education*, 28, 1201-1224.

Levinson, R. (2008). Promoting the role of the personal narrative in teaching controversial socio-scientific issues. *Science & Education*, 17, 855-871.

Lewis, J.M. (Ed.). (1997). *Understanding of basic genetics and DNA technology*. University of Leeds. Learning in Science Research Group, Leeds, UK – Working Paper 2.

Lewis, J. & Leach, J. (2006). Discussion of socio-scientific issues: The role of science knowledge. *International Journal of science Education* 28 (11), 1267-1287.

Lincoln, Y.S. & Guba, E.G. (1985). *Naturalistic Inquiry.* Beverley Hills, California: Sage Publications Inc.

Lincoln, Y.S. & Guba, E.G. (1990). *Naturalistic Inquiry*. California: Sage Publications Inc.

Lock, R., Miles, C. & Hughes, S. (1995). The influence of teaching on knowledge and attitudes in biotechnology and genetic engineering contexts: Implications for teaching controversial issues and the public understanding of science. *School Science Review 76* (276), 45-59.

Loving, C.C. & Foster, A. (2000). The religion-in-the-science-classroom issue: Seeking graduate student conceptual change. *Science Education*, 84, 445-468.

Loving, C.C, Lowry, S.W. & Martin, C. (2003). Recognising and solving ethical dilemmas in diverse science classrooms. In D.L. Zeidler (Ed.), *The role of moral reasoning and discourse on socio-scientific issues in science education (*pp.183-194). Dordrecht, The Netherlands: Kluwer Academic Press.

Lumpe, A.T., Haney, J.J., & Czerniak, C.M. (1998). Science teacher beliefs and intentions to implement science-technology-society (STS) in the classroom. *Journal of Science Teacher Education*, 9, 1 – 24.

Magolda, M.B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Massarani, L. and Moreira, I. Castro (2005). Attitudes towards genetics: A case study among Brazilian high school students. *Public Understanding of Science*, 14, 201-212.

Martin, A.M. & Hand, B. (2009) Factors affecting the implementation of argument in the elementary science classroom. A longitudinal case study. *Research in Science Education*,39, 17-38.

McClelland, R.T. (2010). Moral education: Too little, too late? *Christian Scholar's Review* 39:4, 439-456.

McComas, W.F., Clough, M.P., & Almazroa, H. (2000). The role and character of the nature of science in science education. In W.F. McComas (Ed.) *The nature of science in science education: Rationales and strategies (*pp.41-52). Dordrecht: Kluwer.

McLean, M. (1952). Religious world views. *Motive* 12, 22-26.

McNeill, K.L., & Krajcik, J. (2007). Middle school students' use of appropriate and inappropriate evidence in writing scientific explanations. In M. Lovett & P. Shah (Eds.). *Thinking with data: The proceedings of the 33rd Carnegie symposium on cognition* (pp.233-265). Mahwah, NJ: Taylor and Francis.

McNeill, K.L. & Pimentel, D.S. (2010). Scientific Discourse in Three Urban Classrooms: The Role of Teacher in Engaging High School Students in Argumentation. *Science Education* 94, 203-229.

McNiff, J. (2002*). Action Research for Professional Development: Concise Advice for New Action Researchers* (3rd Ed.). Retrieved 20 April 2013, from www.jeanmcniff.com/booklet1.html

McSharry, G., & Jones, S. (2000). Role-play in science teaching and learning. *School Science Review* 82 (298), 73-82.

Meilaender, G. (2005). *Bioethics: A Primer for Christians.* Grand Rapids, Michigan: William B. Eerdmans.

Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass Publishers.

Merton, R.K., Fiske, M., & Kendall, P.L. (1990). *The focused interview: A manual of problems and procedures* (2nd Ed.). New York: Free Press.

Messner, N. (2006). *SCM Study Guide to Christian Ethics*. London: SCM Press.

Millar, R. (1996). Towards a science curriculum for public understanding. *School Science Review* 77(280), 7 – 18.

Millar, R. & Osborne, J. (Eds.) (1998). *Beyond 2000: Science education for the future.* London: School of Education, King's College.

Mills, G.E. (2000). *Action Research: A Guide for the Teacher Researcher*. Upper Saddle River, New Jersey: Merrill/Prentice Hall.

Molinattia, G., Giraulta, Y., & Hammond, C. (2010). High School Students Debate the Use of Embryonic Stem Cells: The Influence of Context on Decision-Making. *International Journal of Science Education*, 32 (16) 2235-2251.

Morgan. D.L. (1988). *Focus Groups as Qualitative Research*. Beverly Hills, CA: Sage.

Murphy, J.P., with Rorty, R. (1990). *Pragmatism: from Peirce to Davidson*. Boulder, CO: Westview.

National Curriculum Framework Core Values for Australian Schooling: The National Curriculum Board (2010). The Shape of the National Curriculum: National Declaration on Educational Goals for Young Australians, 10. www.ncb.org.au

National Science Standards Committee (2002). *National professional standards for highly accomplished teachers of science*. Melbourne: The Australian Science Teachers Association and Monash University.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Nelson, D. (2004).Bible Knowledge and Moral Judgement: Knowing Scripture and Using Ethical Reasoning. *Journal of Research on Christian Education* 13:1, 41-57.

Netherlands Genomics Initiative (2007). *NGI Business Plan 2008-2012: NGI reaps the benefits of genomics.* Available at http://www.genomics.nl/Home/Publications.aspx.

Newton, P., Driver, R. and Osborne, J. (1999). The place of argumentation in pedagogy of school science. *International Journal of Science Education*, 21 (5). 553-576.

Nucci, L. & Turiel. (1993). God's word, religious rules, and their relation to Christian and Jewish children's concepts of morality. *Child Development*, 64, 1475-1491.

Nucci, L.P. (2001). *Education in the moral domain*. Cambridge, UK: Cambridge University Press.

Onwuegbuzie, A.J. & Leech, N.L. (2006) Validity and qualitative research: an oxymoron? *Quality and Quantity* 41 (2), 233-249.

Osana, H.P., Tucker, B.J., & Bennett, T. (2003). Exploring adolescent decision making about equity: Ill-structured problem solving in social studies. *Contemporary Educational Psychology* 28 (3), 357-383.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R. And Duschl, R. (2003). What `Ideas-about-Science' should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching* 40(7), 692-720.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, 41 (10), 994 – 1020.

Oulton, C., Dillon. J., Grace, M.M. (2004). Reconceptualising the teaching of controversial issues. *International Journal of Science Education* 26(4), 411-423.

Passmore, C.M. & Svoboda, J. (2012). Exploring opportunities for argumentation in modelling classrooms. *International Journal of Science Education* 34(10),. 1535-1554.

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods*. 3rd Ed. Thousand Oaks, California: Sage Publications Inc.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision making on socio-scientific issue: Implications for teaching. *International Journal of Science Education*, 21, 745-754.

Pedretti, E. (1999). Decision making and STS education: Exploring scientific knowledge and social responsibility in schools and science centres through an issues-based approach. *School of Science and Mathematics*, 99, 174-181.

Pedretti, E. (2003). Teaching science, technology, society and environment and science education (STSE) education: Pre-service teachers' philosophical and pedagogical landscapes. In D.L. Zeidler (Ed.), *The role of moral reasoning on socio-scientific issues and discourse in science education*. Dordrecht: Kluwer Academic Press.

Perry, B. & Dockett, S. (1998). Play, argumentation and social constructivism. *Early Child Development and Care*, 140 (1), 5-15.

Perry, W.G. (1979). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehard & Winston.

Picoult, J. (2004). *My Sister's Keeper*. Crows Nest, Australia: Allen & Unwin.

Pool, R. (1991). *Science literacy: The enemy is us*. Science, 251, 266-267.

Prain, V. & Hand, B. (1996). Writing for learning in secondary school science: Rethinking practices. *Teaching and Teacher Education*, 12, 609-626.

Preece, G.R. (Ed.) (2002). Rethinking Peter Singer. London: InterVarsity Press. p. 144

Rae, S.B. & Cox, P.M. (1999). *Bioethics: A Christian Approach in a Pluralistic Age*. Grand Rapids, Michigan: William B. Eerdmans Publishing Company. pp.74-78, 87.

Rae, S.B. 3rd Ed. (2009). *Moral Choices – An Introduction to Ethics*. Grand Rapids, Michigan: Zondervan.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education*, 19, 167-182.

Ratcliffe, M. & Grace, M. (2003). *Science education for citizenship: Teaching socio-scientific issues.* Philadelphia, PA: Open University Press.

Roberts, D.A. (2007). Scientific literacy/science literacy. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education* (pp.729-780). Mahwah, NJ: Lawrence Erlbaum Associates.

Rest, J.R.(1979). The impact of higher education on moral judgement development. *Moral Research Projects Technical Report No. 5* (Minneapolis, MN: University of Minnesota).

Rest, J.R. (1986). *Moral Development: Advances in Research* and Theory. New York: Praeger.

Reiser, B., Tabak, L., Sandoval, W.A., Smith, B.K., Steinmuller, F., & Leone, A.J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms. In S.M. Carver & D. Klahr (Eds.). *Cognition and instruction: Twenty five years of progress* (pp.263-305). Mahwah, NJ: Erlbaum.

Reiss, M. (1993). *Science Education for a Pluralist Society*. Buckingham: Open University Press.

Reiss, M. (1999). Teaching ethics in science. Studies in Science Education, 34, 115-140.

Reiss, M. (2003). How we reach ethical conclusions. In R. Levinson & M. Reiss (Eds.). *Key Issues in Bioethics (pp.14-23)*. London & New York: Routledge Falmer.

Reiss, M. (2008). The use of ethical frameworks by students following a new science course for 16 – 18 year-olds. *Science and Education*, 17, 889-902.

Remillard, J.T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, 75(2), 211-246.

Ritchie, S.M., Tomas, L. & Tones, M. (2011). Writing stories to enhance scientific literacy. *International Journal of Science Education* 33:5, 685-707.

Rivard, L.P. (1994). A review of writing-to-learn in science: Implications for practice and research. *Journal of Research in Science Teaching*, 31, 969-983.

Rubin, H.J. & Rubin, I.S. (1995). *Qualitative interviewing: the art of hearing data.* Thousand Oaks, CA: Sage.

Sadler, T.D. (2004) Informal reasoning regarding socio-scientific issues. A critical review of research. *Journal of Research in Science Teaching,* 41, 513-536.

Sadler, T.D. (2009). `Situated learning in science education: socio-scientific issues as contexts for practice,' *Studies in Science Education* 45:1, 1- 42.

Sadler, T.D. (2011). `Situating socio-scientific issues in classrooms as a means of achieving goals of science education.' In Troy D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press. 1-9.

Sadler, T.D., Chambers, F.W., & Zeidler, D.L. (2002). Investigating the crossroads of the nature of science, socio-scientific issues, and critical thinking. *Paper presented at the Annual meeting of the National Association for Research in Science Teaching. New Orleans,* LA.

Sadler, T.D., Chambers, F.W. and Zeidler, D.L. (2004). Student conceptualisations of the nature of science in response to a socio-scientific issue. *International Journal of Science Education* 26 (4), 387-409.

Sadler, T.D. & Zeidler, D. (2003). The Morality of Socio-scientific Issues: Construal and Resolution of Genetic Engineering Dilemmas. *Science Education* 88, 4-27.

Sadler, T.D. & Zeidler, D. (2004). The morality of socio-scientific issues: construal and resolution of genetic engineering dilemmas. *Science Education* 88, 4-27.

Sadler, T.D. & Zeidler, D. (2005a). Patterns of Informal Reasoning in the context of socio-scientific decision making. *Journal of Research in Science Teaching*, 42 (1), 112-138.

Sadler, T.D. & Zeidler, D. (2005b). The significance of content knowledge for informal reasoning regarding socio-scientific issues: applying genetics knowledge to genetic engineering issues. *Science Education* 89, 71-83.

Sadler, T.D., & Donnelly, L.A. (2006). Socio-scientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education* 28, 1463-1488.

Sadler, T.D., Barab, S.A., & Scott, B. (2007). What do students gain by engaging in socio-scientific inquiry? *Research in Science Education*, 37(4), 371-391.

Saltzstein, H.D. (1994). The relation between moral judgment and behaviour: A social-cognitive and decision-making analysis. Human Development, 37, 299-312.

Salters-Nuffield Advanced Biology Book (2002). Michael Reiss & Angela Hall. Institute of Education, University of London. http://www.advancedbiology.org. Retrieved on 22 Dec 2008. 93-94.

Sampson, V. & Clark, D. (2009). The effect of collaboration on the outcomes of argumentation. *Science Education*, 93(3), 448-484.

Sampson, V., Simon, S., Amos, R. & Evagorou (2011). Metalogue : Engaging students in scientific and socio-scientific argumentation. In Troy D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press. 193-199.

Sandoval, W.A. & Reiser, B.J. (2004). Explanation driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education* 88 (3), 345-372.

Saunders, K. J. & Rennie, L.J. (2013). A pedagogical model for ethical inquiry into socio-scientific issues in science. Research in Science Education 43 (1), 253-274.

Schallies, M. & Solterer, A. (1992). Working Group 2.4. Evaluation of dissemination and implementation of EIBE material – How are the students in the region between the Rhine and the Neckar coping with the new study resources in biotechnology? A study in the framework of the `European Initiative for Biotechnology Education' (EIBE).

Schneewind, J.B. (1998). *The invention of autonomy: A history of modern moral philosophy.* Cambridge, HK: Cambridge University Press.

Seethaler, S., & Linn, M. (2004). Genetically modified food in perspective: An inquiry-based curriculum to help middle school students make sense of tradeoffs. *International Journal of Science Education*, 26 (14), 1765-1785.

Shape of the Australian Curriculum (2009). Australian Policy Online Website. Retrieved Jan 2, 2011 from http://apo.org.au/research/shape-australian-curriculum-science.

Shure, G.H., and R.J. Meeker (1965). *A personality/ attitude schedule for use in experimental bargaining studies*. TM-25-43. Santa Monica, California: System Development Corporation.

Siebert, E.D. & McIntosh, W.J. (Eds.). (2001). *College pathways to the science education standards.* Arlington, VA: NSTA Press.

Siegel, M.A. (2006). High school students' decision making about sustainability. *Environmental Education* 19(2), 166-189.

Simmonneaux, L. (2001). Role-play or debate to promote students' argumentation and justification on an issue in animal transgenesis. *International Journal of Science Education*, 23(9), 903-927.

Simmonneaux, L. (2002). Analysis of classroom debating strategies in the field of biotechnology. *Journal of Biological Education*, 37(1), 9-12.

Simon, S. Erduran, S., & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education*, 28 (2-3), 253-260.

Singer, M.S. (1999). The role of concern for others and moral intensity in adolescents' ethicality judgements. *The Journal of Genetic Psychology*, 160, 155-166.

Smetana, J. (1989). Toddler's social interactions in the context of moral and conventional transgressions in the home. *Developmental Psychology*, 60, 1052-1067.

Sprod, T. (2011). *Discussions in Science.* Victoria, Australia: ACER Press.

Stake, R.E. (1994). Case studies. In N.K. Denzin and Y.S. Lincoln (Eds.). *Handbook of Qualitative Research. L*ondon: Sage, 236-247.

Stake, R.E. (1995). *The Art of Case Study Research*. Thousand Oaks, CA: Sage.

Stanovich, K.E., & West, R.F. (1998). Individual differences in rational thought. *Journal of* Experimental Psychology. General, 127, 161 – 188. doi: 10.1037/0096-3445.127.2.161

Stock, G. & Campbell, J. (2000). Engineering the human germline: An exploration of the science and ethics of altering the genes we pass to our children. New York: Oxford University Press.

Stott, J. 4th Ed. (2006). *Issues Facing Christians Today*. Grand Rapids, Michigan: Zondervan.

Suthers, D., Toth, E.E. & Weiner, A. (1997). *An integrated approach to implementing collaborative inquiry in the classroom.* 2nd International Conference on Computer Supported Collaborative Learning (pp.272-279). Toronto, Ontario, Canada: University of Toronto.

Swanborn, P. G. (2010). *Case Study Research – what, why and how?* London: Sage Publications Ltd.

Tal, R. & Hochberg, N.(2003). Assessing high order thinking of students participating in the `WISE' project in Israel. *Studies in Educational Evaluation*, 29:69–89.

Tashakkori A. & Teddlie, C. (2003). *Handbook of Mixed Methods in Social and Behavioural Research.* Thousand Oaks, California: Sage Publications Inc.

Teddlie, C. & Tashakkori, A. (2009). Foundations of Mixed Methods Research. Thousand Oaks, CA: Sage.

Teixeira Dos Santos, F.M. & Mortimer, E.F. (2003). How emotions shape the relationship between a chemistry teacher and her high school students. *International Journal of Science Education*, 25(9), 1095-1110.

Thiessen, M. & Wells, S. (Eds.). (2000). Faithfulness and Fortitude in Conversation with the Theological Ethics of Stanley Hauerwas. Edinburgh: T & T Clark.

Tisak, M. (1995). Domains of social reasoning and beyond. *Annals of Child Development*, 11, 95-130.

Tisak, M., & Turiel, E. (1988). Variation in seriousness of transgressions and children's moral and conventional concepts. *Developmental Psychology*, 24, 353-357.

Tobin, K. & Fraser, B.J. (1990). What does it mean to be an exemplary science teacher? *Journal of Research into Science Teaching*, 27 (1), 3 – 25.

Topcu, M.S., Sadler, T.D. & Yilmaz-Tuzun, O. (2010). Pre-service science teachers' informal reasoning about socio-scientific issues: The influence of issue context. *International Journal of Science Education* 32(8), 2475-2495.

Tronto, J.C. (1987). Beyond gender difference to a theory of care. *Signs: Journal of Women in Culture and Society*, 12, 644-663.

Turiel, E. (1983). *The development of social knowledge: Morality and convention.* Cambridge, UK: Cambridge University Press.

Turiel, E. & Smetana, J. (1984). Social knowledge and social action: The co-ordination of domains. In W.M. Kurtines, & J.L. Gewirtz (Eds*.). Morality, moral behaviour, and moral development: Basic issues in theory and research* (pp.261-282). New York: Wiley.

Tweney, R.D. (1991). Informal reasoning in science. In J.F. Voss, D.N. Perkins, & J.W. Segal (Eds.), *Informal reasoning and education (*pp.3-16). Hillsdale, NJ: Erlbaum.

Tytler, R. (2007). Re-imagining science education: Engaging students in science for Australia's future. Camberwell, Victoria: Australian Council for Educational Research Press. Retrieved Jan 20, 2010, from http://www.acer.edu.au

Vellom, R.P. & Anderson, C.W. (1999). Reasoning about data in middle school science. Journal of Research in Science Teaching, 36(2), 179-199.

Venville, G. J., & Dawson, V.M. (2010). The impact of a classroom intervention on grade 10 students' argumentation skills, informal reasoning, and conceptual

understanding of science. *Journal of Research in Science Teaching* 47(8), 942-977.

Voss, J.F. & Means, M.L. (1991). Learning to reason via instruction in argumentation. *Learning and Instruction*, 1, 337-350.

Vygotsky, L.S. (1981). The genesis of higher mental function. In J. Wertsch (Ed.). *The concept of activity in Soviet psychology* (pp.144-188). Armonk, NY: Sharpe.

Walker, K.A. & Zeidler, D.L. (2003, March). Students' understanding of the nature of science and their reasoning on socio-scientific issues: A web-based learning inquiry. Paper presented at the Annual Meeting of the National Association of Research in Science Teaching, Philadelphia, PA.

Wainryb, C. (1991). Understanding differences in moral judgements: The role of informational assumptions. *Child Development*, 62, 840-851.

Webster, S. (2008). How a Deweyan science education further enables ethics education. *Science & Education* 17, 903-919.

Wellington, J. & Osborne, J. (2001). *Language and Literacy in science education*. Philadelphia, PA: Open University Press.

Wilson, M., & Sloane, K. (2000). From principles to practices: An embedded assessment system. Applied Measurement in Education, 13 (2), 181-208.

Winter, G. (2000). A comparative discussion of the notion of `validity' in qualitative and quantitative research. Qualitative Report 4. (3 and 4) Retrieved 6 July 2011 from website: www.nova.edu/sss/QR/QR4-3/winter.html.

Wong, S.L., Tal, T. & Sadler, T.D. (2011). Metalogue: Using issues and participatory experiences to enhance student learning and interest. In Troy, D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press.

Wray, D. & Lewis, M. (1997). Extending literacy: Children reading and writing non-fiction. London: Routledge.

Wu,T-T., & Tsai, C-C. (2007). High school students' informal reasoning on socio-scientific issues. Qualitative and quantitative analyses. *International Journal of Science Education*, 29(11), 1163-1187.

Yager, R. E. (Ed.). (1996). *Science/technology/society as reform in science education*. Albany: State University of New York Press.

Yang, F.Y. & Anderson, O.R. (2003). Senior high school students' preference and reasoning modes about nuclear energy use. *International Journal of Science Education*, 25; 221-244.

Yehudit, J.D. & Revital, T.T. & Tasushu, M. (2003). Teaching Biotechnology through case studies – can we improve higher order thinking skills of non-science majors? *Science Education* 87, 767-793.

Yin, R.K. (2009). *Case Study Research: Design and Methods*. Thousand Oaks, California: Sage Publications, Inc. (First published 1984; 2nd Ed. 1994; 3rd Ed. 2003)

Yore, L.D., Bisanz, G.L., & Hand, B.M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education*, 25 (6), 689-725.

Zeidler, D.L. (1984). Moral issues and social policy in science education: Closing the literacy gap. *Science Education* 68, 411-419.

Zeidler, D.L. (1997). The central role of fallacious thinking in science education. *Science Education* 81, 483-496.

Zeidler, D.L. (2003). The role of moral reasoning and discourse on socio-scientific issues in science education. Dordrecht, The Netherlands: Kluwer.

Zeidler, D.L. & Keefer, M. (2003). The role of moral reasoning and the status of socio-scientific issues in science education: Philosophical, psychological and pedagogical considerations. In D.L. Zeidler (Eds.) *The role of moral reasoning and discourse on socio-scientific issues in science education.* Netherlands: Kluwer.

Zeidler, D.L., Lederman, N.G. & Taylor, S.C. (1992). Fallacies and student discourse: Conceptualizing the role of critical thinking in science education. *Science Education* 76, 437-450.

Zeidler, D.L., Walker, K.A., Ackett, W.A., Simmons, M.L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socio-scientific dilemmas. *Science Education*, 86, 343-367.

Zeidler, D.L., Sadler, T., Simmons, M.L. & Howes, E. (2005). Beyond STS: A Research-based framework for socio- Zeidler, D.J. , Sadler, T.D., Applebaum, S. & Callahan, B.E..

Zeidler, D.J. , Sadler, T.D., Applebaum, S., Callahan, B.E. & Amiri, L. (2005a, April). Socio-scientific issues in secondary school science: Students' epistemological conceptions of content, NOS and ethical sensitivity. Paper presented at the National Association for Research in Science Teaching, Dallas, TX.

Zeidler, D.L. & Sadler, T. (2008). The Role of Moral Reasoning in Argumentation: Conscience, Character and Care. In S. Erduran & M. P. Jimenez-Alexandre (Eds.) *Argumentation in science education: Perspectives from Classroom-Based Research* (pp.201-216). Dordrecht: Springer.

Zeidler, D.J., Sadler, T.D., Applebaum. S., Callahan, B. (2009). Advancing reflective judgement through socio-scientific issues. *Journal of Research in Science Teaching*, 46, 74-101.

Zeidler, D.L., Applebaum, S.M. & Sadler, T. (2011). Enacting a Socio-scientific Issues Classroom: Transformative Transformations. In Troy D. Sadler (Ed.). *Socio-scientific issues in the classroom*. Dordrecht: Kluwer Academic Press. 277-305.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39 (1), 35 – 62.

Zoller, U. (1982). Decision-making in future science and technology curricula. *European Journal of Science Education*, 4 (1), 11-17.

Zoller, U. (1999). Scaling Up of Higher-Order Cognitive Skills-Oriented College Chemistry Teaching. *Journal of Research in Science Teaching* 36(5), 583-596.

Zuber-Skerritt, O. (1996). Emancipatory action research for organisational change and management development. In O. Zuber-Skerritt (Ed.). *New Directions in Action Research*. London: Falmer, 83-105.

Appendices

Appendix 1A Year 10 BIOTECHNOLOGY PROGRAM OVERVIEW

CHRISTIAN COLLEGE

Program Overview

Term 3, 2010

Text: Science Aspects 4 & Biotechnology Supplement Notes 10-Week Program Year 10 Science

General Outcomes
1. Students analyse the social issues in applications of science in society and to everyday use. 2. Students use scientific concepts to examine the costs and benefits of the applications of science. 3. Students look at both sides of the debate about the controversial applications of science.
Specific Outcomes
1. Students understand that ethical considerations require that people are made aware of the benefits and costs to society of scientific advances. 2. Students understand that the use of animals and humans for scientific purposes is subject to ethical and moral considerations 3. Students understand that personal, social, political and economic factors can impact on scientific research and application

4. Students understand that biotechnology can alter genetic composition by replacing the genes of one organism with genes from another organism
5. Students can also use terms correctly when describing traditional biotechnology, genetic engineering and new biotechnology.
6. Students use decision-making processes, analytical reasoning and ethical frameworks involving ethical considerations when dealing with controversial issues such as the issue of patenting scientific discoveries, inventing genetically engineered product or genetically modified crop.

W	Content	Key Concepts	Teaching Strategies Activities/Investigations/Experiences	Research Data Collection	Evaluation of Teaching Practice
1	**Supplement- Biotechnology** a. What is Biotechnology? Applications of Biotechnology	Biotechnology – what does it involve? Traditional Biotechnology Micro-organisms in Food Industry Selective Breeding	Tues - Power point Concept teaching Wed – Concept teaching Concept Mapping Fri – Concept teaching	Pre-Quiz – Genetics Term 2 Or start of Term 3 Student Journal each week **Project 1 – Creativity – generate an illustrated book for teaching Year 7 -8s**	Student Questionnaire Peer evaluation Self-reflection worksheet Teacher journal
2	**Supplement- Biotechnology** **Science in Biotech** **SA 4 Focus 3.8** **Genetics and Health**	New Technology Manipulation of DNA and human health – IVF, stem cells, cloning, gene splicing, gene therapy, germline genetic	Tues - Power point Concept teaching Wed - Lab Session 1	**Student Self Evaluation A**	Self-reflection worksheet Teacher journal

		engineering, ethics	Fri - Concept teaching		
3	**Supplement: Biotechnology** **Science in Biotech** **SA 4 Focus 3.9** **Genetics and Industry**	New Technology Manipulation of DNA for industry Selective breeding GM Foods Forensics Conservation Genetics	Tues - Power point Concept teaching Wed – Review Graphic Organiser – Pro/Con/Consequence/Value Chart Topic: GM Food/Organ Transplant <u>Prepare for Debate</u> Fri - Biotechnology On-line	**Tues – Project 1 due** **Student Reflection** **Questionnaire** **Fri – Project 2** **Biotechnology – Topic Issue – Science in Society** **Due Week 7**	Self-reflection worksheet Teacher journal
4	**Supplement: Biotechnology** **Ethics in Biotech – Overview of Issues**	Ethical issues in: 2.1 Genetically Modified Food 2.2 Organ Transplant	Tues & Wed- 1- 2 Workshops on teaching `argumentation' and thinking logically: 4 Periods - Framing questions - Presenting arguments - Weighing arguments (Dr M. T/ S Y)	**Informal Observations in 10S** **Student-centred –** **Technique of asking questions**	Self-reflection worksheet Teacher journal

		2.3 Gene Technology	Decision Making Process Fri- Debate A. Genetic Modified Food B. Xenotransplantation	**& crafting arguments** **Students begin gathering a pool of questions generated based on biotech concepts and lines of argument.** **Student Self Evaluation B**	Peer Evaluation
5	**Ethics in Biotech** **Class Discussion of Various Issues** **From Newspaper Articles**	Media articles of interest	Tues In- class activities Practice Advantages and Disadvantages Wed- Developing Viewpoints Use of Ethical Frameworks Fri – In class practice	**Interviews** **Tape recordings** **Observations in 10D and 10S**	Self-reflection worksheet Teacher journal Peer Evaluation

			Role Playing		
6	**Activities – Use of Ethical Framework** **Organ Transplant**	Medical Biotechnology	Tues - 1 Workshop on `Ethical Framework' Wed – Practice on Different Scenarios Fri – Activity 1 Written Worksheet – Sister Keeper (Homework)	**In class activities** **Tape Recordings** **Students Self Evaluation C**	Self-reflection worksheet Teacher journal
7	**Activities - Use of Ethical Framework** **View – My Sister's Keeper**	Medical biotechnology	Tues - Practice – Use of Ethical Frameworks in given scenarios Wed - Interviews Friday – Period 3 & 4 DVD Presentation 1 Period – Evaluation of Use of Ethical Frameworks	In class assessment Interview Tape Recordings **Student Reflection** **Questionnaire based on Project 2**	Self-reflection worksheet Teacher journal

8	**In-House Gene Technology** **Electrophoresis (Incursion)**	Biotechnology Applications in Forensics - DNA Profiling	Tues – Lab Session 2 DNA Profiling Wed - Revision for Test Fri – Term Assessment	Post – Quiz **Formal Assessment** Incursion Applications of Biotech Interviews	Self-reflection worksheet Teacher journal
9 **10**	**REVIEW**		Students conduct their own quiz based on their questions generated from Week 4 – 8.	Questions generated by students - Informal Quiz **Student Self Evaluation D**	Teacher journal

Appendix 1B PRE AND POST QUESTIONNAIRE

Thank you for volunteering to participate in this questionnaire

In the following questionnaire are questions about your understanding and opinions of biotechnology (section A, B,C and E) as well as some questions regarding your religious faith (section D).

Please note the following important information regarding the questionnaire.

1. *It is not a test*
2. *It will not contribute towards any part of your school assessment.*
3. *If a question makes you feel uncomfortable you are not required to answer it.*
4. *Your answers will be confidential. Because I respect protect your privacy your names will not be recorded with your answers.*

If you like to talk to someone about any of the issues raised in the questionnaire we would encourage you to discuss them with someone you feel comfortable with, this may include your parents or your biology teacher.

Part A: Evaluating Student's Attitude and Reasoning about Biotechnology (Pre-test/Post-test)

Circle the letter(s) that is/ are the best indications of your feelings about the statement.

SA = Strongly agree

A = Agree

N = Neutral

D = Disagree

SD = Strongly Disagree

Pair			Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Give Reasons
1	1A	Problems resulting from science or biotechnology hardly ever affect me.						
2	1B	Problems resulting from science or biotechnology will only affect some people in our society.						
3	1C	Problems resulting from science or biotechnology will affect an entire country, and even the world.						
4	2A	I would like to know how problems in science or biotechnology affect me.						
5	2B	Most people will not act on science and biotechnology even if they understand why action is needed.						
6	2C	If I knew more about science and biotechnology issues, I could do more about them.						
7	3A	There should be some guidelines provided by the government to solve science and biotechnology problems.						
8	3B	Science and biotechnology should use a problem-solving approach.						
9	4A	The government should give priority to problems of						

		biotechnology affecting humans first.						
10	4B	The government should give priority to problems of biotechnology affecting both humans and animals.						
11	4C	The government should give equal attention to solving problems of biotechnology affecting humans, animals and the environment.						
12	5A	As long as biotechnology can solve problems now, it should be fully used.						
13	7A	Having enough scientific knowledge will solve problems in biotechnology.						
14	8A	Members in society have the responsibility to develop the appreciation and respect for the rights of others within the society.						
15	8B	All science classes should include science and biotechnology issues and topics in the curriculum.						
16	8C	Open discussions using scientific knowledge and ethical principles should be encouraged in science and biotechnology teaching.						
17	9A	The use of ethical frameworks is a good strategy to better understand and deal with science and biotechnology issues.						
18	9B	It is important for students to be taught how to think through critically and make decisions about science and biotechnology issues.						

What is the number one Science and Biotechnology related issue facing the world today?

Why do you think this?

Part B

Please circle whether you think that the following statements are True or False

T	F	DNA stands for Dehydrated Nucleic Acid
T	F	A human has 23 pairs of chromosomes in a regular cell nucleus.
T	F	The chromosomes in the cells of your eyes contain the information for your eye color.
T	F	The chromosomes in the cells of your kidneys contain the information for your eye color.
T	F	AIDS is a genetic disease.
T	F	Genetic diseases can be prevented with good hygiene.
T	F	Children resemble their parents because they have the same type of red blood cells.
T	F	A couple has heard from the doctor that they have a one in four chance of having a child with a hereditary disease. This means that if the first child has the disease, the following three children will not.

T	F	Genetic modification is the deliberate changing the hereditary characteristics of living things.
T	F	It is possible to clone a human.
T	F	It is currently prohibited in Australia to clone human embryos.
T	F	The government must always give consent before a genetically modified plant may be grown.
T	F	It is possible to use genetic testing to find out if someone has a higher than average chance of developing some types of cancers.
T	F	It is possible to determine what a baby's IQ or intelligence will be during pregnancy.
T	F	It is possible to change the hereditary qualities of a baby before it is born, so the child will be stronger and smarter
T	F	It is possible during pregnancy to determine whether a child has Down's Syndrome?
T	F	It is possible to change the hereditary characteristics of an animal so that the animal will make human growth hormone.
T	F	It is possible for the hereditary characteristics of plants to change so that the plants themselves make pesticides against certain insects.
T	F	It is possible to transfer genes from humans to bacteria.
T	F	Ordinary tomatoes have, as opposed to genetically modified tomatoes, not genes.

T	F	If you eat genetically modified fruit your genes may also be genetically modified.
T	F	Xenotransplantation is the transfer of an animal organ into a human body .
T	F	Bacteria are used in the preparation of yoghurt.
T	F	Biotechnology is used in the production of drugs and hormones.
T	F	Genetically modified animals are always smaller than normal animals.

Part C

Indicate how strongly you agree or disagree with each of the following statements

		Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
1.	Genetically modified foods can help solve food problems in third world countries.	*1*	*2*	*3*	*4*	*5*
2.	Biotechnology makes our lives healthier, easier and more comfortable.	*1*	*2*	*3*	*4*	*5*
3.	The natural resources of the earth will soon be exhausted because of the advances in biotechnology.	*1*	*2*	*3*	*4*	*5*
4.	Genetically modified food is a threat to future generations.	*1*	*2*	*3*	*4*	*5*

5.	Further research will solve any dangers associated with genetic modification.	*1*	*2*	*3*	*4*	*5*
6.	Genetic research in humans is wrong.	*1*	*2*	*3*	*4*	*5*
7.	I think that the genetic modification of food is unnatural.	*1*	*2*	*3*	*4*	*5*
8.	The genetic modification of animals is wrong.	*1*	*2*	*3*	*4*	*5*
9.	Animals have rights that humans should not infringe upon.	*1*	*2*	*3*	*4*	*5*
10.	Genetic modification is a threat to nature.	*1*	*2*	*3*	*4*	*5*

		Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
11.	Genetic modification in humans is 'playing God'.	*1*	*2*	*3*	*4*	*5*
12.	Genetic techniques can easily be abused.	*1*	*2*	*3*	*4*	*5*

13.	Cloning is safe	*1*	*2*	*3*	*4*	*5*
14.	The genetic modification of bacteria will result in future problems.	*1*	*2*	*3*	*4*	*5*
15.	I think that biotechnology is advancing too fast.	*1*	*2*	*3*	*4*	*5*
16.	Genetic modification is good.	*1*	*2*	*3*	*4*	*5*
17.	It is difficult to find anything positive about the applications of biotechnology	*1*	*2*	*3*	*4*	*5*
18.	I am uninterested in biotechnology	*1*	*2*	*3*	*4*	*5*
19.	Biotechnology is essential for future survival.	*1*	*2*	*3*	*4*	*5*
20.	The genetic modification of plants does not exceed the limits that humans should not cross.	*1*	*2*	*3*	*4*	*5*
21.	Eating genetically modified food is dangerous	*1*	*2*	*3*	*4*	*5*
22.	Genetic research in animals will benefit human health.	*1*	*2*	*3*	*4*	*5*
23.	Genetic research in animals is absolutely unnecessary	*1*	*2*	*3*	*4*	*5*
24.	Genetic modification is a necessary part of modern life.	*1*	*2*	*3*	*4*	*5*
25.	Studying genetics in humans is of no value.	*1*	*2*	*3*	*4*	*5*

26.	Genetic research in humans is essential.	*1*	*2*	*3*	*4*	*5*
27.	I have faith in science.	*1*	*2*	*3*	*4*	*5*
28.	I would buy genetically modified food if it were available at my local supermarket.	*1*	*2*	*3*	*4*	*5*
29.	I would not eat at a restaurant if the food they served contained genetically modified ingredients.	*1*	*2*	*3*	*4*	*5*
30.	I would buy genetically modified food if it were cheaper than ordinary food.	*1*	*2*	*3*	*4*	*5*
31.	I would eat genetically modified food if it tasted better than ordinary food.	*1*	*2*	*3*	*4*	*5*
32.	I would eat genetically modified food if it contained less fat than ordinary food.	*1*	*2*	*3*	*4*	*5*

How concerned are you about the following areas of biotechnology?

		Very concerned	*Moderately concerned*	*Slightly concerned*	*Unconcerned*	*Unsure*
33.	In Vitro fertilization	*1*	*2*	*3*	*4*	*5*
34.	Genetic Research	*1*	*2*	*3*	*4*	*5*
35.	Genetic modification	*1*	*2*	*3*	*4*	*5*

36.	Cloning	*1*	*2*	*3*	*4*	*5*

Would you be willing to:

		Definitely	*Probably*	*Maybe*	*Probably not*	*Definitely not*
37.	Take a genetic test during your or your partner's pregnancy?	*1*	*2*	*3*	*4*	*5*
38.	Take a genetic test to find out whether you are at risk of a serious illness when you are older?	*1*	*2*	*3*	*4*	*5*
39.	Undergo gene therapy to correct your genes if tests showed that you were highly likely to get a serous genetic disease later?	*1*	*2*	*3*	*4*	*5*
40.	Allow your child to undergo gene therapy to improve or change their genes if your child suffered from a severe or fatal genetic disease?	*1*	*2*	*3*	*4*	*5*

Part D

1.	How often do you attend religious services?	Never	Once or twice a month	Once a month	Once a week	More than once a week

2.	When you have problems or difficulties in your school, family, or personal life, how often do you seek spiritual comfort?	Always	Often	Sometimes	Rarely	Never

Indicate how strongly you agree or disagree with each of the following statements

		Strongly agree	Slightly agree	Neutral	Slightly disagree	Strongly disagree
3.	In general, religious beliefs are very important in my day-to-day life?	*1*	*2*	*3*	*4*	*5*
4.	I would consider myself a religious person?	*1*	*2*	*3*	*4*	*5*
5.	Jesus Christ was the Divine Son of God.	*1*	*2*	*3*	*4*	*5*
6.	The Bible is an important book of moral teachings, but it was not inspired by God any more than other historical books.	*1*	*2*	*3*	*4*	*5*
7.	The concept of God is an old superstition that is no longer needed to explain things in this modern time.	*1*	*2*	*3*	*4*	*5*
8.	Through the life, death and resurrection of Jesus, God provided a way for forgiveness of man's sins.	*1*	*2*	*3*	*4*	*5*
9.	There is no such thing as a God who is aware of man's actions.	*1*	*2*	*3*	*4*	*5*

10.	Jesus was crucified, died, and was buried, but on the third day He rose from the dead.	*1*	*2*	*3*	*4*	*5*
11.	Life originated differently than is suggested by the Bible.	*1*	*2*	*3*	*4*	*5*
12.	The precise words spoken by God may be found in the Bible.	*1*	*2*	*3*	*4*	*5*
13.	The Bible contains God's rules for living.	*1*	*2*	*3*	*4*	*5*
14.	The Bible is the product of man's imagination.	*1*	*2*	*3*	*4*	*5*
15.	The Bible should be read as God's inspired writings.	*1*	*2*	*3*	*4*	*5*
16.	The Bible contains religious truths.	*1*	*2*	*3*	*4*	*5*
17.	The Bible should be regarded more as beautiful writing than religious truths.	*1*	*2*	*3*	*4*	*5*
18.	The Biblical account of creation is accurate.	*1*	*2*	*3*	*4*	*5*
19.	Quotations appearing in the Bible are true.	*1*	*2*	*3*	*4*	*5*
20.	We can put our trust in the teachings of the Bible.	*1*	*2*	*3*	*4*	*5*
21.	Most of the writing in the Bible should be taken literally.	*1*	*2*	*3*	*4*	*5*

		Strongly agree	Slightly agree	Neutral	Slightly disagree	Strongly disagree
22.	The miracles reported in the Bible actually occurred.	*1*	*2*	*3*	*4*	*5*
23.	The Bible is the ultimate source of truth.	*1*	*2*	*3*	*4*	*5*
24.	The Bible accurately predicts future events.	*1*	*2*	*3*	*4*	*5*
25.	The Bible is a collection of myths.	*1*	*2*	*3*	*4*	*5*
26.	There are more accurate accounts of history than the Bible.	*1*	*2*	*3*	*4*	*5*

Part E

For each of the following biotechnologies indicate whether you agree or disagree with the technology and provide as much detail as possible why you made your decision, including any ethical or moral principles that influenced your decision.

1.	Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are draught and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.
	Agree Disagree *Outline as many reasons for your selection that you can.*

2.	Using in vitro fertilization and genetic screening techniques it is possible to screen embryos before they are implanted. Using this technique it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future it may even be possible to select for other traits such as eye color or intelligence.
	To what extent do you agree or disagree with this technology? *Outline as many reasons for your position that you can.*

3.	Many otherwise healthy couples are unable to bear children. Modern reproductive Technologies, like fertility drugs and in vitro fertilization, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a fetus and eventually be born as a baby.

	Agree Disagree *Outline as many reasons for your selection that you can.*
4.	In therapeutic cloning a cloned embryo is created and stem cells are removed. The stem cells are stimulated to grow into specific types of tissue or even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it.
	Agree Disagree *Outline as many reasons for your selection that you can.*

Thankyou ☺

A Note on Part C Questions:

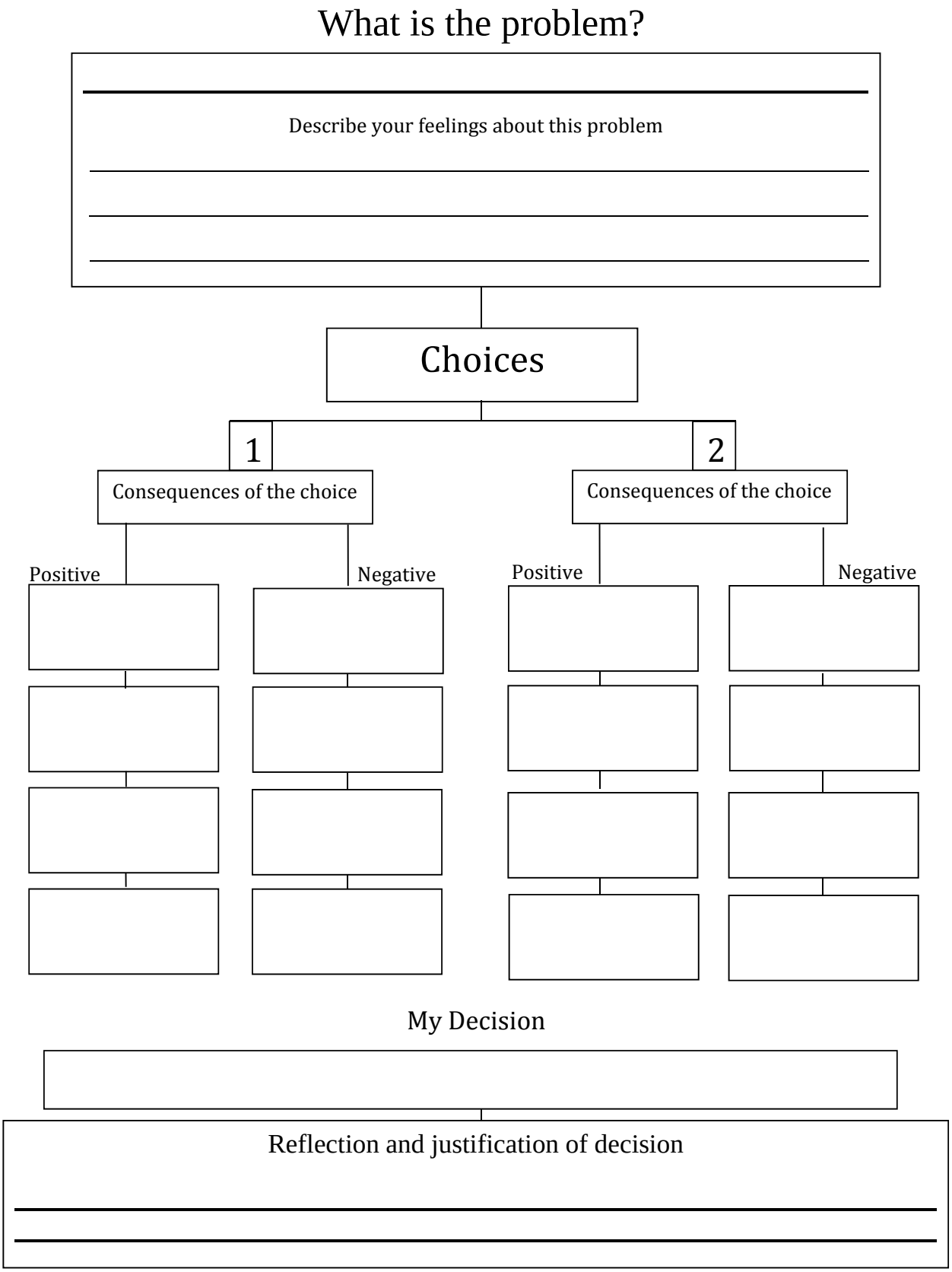
Positively constructed – Items 1,2,5,19,20,22,24,26,27,28,30,31,32 (#13)

Negatively constructed – Items 3,4,6,7,8,9,10,11,12,14,15,17,18,21,23,25,29 (#17)

Concern – Item 33 – 36

Behaviour – Item 37 – 40

Appendix 2A TEMPLATE OF THE COMPARISON GROUP FRAMEWORK



Appendix 2B TEMPLATE OF THE EXPERIMENTAL GROUP FRAMEWORK

ETHICAL FRAMEWORK TEMPLATE

What is the problem?

_____

Describe your feelings about this problem.

_____

_____

Five Ethical Frameworks

Balancing Rights
Maximising the Benefits (Utilitarian)
Making Decisions for Yourself
Leading a Virtuous Life (virtue)
Christian (Moral) Ethics

My decision

Reflection and Justification of Decision

Appendix 3 PRE AND POST QUESTIONNAIRES – `THE FOUR SCENARIOS' QUESTIONS

Part E – The Four Scenarios

For each of the following biotechnologies, indicate whether you agree or disagree with the technology and provide as much detail as possible why you made your decision, including any ethical or moral principles that influenced your decision.

1	Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are drought and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.
	Agree Disagree Outline as many reasons for your selection that that you can.
2	Using *in vitro* fertilisation and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future, it may even be possible to select for other traits such as eye colour or intelligence
	To what extent do you agree or disagree with this technology? Outline as many reasons for your position as you can.
3	Many otherwise healthy couples are unable to bear children. Modern reproductive technologies, like fertility drugs and *in vitro* fertilisation, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a foetus and eventually be born as a baby.

	Agree Disagree Outline as many reasons for your selection that you can.
4	In therapeutic cloning, cloning a cloned embryo is created and the stem cells removed. The stem cells are stimulated to grow into specific types of tissues and even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it.
	Agree Disagree Outline as many reasons for your selection that you can.

Appendix 3A SUMMARY OF STUDENT RESPONSES – COMPARISON GROUP

Part E -The Four Scenarios

1 Genetically Modified Food	**Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are drought and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.** Agree/ Disagree Outline as many reasons for your selection.
2 IVF and Genetic Screening Techniques	**Using *in vitro* fertilisation and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future, it may even be possible to select for other traits such as eye colour or intelligence.** To what extent do you agree or disagree with this technology? Outline as many reasons for your selection.
3 Reproductive technologies	**Many otherwise healthy couples are unable to bear children. Modern reproductive technologies, like fertility drugs and *in vitro* fertilisation, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a fetus and eventually be born as a baby.** Agree/ Disagree

	Outline as many reasons for your selection.
4 Therapeutic cloning and Stem cells	**In therapeutic cloning, cloning a cloned embryo is created and the stem cells removed. The stem cells are stimulated to grow into specific types of tissues and even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it.** Agree/ Disagree Outline as many reasons for your selection.

No	**PRE RESPONSE (yellow)**	**POST RESPONSE (purple)**
32	No submission	1 Agree World hunger; more income for the farmers
		2 Agree to some extent I agree only if it is safe for the child and he/she will not have problems in the society such as being teased or treated as different from the other children. Reason – better features and lower health risks
		3 Agree No response
		4 Agree It would save lives and won't risk others.
No	**PRE RESPONSE**	**POST RESPONSE**

33	1 Disagree We shouldn't eat GM food.	1 Agree If all of these things are true, then I will like GM food, but I think biotechnology is silly.
	2 Agree We can screen and know the gender of the child and the diseases he/she may get.	2 Disagree The intelligence or eye colour should not get changed. It is breaking boundaries that we should not cross.
	3 Agree Childless couple can have children.	3 Disagree Why don't they just adopt?
	4 Disagree Unknown	4 Agree No response
No	**PRE RESPONSE**	**POST RESPONSE**
34	1 Disagree This may harm people and alter the creation of God.	1 Agree Help with the global food crisis.
	2 Strongly disagree If something goes wrong, it can cause danger to the person. This is altering the creation of God.	2 Disagree I would not recommend it because of my religion.
	3 Disagree There is a reason why God didn't let them have children.	3 Disagree If it was me and I couldn't have children, then it would be God's will.
	4 Disagree In the bible, it says you should not clone. (not stated in Bible).	4 Agree Live longer, healthier and happier life.

No	**PRE RESPONSE**	**POST RESPONSE**
	1 Agree No response	1 Agree The drought resistant plants could be grown in third world countries
	2 ?	2 Disagree No response
	3 Disagree No response	3 Neutral No response
	4 Agree No response	4 Agree No response
No	**PRE RESPONSE**	**POST RESPONSE**
36	1 Disagree If farmers also had as much research done in agriculture and farming techniques, this could be applied to other areas.	1 Agree It can help but only in extreme situations like this.
	2 Disagree God made you as you are and with a purpose. Stick to it.	2 Strongly disagree It is bad. This is playing God – wrong use of technology.
	3 Agree Same as #2. Says something in the bible about cloning is bad.	3 Disagree Same response as #2 It can be dangerous**.**
	4 Disagree Same as above and #2	4 Disagree As above

No	PRE RESPONSE	POST RESPONSE
37	1 Agree No response	1 Agree As this would, or could make food cheaper, taste better and also have better nutritional value.
	2 Disagree Playing God This is letting your parents choose what you look like and not what God meant.	2 Disagree to the point of curing diseases Changing a person's eye colour, gender or any other traits is playing God and is wrong from a Christian point of view. But curing diseases would be a good thing as you are altering the person as you are curing them.
	3 Agree This will give the childless couple more hope.	3 Disagree This is wrong as God had a reason for that particular couple to be infertile. Cloning is `playing God'.
	4 Agree No response	4 Agree It is not as bad as cloning a person as you are making parts of a person to help others, but to some extent it is `playing God'.
No	**PRE RESPONSE**	**POST RESPONSE**
38	1 Agree No response	1 Agree No response
	2 No indication Don't know what it is!	1 Disagree Because I don't think it is right to pick the gender of your baby or what it

		should look like.
	3 Agree No response	3 Agree No response
	4 Disagree No response	4 No indication Not sure.
No	**PRE RESPONSE**	**POST RESPONSE**
39	1 Agree It helps fight world hunger and malnutrition. It provides plants resistance to disease or herbicides. It produces quicker.	1 Agree It is easier to grow, ripe for longer and still have the same taste. It does not go soft quickly (referring to crops, etc.)
	2 Agree to some extent I agree so long as it doesn't have disease but disagree with the rest. We shouldn't be able to choose intelligence, eye colour or family traits. It is wrong.	2 Agree to some extent Agree to have a child, disagree with everything else – choosing the sex, eye colour and other traits. This is wrong. It could save people's lives but playing God is too much.
	3 Disagree Cloning is wrong. If something goes wrong during the process, it would sexually harm the child and everyone involved.	3 Disagree This is unnatural and playing God.
	4 No response	4 Don't care
No	**PRE RESPONSE**	**POST RESPONSE**
40	**No submission**	1 Agree No response
		2 Disagree I think this is unethical. It is choosing traits. I believe God plans a person's life

		and we shouldn't change that.
		3 Disagree This is wrong because God has chosen the child as it is.
		4 Disagree To some extent, this is `playing God'.
No	**PRE RESPONSE**	**POST RESPONSE**
41	1 Disagree Even though it can be of great help to people in the sense, it could be healthier and might fight world hunger and make it better quality, GM food might make the earth adjusted to it and people become dependent on it. The earth might not produce any more natural stuff as easily. We might have to use more and more to keep the same quality.	1 Agree I think that GM food is not that bad because by doing this, we could produce better quality food and more food which would help people. I do reckon though that there are dangers involved such as it could upset nature and can produce a result that was not intended.
	2 Agree to some extent It could save a baby's life or that it could make them healthier in the future. But I don't think it is right to change the natural characteristics such as eye colour. God created a person to be like they are. Like having blue eyes	2 Disagree I think that IVF is unnatural but it is sort of acceptable because the embryo is naturally forming. But changing the embryo is like playing God. It will result in a society where everyone looks the same according to a `perfect' standard defined by society.

	or brown hair, or being good at sport or music. If we change that, we are going against what God created and are basically `playing God' ourselves by changing the person to suit our preferences.	
	3 Disagree Everyone is supposed to be different and creating a baby genetically identical to yourself is not natural and against God's will.	3 No response
	4 Disagree No response	4 No response
No	**PRE RESPONSE**	**POST RESPONSE**
42	1 Disagree No response	1Agree No response
	2 Disagree I think it goes far beyond stopping diseases.	2 Disagree Leave things as they are
	3 Agree Sounds good.	3 Agree But wouldn't do it.
	4 Agree No response	4 Disagree No response
No	**PRE RESPONSE**	**POST RESPONSE**
43	1 Agree GM food can help us in many ways because of how we do genetic testings. If things are	1 Agree It depends on the uses of technology.

	not taken seriously, it can change things in the environment.	
	2 Agree to some extent I think we should be able to view the embryo and check if it has any diseases and not any further.	2 Agree to some extent I agree if it is used with ethical reasons. If it isn't for ethical reasons (eg. parents can bear a child naturally but they choose IVF just to determine what the child will look like or be. Then I will disagree.
	3 Disagree There is a chance of failure when inserting a needle into the ovary.	3 Agree They can use reproductive cloning.
	4 Agree There is a possibility of transplant and it won't harm the patient in any way.	4 Disagree Some don't want to donate.
No	**PRE RESPONSE**	**POST RESPONSE**
44	1 Agree No response	1 Agree It helps people who are in the third world countries.
	2 Agree No response	2 No response
	3 Agree No response	3 No response
	4 Agree No response	4 No response (may be away during some lessons?)
No	**PRE RESPONSE**	**POST RESPONSE**
45	1 Agree It would help the third world	1 Agree Not many 3rd world countries know

	countries (poor nations).	about GM food. The food is cheaper and the quality is not much different.
	2 Disagree No response	2 No response
	3 Disagree Adopt a baby, not make one.	3 No response
	4 Disagree No response	4 No response
No	**PRE RESPONSE**	**POST RESPONSE**
46	1 Disagree I am against GM food because, as a Christian, I believe that God created all things in a certain way and I do not think He wants us to change His creations. I think it is also insulting to God as it generally sends out the message that we think we can `improve' his creation.	1 Disagree It would create an even larger gap between the rich and the poor. We do not know all of the dangers of genetic modification. It is playing God and it is unethical.
	2 Strongly disagree I disagree with the selection of traits as that again, is some sort of telling God you can improve his creations. If it is a life-threatening disease that would people in pain, I think	2 Agree to some extent I agree with the technology as long as it is used for medical reasons and not for vanity. Medical reasons → could save people's lives; → increase quality of life

	we can modify the genes.	Vanity → unethical, put pressure on a child to become someone he is not, playing God and bigger gap between rich and poor.
	3 Disagree This is not the way God wanted us to have children. We should instead pray for a miracle and not try to be God.	3 Disagree Playing God and unnatural
	4 Agree If it will save someone's life and it does not have any side effects or it does not physically harm anyone, I don't see any problem with it.	4 Agree It could save many lives It also improves the quality of life.
No	**PRE RESPONSE**	**POST RESPONSE**
47	1 Agree There are many people and children around the world that are starving in hunger.	1 Agree Many children around the world are dying of hunger. GM food can be used to try and save. It will not cost them much because GM food can be grown quite quickly.
	2 Disagree I do not think the gender should be changed. God is the creator and is the only one who decides the gender of the child. There is also risk of failure with such procedures.	2 Disagree I disagree with changing the gender. It is playing with `God's image'.
	3 Disagree They could adopt a child rather than cloning one. Besides, the procedure is expensive.	3 Disagree The baby would be similar to that of the parent. This would have problems in the future.
	4 Agree	4 Agree It won't cost people to donate their own

	It would save people. Also, some healthy people may not wish to donate organs after they die (so this is a way forward).	cells/ tissue. It would also not be safer for the cloned organisms they might have an effect on the patients. (student is confused here).
No	**PRE RESPONSE**	**POST RESPONSE**
48	1 Agree It is true that it will prevent factors which slow down or destroy food growth. Therefore there is more food for everyone and those in need.	1 Agree Less chemicals, resistance to diseases, etc. more nutritious, fight hunger
	2 Agree slightly I do not understand fully how it works.	2 Disagree It is unnatural to change the outcome of a baby. It would be considered as `cheating' and it is unfair since only the rich can afford it.
	3 Disagree It sounds wrong to create baby who is not born from the womb of its mother.	3 Disagree It isn't natural and it may be God's choice not to let them have children. I think there is enough people on earth already.
	4 Agree It would be a great advantage and it would save many lives.	4 Agree If it is used to save lives, then I think it is ok. But if it is given to people who continues destroying themselves, them no (referring to Claire Murray drug addict case)
No	**PRE RESPONSE**	**POST RESPONSE**
49	1 Agree Well, logic says it will help.	1 Agree It can produce more food making it more affordable in the third world countries.
	2 Agree to some extent To the point where it fixes	2 Neutral

	diseases, and nothing more.	I don't follow it so I am not sure. I don't know everything about it.
	3 Agree Sounds good	3 Agree It helps them to have a kid so go for it.
	4 Agree Helps people in the long run	4 Agree It could prove to be very useful and save many lives, but on the other hand, we do have to die sometime.
No	**PRE RESPONSE**	**POST RESPONSE**
50	1 Agree to some extent Changing the genes to benefit because they use less chemicals and produce more crops. We can change/ reduce poverty/ hunger/ malnutrition around the world. God created the plants like they are so we can't change the whole plant but some parts to make it better.	1 Agree GM food is food where genes have been altered. GM foods could fight world hunger and malnutrition. Altering genes can provide resistance to disease or herbicides.

	2 Agree to some extent We can use this to make sure the baby does not have diseases but not the others. God already knows who the babies are going to be and what they are going to look like so we can't change that.	2 Disagree It is not right to do this. This would only be available for rich parents. This can increase the gap between the rich and the poor. Humans are doing God's job.
	3 Disagree It is not right to make a copy of oneself but one can try and adopt. If it is their option, they can possibly clone but only after all their options are exhausted.	3 Disagree This could help infertile couples but I don't think it is morally right to make clones of people. Infertile couples can adopt if they want a family. By cloning, this would make dad and son alike and so there is no uniqueness.
	4 No indication This could possibly change lives by giving waiting patients a second chance.	4 Disagree The cloned embryo would be killed which means that a person's life would be destroyed because the ball of cells is still a person.
No	**PRE RESPONSE**	**POST RESPONSE**
51	**No response**	1 Agree This can be helpful for those people you cannot eat certain foods.
		2 Disagree It could be very dangerous and can have long term effects.
		3 Agree It allows the infertile couple to have children and live normal lives.
		4 Disagree It is a hard process and can lead to long term effects

No	PRE RESPONSE	POST RESPONSE
52	**No response**	**No submission**
No	**PRE RESPONSE**	**POST RESPONSE**
53	1 Agree If done this way, I think this can help fight hunger. But I personally see it as against God's word.	1 Disagree Playing God, immoral, unnatural
	2 Disagree There are ethical issues. It is immoral and against Christianity. There are potential health risks.	2 Neutral Disagree with the modification Agree with having babies
	3 Disagree I don't agree with this because I see it as going against God's word. It is unnatural and immoral.	3 Disagree Against God, immoral
	4 Agree It can help save lives but it is very unnatural and there are potential risks.	4 Agree Saves lives, keep healthy and doesn't require more organs
No	**PRE RESPONSE**	**POST RESPONSE**
54	**No response**	1 Disagree These foods are not natural although they may be able to help fight against world hunger. I disagree with it. We are interfering with nature's way if

		we do this.
		2 Strongly disagree If we do this, then we are `playing God'. This is very bad.
		3 Disagree I disagree with these actions.
		4 Agree I agree with therapeutic cloning for the production of organs for patients.
No	**PRE RESPONSE**	**POST RESPONSE**
55	1 Agree Because less work means less need for hand labour, thus it saves money. It is good because it is economical.	1 Disagree The poorer farmers may not be able to buy the GM crops (seeds), so the rich get richer and the poor get poorer.
	2 Disagree God planned the way we look and if we alter that, we are altering God's handiwork.	2 Strongly disagree They are trying to play the role of God.
	3 Neutral God has still provided natural ways to have children such as adoption.	3 Disagree If God doesn't want them to have children, they won't.
	4 Agree It is okay for medicine to help but to make the whole human is wrong. (student's misunderstanding of the question).	4 Agree *Writing is illegible.*
No	**PRE RESPONSE**	**POST RESPONSE**
56	1 Agree If it was proven to have no side effects, it could be good for third world countries but I	1 Agree It will stop world famine which is good but I don't think it should be used in a

	would not use it in Western or developed nations.	modernised countries.
	2 Agree to some extent It could stop the child from having a disease or dying young but I strongly disagree with changing intelligence or personality traits, etc. God created us in our specific ways; we should never change the way we look or act. It defies Him. It would make some people look better than others or smarter. But this is not what they choose to be.	2 Disagree I think changing the gene and gender is not natural and the baby should be formed the natural way. It is like playing God and saying who or what they are going to be. And if they do that, the child has no choice. It is supposed to be random and not controlled.
	3 Disagree If they are unable to conceive and for a reason, I don't think it is right to go for this technology as it is not natural. They could adopt or foster.	3 Disagree I don't think cloning is at all ethical. I believe it is wrong to create another human being like another and it could used for bad things if in the wrong hands. It should not be allowed. Also, there is a small success rate and no knowing what might happen to the child.
	4 Disagree I don't believe cloning is right. It is not natural and should not happen. It could have side effects that no one knows or has fully researched.	4 Disagree It is like killing a baby. It takes a human life and it is wrong. (Misunderstanding the question here.)

No	**PRE RESPONSE**	**POST RESPONSE**
57	1 Agree The reasons for doing so seems very reasonable and it is true that part of the world is facing hunger so this technology can help them around and the world from starvation. I'll accept.	1 Agree No response
	2 No indication I have no idea what IVF is.	2 No response
	3 Unsure	3 Agree The patient would have a family.
	4 Agree It seems like there is a possibility that the transplant will not harm any patient any way.	4 Agree No response
No	**PRE RESPONSE**	**POST RESPONSE**
58	1 Disagree It is not natural. Poor people cannot afford it.	1 Agree GM food may be cheaper and easier to grow in the third world countries.
	2 Strongly disagree. Poor people cannot afford it. It is not natural.	2 Disagree It is not natural. God didn't plan for you to choose your baby's characteristics.
	3 Disagree It is not natural. Adopt a baby and save a life.	3 Disagree Because there are millions of children waiting to be adopted. It is not right using this technology. It is playing God.
	4 Agree	4 Agree

	It is good.	It would benefit lots of people.
No	**PRE RESPONSE**	**POST RESPONSE**
59	1 Agree No response	1 Agree You can use it to make food much more quickly.
	2 Don't know what it means.	2 Disagree I think it is wrong but I am not sure. God made you the way you are for a reason and you shouldn't change it.
	3 No response	3 Disagree Cloning is wrong.
	4 No response	4 Disagree No response
No	**PRE RESPONSE**	**POST RESPONSE**
60	**No submission**	1 Agree No response
		2 Strongly disagree It is extremely wrong.
		3 Agree No response
		4 Agree No response
No	**PRE RESPONSE**	**POST RESPONSE**
61	1 Agree GM food could help save many lives and would stop the fight against world hunger.	1 Agree It could help stop world hunger and malnutrition in third world countries. It could provide more food and it would be cheaper too. Healthier food with no harmful stuff such as chemicals would

		be good.
	2 Agree to a certain extent I agree with trying to stop the child from getting a disease but I disagree when they go over board to have the perfect baby with the perfect eye colour, etc.	2 Agree to some extent I agree that by doing this we can see if the child will get a certain disease so we can stop it. I don't agree with choosing what gender and how the child should look like as this is not natural. Reasons – not natural, we are acting as God like figure if we choose what our child looks like, not fair, cruel
	3 Agree This would help infertile couple to have children but they could also adopt a child. I understand that sometime a parent would want to have their very own child.	3 Agree I agree but it could be a last option the couple can think about adopting or surrogacy.
	4 Agree It could help save people who need organ transplants.	4 Agree This is a good way to save lives as there are no risks and other people won't risk of dying from donating an organ.
No	**PRE RESPONSE**	**POST RESPONSE**
62	1 Agree No response	1 Agree It will help. It makes farmers may less and can fight against world hunger. Why wouldn't it be good?
	<u>Some illegible handwriting and doodling</u> <u>(indicative of boredom)</u>	2 Disagree We shouldn't play God. The price will make rich people have the best kids because it will cost so the rich will have the smartest looking kids around.
		3 Agree It will help people have children they want.
		4 Agree

		It will help people live.
No	**PRE RESPONSE**	**POST RESPONSE**
63	1 Agree It would help stop world hunger and malnutrition.	1 Agree Because the crops can stop the world hunger.
	2 Agree to some extent I agree with stopping diseases but anything else should be left alone. People are better the way they were supposed to be.	2 Disagree It is not natural to choose or design what baby you want to have.
	3 Disagree If they can't have an actual baby, they can adopt.	3 Disagree It would be better to adopt than clone.
	4 Agree As long as it doesn't harm a life and saves someone, it is okay.	4 Agree It is not a life that is being created but perfect parts to save a life.

Some Reflections

Without specific reference to Christian ethical frameworks, it is interesting how Christian values/ beliefs are articulated rather strongly here. Perhaps, there is a lack in alternatives provided.

I wonder if our Christian beliefs/ values switched our minds off on thinking of some of these controversial topics. There are quite a number who responded to the first section but not on the case studies. Strong use of clichés (playing God and unnatural)

Attitudes normally do not change over the course of the program (ten weeks) but what is observed is that with scientific understanding of the benefits of some technology and evaluating them, some students have come around to accept GM. With the cloning and reproductive technologies, it appears underlying convictions creates a certain resistance to finding out a bit more about the value of such technologies. Attitude/

emotions affect learning. Does it hinder reasoning skills development in controversial areas?

Appendix 3B SUMMARY OF STUDENTS' RESPONSES – EXPERIMENTAL GROUP

Part E – The Four Scenarios

1 Genetically Modified Food	**Genetically modified food is food that has been grown from plants that have had their genome changed by deliberately removing genes or adding genes from another organism. This enables scientists to alter specific characteristics of the plants. Plants are often given genes that provide resistance to disease or herbicides. Genetically modified crops produce more food and farmers do not have to use as much chemicals. Other plants have been genetically modified so that they are drought and disease resistant or more nutritious. These crops could greatly help in the fight against world hunger and malnutrition.** Agree/ Disagree Outline as many reasons for your selection.
2 IVF and Genetic Screening Techniques	**Using *in vitro* fertilisation and genetic screening techniques, it is possible to screen embryos before they are implanted. Using this technique, it is possible to select the gender of a child or even make sure that it does not have certain diseases. In the future, it may even be possible to select for other traits such as eye colour or intelligence.** To what extent do you agree or disagree with this technology? Outline as many reasons for your selection.
3 Reproductive technologies	**Many otherwise healthy couples are unable to bear children. Modern reproductive technologies, like fertility drugs and *in vitro* fertilisation, have enabled some of these individuals to have their own children. However, some couples remain infertile and unable to have a baby. For these individuals, cloning could be used as another reproductive technology. In this case, one of the parents would serve as the genetic donor. The donor's genetic material would be inserted into an egg cell, and then the embryo (the egg carrying a complete set of the donor's genetic material) would be implanted into the woman. The embryo would develop into a fetus and eventually be born as a baby.** Agree/ Disagree

	Outline as many reasons for your selection.
4 Therapeutic cloning and Stem cells	**In therapeutic cloning, cloning a cloned embryo is created and the stem cells removed. The stem cells are stimulated to grow into specific types of tissues and even possibly whole organs such as a kidney, which could then be used for organ transplants. Two major problems that are associated with organ transplantation are a lack of available organs, and immunological rejection. Organs and tissues produced by means of therapeutic cloning would solve both of these problems. Patients awaiting transplants could donate their own genetic material for the production of the cloned embryo and the immune system would not reject it.** Agree/ Disagree Outline as many reasons for your selection.

No	PRE RESPONSE (Green)	POST RESPONSE (Red)
1	1 Disagree It should be made natural.	1 Disagree No response
	2 Disagree Selecting the gender of a child is wrong except the only good thing is treating a disease. You should love the child the way it is born, because it is God's plan. If you know our child will have a disease, then in that case, you should use it.	No response
	3 Disagree God is the only one who knows your body. I think that this is wrong and they should just adopt a child instead.	No response
	4 Disagree No Response	No response

No	PRE RESPONSE	POST RESPONSE
2	1 Agree The positive advance in research of gene modification and its uses being applied are stepping stones for a better quality of life. The positive reasons were outlined in the paragraph with negative ones being subjective morality/ ethics only.	1 Agree Given testing for any harmful possibilities, the opportunities for genetic modification are numerous. All reasons stated in the paragraph. (Awareness of the harmful effects and consider still safe to proceed).
	2 Slightly agree The procedure (excluding prevention of disease) should be optional to parents when deemed safe.	2 Slightly agree Nullifying genetic disease is a bonus though the question of whose choice it is to alter life comes up. Parents should be given this choice and would be responsible for the outcome in the child's life. (awareness of choice and consequence)
	3 Agree This procedure fixes the flaw of a person and allows the couple to experience genetic parenthood which they would not otherwise wise with adoption.	3 Agree This should be an option to infertile parents that are not gay. It would allow them to have a chance at parenthood.
	4 Agree This is a large step forward in the cure of many illnesses and conditions facing humans today and would save many lives.	4 Agree Reasons are stated in the question. I do not consider such early stage embryo to be life and this would make organ transplantation much more efficient**.**
No	**PRE RESPONSE**	**POST RESPONSE**
3	1 Agree We may go too far with the	1 Agree Everyone has a right to a good life.

	technology (and there may be a risk) but we have not reached that yet.	The plants/crops allow for world hunger to be stopped and have a better world.
	2 Unsure God made us how we are.	2 Disagree God made us how we are and we shouldn't be playing with that. Discarding an embryo is killing the child's right to live and it is genetic discrimination.
	3 Unsure Listed pros and cons Illegible writing – not clear response	3 Disagree If it is not to be, it is not to be. Cloning is `playing God' and should not be happening.
	4 Unsure Listed pros and cons, then nothing stated	4 Disagree Every child has a right to life, and life is sacred. (reference to cloned embryo, I think)
No	**PRE RESPONSE**	**POST RESPONSE**
4	1 Agree All this sounds good, and could be possible (if not already). However, it could get out of hand. This should not be taken advantage of.	1 Agree Crops can grow in drought, in the poorer countries so that people that are dying of hunger (or in poverty) can have some food.
	2 Disagree It is changing the natural side of things. Changing God's natural creation To an extent, abusing materials God put on this earth to modify more of his creation (children) Totally forgetting about the way God creates humans Changing a baby's genes/ physical appearance is forgetting God created man in his own image.	2 Disagree I agree that the technology is possible but I disagree on the fact of using it. I don't think this technology is good at all. People should have children naturally and wait to find out the phenotype of their child. (Note using vocabulary taught in class). This technology is stupid and one day, if it is ever put into practice, it will fail! (strong emotive words coming through a usually quiet student).

	3 Disagree Cloning is wrong. God would not be pleased because he created man and woman to have babies, and by cloning, it is sort of saying to God that man can do a better job than Him.	3 Disagree Cloning is dangerous and should not be used. It is really up to the people having the baby but personally I wouldn't do it. God has a reason why He does not want specific people not to have a baby.
	4 Disagree Overall, I disagree with cloning anything because it is not a natural way of life that God created.	4 Disagree Cloning to get stem cells is wrong. An embryo is a potential person so it is kind of killing them.(Not much attitudinal change so far between pre and post)
No	**PRE RESPONSE**	**POST RESPONSE**
5	1 Disagree I think this is all human thoughts. God wanted us to plant and work hard but these days, humans want to make all things easier but it will end up with giving the people all the diseases.	1 No Response
	2 Agree to some extent I agree with that it helps to make sure it does not have certain diseases I disagree with that it is possible to select the gender of a child. It is good to check the unborn child's health. But if the people start to select the gender and other characteristics, it would be a disaster since they are disobeying God's words.	2 Disagree There will be a huge difference between the poor and the rich. Only the rich might be able to use this technology. Everyone will want to do it. Then every people on earth, later on, will be too smart/ intelligent.
	3 Disagree If they start to use the technology of cloning , later on everyone might use that technology.	3 Agree No Response

	4 No Response	4 No Response
No	**PRE RESPONSE**	**POST RESPONSE**
6	1 Disagree Even if it helps fight against world hunger and malnutrition, it is still genetically modified. What if, it didn't work out right but no one found that out, people could die.	1 Agree Because it helps a country that lack food. It grows fast and can withstand bad weather.
	2 Disagree Even if it helps and detect the gender, it is not right changing eye colour and physical traits.	2 Maybe Because since people are designing babies to suit what the couple wants, why not choose the eye colour and intelligence as well!
	3 Agree No response	3 Agree Even though it may not be natural, it still helps the couple to have a baby.
	4 Disagree No response	4 Agree No response
No	**PRE RESPONSE**	**POST RESPONSE**
7	1 Agree I think it is a good idea because we are making the food better and by doing this we can get rid of the bad	**1 Agree** If you could make a fast growing , disease-proof ,long lasting, famine-protected plant in a third world

	things that happen to fruit/ vegetables.	country, I would help!
	2 Strongly disagree Just like cloning, it is taking a human and recreating him, we as man should not do this and it's only human that our God gives live to; as humans if we try, we will fail.	2 Agree Being able to save your baby helps you to be more get used to it and to change it to avoid future problems. (quite a change of perception here).
	3 Disagree Cloning, like I said before, is taking and modifying humans, we the humans can't even connect a memory, would never know how to make life, and give it a `will' or better known as `free will'. This is wrong and man should not act as `God'.	3 Agree/ Disagree - Neutral Cloning is generally bad if you abuse it. But for people who cannot have babies, even in IVF, it is possible to get one.
	4 Agree and Disagree I think it is a good thing to donate organs as we are not creating them, but we are merely giving them. Tests are required to make sure that it is possible to donate. But I disagree with cloning, though it is harsh to not help people with problems. Cloning is creating and human cannot `create life'. Only God can.	4 Agree/ Disagree It is right to help people but to help someone at others' expense, it is wrong.
No	**PRE RESPONSE**	**POST RESPONSE**
8	1 Disagree No response	1 Agree No Response
	2 Agree to some extent I only agree if it has things to do with the diseases but anything else like skin colour, eye colour etc, I disagree with.	2 Agree to some extent I believe it is only except one to change the genetic material if the embryo has a genetic disease but not to change the characteristics of the embryo.

	3 Disagree No Response	3 Agree No Response
	4 No Response (missed a couple of lessons)	4 No Response
No	**PRE RESPONSE**	**POST RESPONSE**
9	1 Disagree 2 – 4 No Response	**<u>Left the course halfway.</u>**
No	**PRE RESPONSE**	**POST RESPONSE**
10	1 Agree If the GM food can help to save the third world countries and also make it cheaper, I think it is ok to modify the food.	1 Agree GM food would be cheaper, so it could be grown in third world countries and be able to withstand extreme conditions. Further research needs to be done as we are unsure of the health to many people.
	2 Disagree to some extent I do not think this is a good idea. We should not choose our children features. Only to do so if we can cure genetic diseases.	2 Disagree It is wrong to use this technique and parents should not be allowed to choose gender and characteristics. There are many ethical issues raised. The baby has rights (Awareness of other issues and rights).
	3 Disagree No response	3 Agree This could help many people who are unable to have children.
	4 Agree No response	4 No response

No	PRE RESPONSE	POST RESPONSE
11	1 Disagree Although changing the genes may look promising, what research has been done on how it may benefit or harm human health? God made the plant that way and we are doing nothing but messing with His creation by modifying the genes**.**	1 Disagree I think that generally GM food is unnatural – natural food doesn't need new genes in it to improve it. There could be serious health risks involved which are still unknown to scientists. Most countries waste millions of dollars every year, and if that money was given to third world countries, that could solve poverty.
	2 Slightly agree It most probably would be important to check if the baby doesn't have any genetic diseases, but changing the gender or traits is totally unacceptable. It may harm the child and the baby should have the right to develop naturally.	2 Agree to some extent I think it could be okay to use for a couple who cannot have children, but only detecting it has a disease or not, but if the embryo didn't have a disease, it could be okay. For couples who are barren, it may be ok as long as it is not used to select traits such as intelligence etc because that the process is unfair to all those who can't afford it, and it could potentially harm the baby with genetic screening. A major issue is that it may result in the termination of pregnancies if the baby is found to have the disease, which is no good
	3 Not sure It seems slightly unfair on the baby because the parents are really not the biological parents and other options could be considered like adoption. Cloning isn't good because it creates similarities between the children and cloning seems to be	3 Disagree – not sure If there is an absolutely no other option, then it could possibly be ok but I don't think it is the best thing to use because it is an unnatural process and other couples could consider adoption if they wanted a child, but the rate of cloning success isn't high and it could be unfair to

	unnatural and if the genetic material is cloned, then it becomes a `fake' process rather than a gift from God.	the child if there is low survival rate, etc.
	4 May be It would possibly be ok, but the problem is that the embryo obviously doesn't have a say whether they agree or disagree. Some children later one may think they were only created to give organs.	4 Not stated A major issue with therapeutic cloning is that once the stem cells have been removed, the blastocyst (interesting use of the term and implies the bunch of cells is `life') dies. While the promise may look good, I don't think it is an ethical decision to use stem cells because it is unfair to the embryo.
No	**PRE RESPONSE**	**POST RESPONSE**
12	1 Disagree Though there have been no long term studies on the effects of GM food on people. So until there is definite proof, there is no side effect. We cannot give GM food to people until this is proven or we will make the situation worse.	1 Agree (change of heart here**)** Just the fact that GM plants may produce more food can help with the food crisis. However, if plants are not stable, it could cause more problems. (Agrees with some qualifying statement.)
	2 Strongly disagree It is wrong to choose a child just because of its gender and the future problems that may arise. It is even more wrong to practically engineer a child and pick everything about it because it is like `playing God'.	2 Disagree I think it is wrong to choose the gender, intelligence and eye colour of a child. Reason – it is religiously wrong as children are a gift from God and should not be picked based on gender or traits they might express.
	3 Disagree That again is wrong as children should be allowed to be individuals and not just clones of parents**.**	3 Disagree It is wrong as the child is just a copy of someone else and may then live or be a child of a gay or lesbian couple. (note social implications).

	4 Disagree This is wrong in the fact that it is harming or killing a human life form (embryo). However, the implications seem good though I don't fully agree.	4 Disagree An embryo is technically a live and it means they are willing to kill someone just for the organs.
No	**PRE RESPONSE**	**POST RESPONSE**
13	1 Agree and Disagree Agree – help fight poverty; easier for farmers Disagree – seems bad to modify God's creation	1 Agree I believe it is a very controversial issue and I still haven't completely made up my mind about. I think that all GM food that is resistant to harsh environmental factors will save lives, - then it is a good thing. But it shouldn't be mixed with the original crops. The thing is – will it cost more annually than the $20b needed to eradicate world poverty?
	2 Disagree I believe it is bad to choose the gender of a child. I disagree to gender choosing and selecting eye colour and intelligence level. But I agree to it if severe diseases can be cured.	2 Agree to some extent I agree with this technology to some extent because it is good for small things, but I don't like the look of the `future' (above). Screening for diseases – OK I believe. Selecting a gender is not so good. Selecting the traits of a child is very bad, because soon enough everyone would be the same!
	3 Disagree Cloning of humans = BAD If I couldn't have a baby with my wife, I would adopt because that 's how it is and there are many children out there who need	3 Disagree (circled intensively) I strongly disagree with cloning because I think it is unnatural and wrong. The couple could look at adoption.

	parents.	
	4 Disagree I believe it should be compulsory to donate your organs when you die and if certain religious groups don't want to, they don't get donated organs. (a bit emotive)	4 Agree This is a good thing I believe, but I am not 100% sure, because it involves destroying the embryo later.
No	**PRE RESPONSE**	**POST RESPONSE**
14	1 Agree These foods would help people survive easier. I saw a TV program once and the food was very good and it helped poor people very well**.**	No response – as student was away
	2 No indication/I don't know what in vitro fertilisation is. (Due to poor health student missed many classes.)	No response
	3 Agree Although this all seems a little bit like playing God, but if it could help people have babies, it seems like a really good idea.	No response
	4 No indication I don't know.	No response
No	**PRE RESPONSE**	**POST RESPONSE**
15	1 Disagree It is not the way God made plants. It could be hazard to humans. It is unnatural.	Student left halfway through the course for homeschooling**.**
	2 Strongly Disagree An embryo is actually a baby. If you change it, you are messing with a real human being, not just a blob.	

	It is unnatural. God created us to have children inside us, and not know what they are like until they are born, not to pick and choose your dream baby.	
	3 Disagree God has made some couples infertile, that is how he wanted it. They should accept that and instead of messing with their unique genes they could adopt. There are plenty of children who have been rejected and want a home. It is unnatural. Even though many may be able to build or create a human body, it is God who supplies the soul.	
	4 Disagree It is murder! An embryo is a human being and to make a human just to steal it and sells and kill it is horrible. God is in control of everything and he made it that those people needed organ transplants but maybe it was planned for their time to go. We should not preserve life unnaturally when God destined us to go.	
No	**PRE RESPONSE**	**POST RESPONSE**
16	1 Agree The food is more drought resistant or more nutritious and they can also help in the fight against world hunger and malnutrition.	1 Agree The GM foods can help people survive in places where there are drought, diseases and severe heat. Overall, these will benefit people in third world countries; however, consuming GM foods can result in some problems**.**

	2 Disagree to an extent. You can't alter God's creation You should love your child for who they are. Problems for the child could occur in the future.	2 Agree to some extent I agree to the extent that you can select the gender of the child and eliminate disease genes. I agree to the extent that we can genetically modify our child to make them healthier and live longer but in the future, we may have a race of `perfect humans'. (ambiguity ?)
	3 Disagree Cloning is a false form of creation and there can only ever be one unique version of yourself that is created by God.	3 Disagree I think that it is wrong to clone humans because they weren't created naturally and many people may just want to clone to do stuff for them while they relax and do nothing. **(**some misconception here about cloning).
	4 Disagree Since this is a false creation, it is obvious that would be problems with the clone. In my opinion, cloning is for lazy people and for people who won't want more than one copy of their body that God made for them**.**	4 Disagree Therapeutic cloning can't always solve the problems to do with organ transplants as the new organs could fail and the immune system could reject it all together. (failure to understand therapeutic cloning concept here.)
No	**PRE RESPONSE**	**POST RESPONSE**
17	1 Disagree For thousands of years, we have survived without GM crops. I don't think genetically modified foods could solve world hunger as this can only be treated by getting foods to places that need it in the first place**.**	1 Agree (change of mind here). World hunger is a massive problem these days, and not much that has been done has worked. Maybe GM food is the answer. Pesticides have caused diseases and physical defects in the past. GM foods may prevent this from happening again.
	2 Disagree I disagree with some aspects of this	2 Disagree God makes us the way we are, and

	technology. I disagree with the fact that modifications can be made to eye colour or intelligence. The baby should be left as God intended it to be. On the others, I agree with the doctors being able to determine if the child will have a disease**.**	loves us despite how intelligent we are or what we look like. People traits should not be selected, or their gender. If this technology was made accessible, there would be vast numbers of blonde haired, blue-eyed people.
	3 Disagree Cloning is wrong. Again, it is altering the way God intended pregnancy and reproduction to be.	3 Disagree In the bible, there were quite a few barren women. Like they did, maybe couples should have faith and pray for a child. Cloning is unnatural. If the couple is not of the Christian faith, maybe they should consider adoption.
	4 Agree This could improve human life so it is good as long as it is fool proof.	4 Disagree No response
No	**PRE RESPONSE**	**POST RESPONSE**
18	1 Agree If not as many *chemicals* are being put in the crops, and it can help fight against the world hunger, I don't see why not. It should be used. But I do not see it being used today so there must be more to it than what I know. (student does not fully comprehend what genetic modification is here).	1 Agree Poverty is a huge issue in our world today. If GM food could solve the issue, why wouldn't we use it?
	2 Agree to some extent Increasing your chance of having a specific gender of a baby is OK but	2 Agree to an extent To the extent of the gender and diseases, after that the line is

	to actually select it is wrong. Making sure that it does not get any diseases is good but when it comes to appearance and intelligence, it should be determined naturally.	drawn. We would be having `designer babies'. It ruins the person if they are designed in this way.
	3 Disagree Cloning is wrong in any way, and it should not be done. Scientists are very close to crossing the line. Most is being researched and discovered each day. Cloning should not be researched in great detail, unless it is absolutely necessary.	3 Disagree We should never clone humans. It is not morally right at all. Science is advancing too fast for our own good**.**
	4 Agree If this will save lives and no damage will be done, then it is ok because one's life is much more important than cloning.	4 Agree Many people are dying, waiting on organs, and from the rejection of new organs. This would solve the problem.
No	**PRE RESPONSE**	**POST RESPONSE**
19	1 Agree The farmers could save money on chemicals. Countries with poverty could be helped greatly. The plant/ crops have a higher chance of survival.	1 Agree In harsher environments such as third world countries, the croups could be able to be grown and maintained. There would be higher chance of crop surviving in these environments.
	2 Neutral It is unnatural to be able to change what a baby looks like. It should look like the parents. It would be good to choose what you want your baby to look like. It would be good to enhance the intelligence of a baby.	2 Strongly Agree Biotechnology has already advanced so far and so quickly that it is completely possible that selecting traits such as eye colour and intelligence will be available in the near future.
	3 Agree Couples should be able to have children, even if it means going to	3 Disagree What makes human special or different is the amount of genetic

	certain extremes to get them.	diversity between all of us. Using cloning, there would be much less**.**
	4 Agree This procedure would result in many cured individuals and may greatly help reduce the incidences of cancers/ STD/ STIs (not sure about the latter two diseases).	4 Disagree By doing these things, people are basically taking a life to save their own and I don't think it is appropriate. (student possibly confused with embryonic SCs here**)**
No	**PRE RESPONSE**	**POST RESPONSE**
20	1 Disagree It is still unnatural. When God created the world, everything was made to work. It is human fault that we have to use all the chemicals.	1 Agree I agree that GM crops can do all these things, but the paragraph did not explain the risks. I am not against Australia or the world creating GM food but I would prefer having natural food created perfectly by God (although I realise that this is probably impossible now.)
	2 Neutral If someone wants to change their baby, wouldn't God already have that planned and therefore plan for the baby to be like that?	2 Strongly disagree I think that this is something that can go extremely wrong and that the risks outweigh the benefits by <u>A LOT</u>. I really believe this single technology could ruin the world**.**
	3 Agree Is it still classified as cloning if you get genes from your parents?	3 Disagree I don't like the idea of cloning because whoever that was cloned… it's just weird and super unnatural and not the way the world is meant to be. Like – those couples can adopt someone.
	4 Agree It is for the better of everyone.	4 Disagree It still counts as killing a soul, when these stem cells are taken. These embryos still have rights as well. (confused therapeutic with embryonic SCs.)

No	PRE RESPONSE	POST RESPONSE
21	1 Disagree Plants should be enjoyed for what they are and not what people want them to be.	1 Agree GM food would help a lot in our Australian society. It would be cheaper and more productive for the farmers as the crops would grow quicker and better and the use of chemicals would be unnecessary. It would also be cheaper for consumers to buy. GM food would also help dramatically from the third world countries, where people are dying from starvation.
	2 Disagree I don't think people should be able to select the gender of their child, let alone eye colour or intelligence. It is unethical, unnatural. It may be going against plans that God has for your life and your children.	2 Agree to some extent I agree with the technology to the extent of making sure that the baby does not have certain disease, but that it should be the only thing that parents can choose. In making sure that you baby does not have certain diseases, that would mean there is less diseases & sickness in the world.
	3 Disagree Every child deserves to have their own individuality. It is unethical, and may even be seen as some kind of `abuse' towards the child. They are exactly like one of the parents and they can't do a thing to change it. Wouldn't the parents want their child to be an individual? Not exactly like them? It would be too weird.	3 Disagree When couples have done all that they can to have a child but still can't, then they should look towards adoption. I disagree with reproductive cloning, as the child knows that their parents couldn't naturally be produced, and now they look identical to one of their parents. The child has the right to their own individuality.
	4 Agree It would solve many problems.	4 Agree If would do a lot for the society, in the way of organ transplant, and it

	It would help people.	could help a lot.
No	**PRE RESPONSE**	**POST RESPONSE**
22	1 Agree Growth has less impact with chemicals, and is protected from problems. If used correctly, this can bring many benefits, as long as the food is safe.	1 Agree to some extent These plants will definitely grow better and promise better food in impoverished nations. But they could lead to very high price that nations cannot afford.
	2 Strongly Disagree It is not our right to tamper with human genes**.** If we start to tamper with the unborn embryo, where will it end? This technology could be greatly misused, and be the cause of many problems, such as failed changes in the genes that could cause mutation.	2 Disagree with technology It goes against the natural process and is perhaps saying to God that his creation is not good enough so we are going to change it.
	3 Disagree Many babies available for adoption Modification of human genes, poor genetic diversity, genetic bottleneck	3 Disagree With so many babies available for adoption, these couples should consider this option.
	4 Disagree On the surface, this may appear beneficial, but the tampering with human embryos which would otherwise live to remove stem cells is sacrificing of life of an unborn embryo to help another.	4 Disagree This question is difficult to answer, as the rights of the individual over that of the unborn child is a difficult one.
No	**PRE RESPONSE**	**POST RESPONSE**
23	1 Agree I think fooling with nature and what God created is wrong, because He created it the way it should be. However, if it helped to save people, perhaps it is worth the	1 Agree It would help save the lives of many people but we still need to be careful with it. It makes our farmers more economical, stronger country and helps the environment.

	risk.	
	2 Disagree I think that changing humans to fit our image instead of God's is `playing God' and can have many risks and dangers. God made us perfect the way we are, whether we have Down Syndrome, black eyes or are bald. He loves us the way we are. Changing ourselves to fit human image could affect our relationship with God. It could also have long term effects.	2 Agree to some extent IVF and genetic screening is alright but we shouldn't change the child in any way. We can make sure it doesn't have the diseases though. `Playing God' - we were made in the image of God – so these babies will be made in our image (with our tampering). There could be side effects. It could also mean decrease in number of females as people in many countries will choose sons.
	3 Disagree This could cause emotional and mental distress to the couple. It could also cause problems for the child as he or she may be mocked at in school for the way they were conceived. It may however bring joy to the couple but you don't have to go to extremes. You can adopt.	3 Disagree You could adopt a child You shouldn't clone a human being as you cannot clone a soul The child will look exactly like the father The child may feel not special and unique and that could cause psychological factors.
	4 Neutral `Growing' human organs are dangerous and can have side effects. It is dangerous to toy with nature. However, it could also save lives and stop pain.	4 Agree This will save many lives. But it should be monitored and should use donors first. This would allow for a better life.
No	**PRE RESPONSE**	**POST RESPONSE**
24	1 Agree These methods are okay to use in Australia because there is much drought here.	1 Agree It has its risks, but if it weren't for it, the world would have starved. (awareness of risks/negatives)

	2 Strongly disagree It is murdering child before it is born.	2 Agree to some extent I agree with using it to get rid of genetic disease but I don't agree with using it to make designer babies. It is one of my worst fears to have a baby who inherited my condition. (disturbing thought)
	3 Agree This could be the only way some people will give birth.	3 Agree Couples who find out they can't have children are always devastated to find out.
	4 No indication. Not sure.	4 Disagree I disagree with therapeutic cloning because it is murder**.**
No	**PRE RESPONSE**	**POST RESPONSE**
25	1 Agree They may help in hunger as plants last longer but I don't believe it is healthy as the plants are totally unnatural.	1 Agree I agree that they could help with malnutrition and hunger problems but I do not think it is a good way to go because it is unnatural and there may be risks involved. Genetic modification may increase the yield of food crops.
	2 Totally disagree This way of making a child is very unnatural and not at all how God planned it. It is like you are taking over God's role which is wrong. Human's will are man made.	2 Absolutely disagree This technology is so unnatural and a horrible way of having a child. It is God's job to select characteristics and the gender of the baby, not humans. If you create a child, you know what they will be like, and therefore it will not be a surprise.
	3 Disagree Again, this is a totally unnatural way of having a baby. This is not what God wants. Plus many	3 Agree I think it is okay for a couple who really want a child to use cloning even though it is very unnatural but this technology should not be used

	problems could occur.	for any other reasons. The parents should try adoption first; this should be their last option.
	4 Disagree It is unnatural and problems might occur.	4 Disagree The embryo created for the stem cells would die as a result and this is same as murder. So this is not good technology to use.
No	**PRE RESPONSE**	**POST RESPONSE**
26	1 Agree No response	1 Agree GM food and plants is a technique that will benefit many people. It benefits the farmers who do not have to use too much chemicals and benefits consumers who will have more food, especially the poor countries.
	2 Strongly disagree Our children should be the way God made them and not change to suit ourselves In relation to certain diseases, I guess it would be ok to alter the genes so that the child would not suffer. Other than that, the child was made for a reason and a purpose, and shouldn't be made smarter, prettier, etc.	2 Strongly disagree with the technology as genetic screening can lead to mother's decision to abort their unborn child. I don't agree with genetic screening because although it is informative, most mothers end up aborting the unborn child and this is wrong. The unborn child does not have a right or say whether it lives or not. The unborn should be given a chance to live but genetic screening can prevent that. Using IVF also leads people to change characteristics and traits of their child which is not right. Because God created the child just the way it is, and it should not be modified and its genes should not be changed when they have been made by God.
	3 Disagree There is a reason why some couples can't have children. God	3 Disagree I don't think it is right to clone a human being because God creates

	might have a better plan – adoption for eg.	us uniquely but by using cloning, the baby is not a unique creation but an exact copy of one of the parents. I also think that parents could adopt children if they do not have their own or cannot have their own. I don't think the parents genetic material should be touched but it should be left as it is and not used by unnatural means to create another human being.
	4 Disagree There might be problems caused by organ transplantation so it would be better to get organs another way may be	4 Disagree Because this can result in the death of the embryo which isn't fair because God created and gave life to that child and should not be killed. But if the embryo does not die in the process of the procedure, it is very helpful and beneficial for those who need organ transplants.
No	**PRE RESPONSE**	**POST RESPONSE**
27	1 Agree If they are good for humans, and do not cause any harm, then I don't see why not.	1 Agree They provide resistance to disease. GM food can be produced under drought and disease-free conditions. Food is more nutritious and higher crop yield.
	2 Disagree to some extent Every child is God's creation and if we are to choose its features and intelligence, it is no longer the work of God. I would not pick any child's features and talents. I would like him or her to be entirely made by God.	2 Strongly disagree God has created everyone in His image and who are we to alter his creations? It is wrong, considering all the ethical questions.
	3 Agree	3 Agree

	It is up to an individual if they want this. if they are unable to reproduce and desperately want children, then this is the solution for them. I would only agree to this method if the baby was natural; in other words, the baby was developed naturally. The parents will not pick the baby's features or intelligence**.** (did not quite understand the question; perhaps question was a little too wordy).	It depends on the couple whether they would like to clone, in order to have children. Many ethical questions would have to be considered before doing this.
	4 Agree It is beneficial to humans. But if they were to clone another human being and kill it when the real human needs its part, that would be wrong (not quite understanding the question again).	4 Disagree Stem cells that are used to become a kidney or tissue were still once a human being. They should not kill a baby in order to use the tissue. (not understanding therapeutic cloning and ESCs.)
No	**PRE RESPONSE**	**POST RESPONSE**
28	1 Agree I agree. However, just because they may greatly help in the fight against world hunger and malnutrition does not mean it is ethically right. I think the way God created plants is the best way to keep them. This question is asking whether changing God's creation, to aid another human being is agreeable. To this, I say, to some extent, that it is agreeable. Changing plants is fine as long as it helps others. However, this could lead to ethical problems concerning other aspects of GM food.	1 Agree First, because there are more crops for farmers and farmers may not charge too much for them so people who may be poor could afford to buy them. Second, crops could be GM to grow in regions of severe drought such as Africa. Although it could cost a lot of money to start off, ultimately these countries are able to sustain themselves.
	2 Agree to some extent I agree that screening for the sole	2 Agree to some extent I agree with its use to a certain

	purpose of searching for genetic diseases is okay. However, I believe that the eye colour and gender difference should not be meddled with. Changing eye colour and gender is not vital in the survival of the baby so why change it? Basically, why change something or fix something which is not broken? I believe that God does things for a reason. Treating genetic diseases as soon as they appear in a baby is okay but going to the extent of changing the baby's appearance is not. I think it ruins the experience of having a baby, knowing that it will have blue eyes and blond hair, and 1 meter and 23.5 cm tall at 6 years old, or something like that…	degree but totally disagree with the use of this technology to manipulate a child's eye colour or intelligence. First, I feel that a child is a gift from God. Changing their looks would be like receiving a special present from someone and then saying that you will change it because you do not like it. Second, genetic screening has the potential to diagnose genetic conditions in a baby. This would help in the emotional and physical preparations for this baby. However, as with all technology, there come some people who will misuse it. This is why I think the technology should be used to only a certain degree.
	3 Disagree If God does not allow someone to have a baby, then the person may need to take a look at the reason for this. Perhaps God did not allow this person to have a baby for a reason. Genetic cloning, in my opinion, is very difficult. It is too sensitive to agree or disagree on. If it helps a person or a society, then cloning in my opinion is okay. Cloning for the purpose of having a baby is not okay. There are billions of people on earth who can have babies. The world is not dependent on that one couple to produce the baby.	3 Disagree The main reason is because I believe people who cannot have a child cannot do so because God does not allow them to. God has reasons for this, whether it is because the father has an unknown genetic disease that he may pass to the next generation.
	4 Agree	4 Disagree

	I agree on this method of cloning as it was the patient's own cells – to help oneself. If the cells are there and the technology is there to help others, then why not do it? It is a personal choice whether or not to do it.	Clonal embryos have the potential to develop into people. Therefore using the embryos for research could mean taking a potential life and that constitute murder. (Misunderstood question to refer to embryonic stem cells).
No	**PRE RESPONSE**	**POST RESPONSE**
29	1 Disagree Technology is good as it helps to do lots of things like disease-resistant conditions. But technology can be bad too.	1 Not sure It might help world hunger but create new or even worse problems like new diseases, for example.
	2 Agree to some extent It is not right to make a baby because this is not what God intends it to be- naturally and wonderfully made.	2 Disagree Choosing to change genes is like `playing God'.
	3 Disagree I don't like cloning because it is against my religious beliefs.	3 Disagree No response
	4 Disagree No response	4 Disagree No response
No	**PRE RESPONSE**	**POST RESPONSE**
30	1 Agree and Disagree It would help farmers and even help against world hunger. But it is wrong because it is unnatural.	1 Agree It would help plants grow faster and produce healthier crops. Utilitarian approach.

	2 Strongly disagree It is unnatural. It is not how God made it to be. It is like playing God. It affects the lives of your children.	2 Strongly disagree My own beliefs and values
	3 Disagree No response	3 Disagree My own values and Christian ethics
	4 Disagree No response	4 Agree Utilitarian – there are benefits
No	**PRE RESPONSE**	**POST RESPONSE**
31	<u>Joined half way through the course</u> (German first language)	1 Agree GM food could probably help grow crops in Africa so they have more to eat.
		2 Disagree I think it is really not ethical to design a baby and be able to create the intelligence and good looking stuff… It is not good to play God.
		3 Disagree I don't think cloning is good. Many things can go wrong.
		4 Not sure Don't really get it.

Some reflection notes:

It appears that the underlying Christian worldview/ values/ beliefs shape a number of responses in the pre-section, followed by a somewhat thoughtful and more qualified approach in the post-section. Even then, some strong emotions are detected and where such an approach is taken, the reasoning line become somewhat obfuscated. It would be interesting to see the link between beliefs, values and scientific conceptual understanding and attitude towards science. It would also appear to be going back to faith/ reason – drawing those boundaries again.

Appendix 4 CLASS ACTIVITY- MY SISTER'S KEEPER QUESTIONS

Year 10 Biological Science

Activity: My Sister's Keeper

<u>My Sister's Keeper by Jodi Picoult</u>

A Short Synopsis

Anna is not sick, but she might as well be. By age thirteen, she has undergone countless surgeries, transfusions, and shots so that her older sister, Kate, can somehow fight the leukaemia that has plagued her since childhood. The product of pre-implantation genetic diagnosis, Anna was conceived as a bone marrow match for Kate - a life and a role that she has never questioned... until now. Like most teenagers, Anna is beginning to question who she truly is. But unlike most teenagers, she has always been defined in terms of her sister - and so Anna makes a decision that for most would be unthinkable... a decision that will tear her family apart and have perhaps fatal consequences for the sister she loves. My Sister's Keeper examines what it means to be a good parent, a good sister, a good person. Is it morally correct to do whatever it takes to save a child's life... even if that means infringing upon the rights of another? Is it worth trying to discover who you really are, if that quest makes you like yourself less?

<u>Answer all questions.</u>

1. **What is pre-implantation diagnosis?**

2. **Is pre-implantation diagnosis always a useful technology? Explain your answer.**

3. **Do you think it is ethical to conceive a child that meets specific requirements? Give reasons for your answer.**

4. **Using the ethical frameworks, explain what decision you would have made if you are Mr & Mrs Fitzgerald (Anna's parents) and how why you would necessarily make that decision? (Refer to the grid provided)**

5. **If you do not think it is unethical, do you believe that there should be a specific exception such as the purpose of saving another person's life, or is this just a `slippery slope'?**

6. **Read the excerpt (from pp. 408 & 409) below. Do you agree to the judge's declaration? Give reasons.**

> When Judge DeSalvo comes back to the bench, he brings a framed picture of his dead daughter, which is how I (Campbell, the attorney) know that I've lost this case. `One thing that has struck me through the presentation of the evidence,' he begins, `is that all of us in this courtroom have entered into a debate about the quality of life versus the sanctity of life. Certainly, the Fitzgeralds have always believed that having Kate alive and part of the family was crucial – but at this point the sanctity of Kate's existence has become completely intertwined with the quality of Anna's life, and it's my job to see whether those two can be separated." He shakes his head, "I am not sure that any of us is qualified to decide which of those two is the most important – least of all myself. I'm a father. My daughter Dena was killed when she was twelve years old by a drunk driver, and when I rushed to the hospital that night, I would have given anything for another day with her. The Fitzgeralds have had fourteen years of being in that position – of being asked to give anything to keep their daughter alive a little bit longer. I respect their decisions. I admire their courage. I envy the fact that they even had these opportunities. But as both attorneys have pointed out, this case is no longer about Anna and a kidney, it's about how these decisions get made and how we decide who should make them.

He clears his throat. "The answer is that there is no good answer. So as parents, as doctors, as judges, and as a society, we fumble through and make decisions that allow us to sleep at night – because morals are more important than ethics, and love is more important than law."

Judge DeSalvo turns his attention to Anna, who shifts uncomfortably. "Kate doesn't want to die,:" he says gently, "but she doesn't want to live like this, either. And knowing that, and knowing the law, there's really only one decision I can make. The sole person who should be allowed to make that choice is the very one who lives at the heart of the issue."

I exhale heavily.
"And by that, I don't mean Kate, but Anna.'
Beside me, she sucks in her breath. `One of the issues brought up during these past few days has involved whether or not a thirteen-year-old is capable of making choices as weighty as these. I'd argue, though, that age is the least likely variable here for basic understanding. In fact, some of the adults here seem to have forgotten the simplest childhood rule: You don't take something away from someone without asking permission. Anna," he asks, "will you please stand up?"

She looks at me, and I nod, standing up with her." At this time," Judge DeSalvo says, `I am going to declare you medically emancipated from your parents... I'm going to ask Mr Alexander to assume medical power of attorney for her until age eighteen, so that he may assist her in making some of the more difficult decisions...

7. **What other moral dilemmas are presented in this story? State and explain briefly.**

End of Case Study

Appendix 4A SUMMARY OF STUDENTS' RESPONSES – COMPARISON GROUP

Class Activity – My Sister's Keeper

No	Q3 Do you think it is ethical to conceive a child that meets specific requirements? Give reasons.	Q6. Using ethical frameworks, what decision would you have made if you are Mr & Mrs Fitzgerald (Anna's parents), and explain how/why you would necessarily make that decision?
32	Sometimes because when you are in a situation like Kate's family, they have to think about Kate as well and when they don't have a match that fits with Kate. Then I think it will be ethical so Anna can help her sister.	If I were the parents, I would design a baby to save my sick kid but also when she gets older, I will let her decide for herself if she wants to help or not.
33	Maybe, it depends on what the child is used for. In Anna's case, the parents had no right to use Anna for Kate's wellbeing.	I would have made (as I were) Mr Fitzgerald. Because if she wanted to die, there is no one going to stop her.
34	Not really because you put one child through so much grief and pain so that the others will have a chance to live.	I would have let Kate die if she wanted, then rather risk both daughters' lives during the operations.
35	It really depends on the circumstances of the situation. If someone wants to design their baby, just for the appearance, etc, I think it is wrong.	I would probably choose to try and have Anna though I think I would not have gone as far as the parents did. I would feel what it is like to possibly lose your daughter, and I would probably try and save her, but if it was too hard and too much for her, I would let her go.
36	No, it is very bad. You are making another person and `planning' their life before they are even born. It is like playing God.	First of all, I wouldn't have made the designer baby. If I knew Kate's desires, I would probably change my actions but I don't know. There is a risk involved.
37	No, as the child was not made out of love but to basically do what her parents want her to, and she has no control over her decisions.	It would be a really hard decision to make even if you put the situation in God's hands, it would be very hard to see your child die. I would try everything to save my child, but I would not make a designer baby as that is not why you have a child.
38	I think yes because you want to help your child and you want your child to	No response.

	life and so you'll do anything to make your child live.	
39	No I don't believe it is ethical to have a child that meets specific requirements. You have a child because you want to and whatever he/she turns out to be, you have it for who he or she is.	If I were the parents and had to make the decision, I would not have a `designer' baby. It would help the older sister have a longer life, but the whole purpose of having a baby is to love it, and take care of it and love it no matter what. They made Anna so that her sister can live longer and the purpose for Anna's life is to give body parts to Kate, not to live life as it should be.
40	No, I don't believe it is the right thing to do because Anna, the poor child has no choice but to undergo all these operations.	If I were them, I would not create a designer baby because it is unethical and you should just let God plan Kate's life out, eg. keeping her alive or not.
41	I think it is unfair to do what they did in `My Sister's Keeper', because even though they are helping their one daughter lead a somewhat normal life and helping her survive, they completely take away the rights of the other daughter to lead a normal live. She does not have a say about whether she wanted to be brought into the world just so that parts of her body can be involuntarily taken away from her and given to her sister. She is completely denied her freedom of choice.	I would decide that even if it is horrible, I would not have gotten the second baby for the first kid's sake, because it is unfair to her.
42	No, it is not natural because it isn't the way it is supposed to be.	I would not have another daughter to save someone else.
43	I think that it isn't really ethical but it sometimes comes to the only choice when a life is at stake. The reason why I don't think it is really ethical because it is just taking a person's life away just for another person, unless the person will be able to save multiple people. (Does it seem more justifiable when it can save more than one life?)	The decision that I would have made would search for the right person that would help with Kate's treatment as soon as she was born.
44	Depends on the reason why the child got to be a designer baby. If it was to save someone's life by donating organs to others, yes, it is ethical. However, if it was for the purpose of success in	If I were Anna's parents, I wouldn't have chosen to have a designer baby to save my other child's life because the baby may suffer and will feel like he/she would have been used. If I were them, I would have waited for another

	life, then it is not ethical.	person's kidneys and organs.
45	Yes and No because Kate needs to have a chance but no because it isn't right to take things from Anna.	No, designer babies shouldn't be used because this just isn't natural process.
46	I don't think this is very ethical because the child will have no say in who they want to be. It goes against God's will.	If I were Anna's parents, I would not have conceived the child in the first place because the child would feel like they don't get to choose who they become. It is also unethical and go against God's will.
47	Yes, they are only a few years old and have no idea what they are choosing??	I would not have another daughter to save the other. Just take care of the other child so that she can have a donor from other children that can possibly help.
48	No, it is what is given to you and it is your responsibility to take care of it.	I wouldn't have chosen to create a designer baby to save someone else. It would just be unfair and just using the baby, as if, it doesn't deserve to live. Making a baby in parents' view should be to nurture and care for it, but not do poke it and do surgery on it.
49	In a way, yes and in a way no. It is ok if you are not going to use the child excessively and as long as they still have a quality of life, if not, then no.	I would have let nature take its course and let Kate die because I think it is for the best of the family and Kate.
50	No, I think you shouldn't choose what your child should look lie and what characteristics and genes would be. Only the rich would be able to do this procedure and so the gap between the rich and the poor could grow bigger.	I would have tried to help Kate survive but if she doesn't want to go through another operation and live again, then I would respect her wishes. I think you can do as much as you can but not do too much causing Anna's life to become abnormal.
51	No, because the baby would be used for someone else and which means that he/she is born for a purpose to save someone's life and his/her life could be taken.	No, because if Kate is not meant to live, then there is no reason waiting most of life and time in doing something that will not succeed.
52	No, you are destroying lives even if you think you are saving another. (emotive – effects on the rest of the	If I were Anna's parents, I would go to God for help and ask for healing of Kate. When you put your trust in God,

	Fitzgerald family)	he will never put you to shame or let you down. (Refer to God's authority and His promises)
53	I believe it is wrong. I believe it is breaking natural selection, and going against God's will. As tempting and promising as it could sound, it could have huge effects on the child's life (emotional and physical).	I believe I would choose to give Anna her will because Kate did not want Anna doing the kidney donation and because Anna deserves free will and the ability to have her say in the situation. She shouldn't be forced to give away her body parts.
54	I think it is ethically incorrect to conceive a child that meets specific requirements. It is going against nature. I think that God wanted a baby with specific requirements, we would make one, but we don't need to do it for him.	If I were the parents, I would follow Kate's will. If she wants to die and not undertake any more surgery, she is free to make that decision for herself. I would make this decision by sitting and listening to Kate and Anna's wills.
55	No, as the child would have to live in pain its whole life.	I would have done what they did in the movie –create the designer baby Anna.
56	No, I don't think that it is, as they are basically using Anna for the body parts and it is not natural. Creating another life to save another at the new child's expense is not right.	I would not have another child. I would have let nature take its course and if they did have another child by chance, I would not use him/her. You are putting one child above another. They say you should not do that to adults and children are the same.
57	It is fine for that to happen but what matters most is the reason why you are doing it. You will need to think of all the consequences that could happen if you decide to do this.	No response.
58	Yes, because each child's life matters.	I think Kate should choose because it is her life.
59	No, because it isn't fair on the child being conceived because everyone should have a fair life and Anna would feel like her parents didn't love her and they just wanted to use her. (feelings, emotive driven)	I wouldn't have done the kidney transplant because Kate was going to die with or without it, and it wasn't' fair on Anna because it would affect her whole live and she would get a choice on the matter.
60	No because that is not the way God designed us.	I think I would consult Kate because it is her life and if she doesn't want to live anymore, that would be hard to understand, but I would go with it.

		(Understanding, emotions)
61	Yes and No. Because they could then save people who have cancer and no because it is God's choice on how he create everyone, and it would also be wrong to the designer baby to have to give up their live for someone else and it would also mean that there would be even bigger gap between the rich and the poor for designer babies.	If I were the parents, I wouldn't want my child to die and the only solution to save my child's life was a designer baby, I think I would do the same but I would make sure not to risk the designer baby's life in the process. (How? Can anyone guarantee that?)
62	No, a baby should be allowed to choose what happens.	See what Kate and Anna want. Kate didn't want it so there wouldn't have been a case if the parents had listened.
63	No, because it is not natural or God's way.	As Anna's parents, I would try and convince her to save her sister's life as hard as I can, but I wouldn't force her.

Appendix 4B SUMMARY OF STUDENTS' RESPONSES – EXPERIMENTAL GROUP

Class Activity – My Sister's Keeper

No	Q3 Do you think it is ethical to conceive a child that meets specific requirements? Give reasons.	Q6. Using ethical frameworks, what decision would you have made if you are Mr & Mrs Fitzgerald (Anna's parents), and explain how/why you would necessarily make that decision?
1	I don't think it's ethical to conceive a child specifically just to be born for another person's needs, because it is wrong and the baby would grow up thinking when they are older, they were brought up into the earth, just to save someone's else life.	No response
2	Not ethical if those requirements hinder life.	I would have given more choice to Kate as she might have been ready to die before Anna's conception. Kate would have to live with a large burden of guilt by having a sister made solely to donate against her choice. I would make a choice based on Kate as it is her live in the balance.
3	I don't think it is ethical as it is playing with nature.	I don't think I would have done as I would be pressured into having a child who is healthy and live a happy life. I would value her life (Anna) greatly.
4	In any case, I think it is unnatural . I think it is wrong/unethical to conceive a child to meet requirements; in the case of the movie, the parents wanted to help their child Kate but by creating/ genetically screening Anna, their decision/ outcome ended in Kate surviving a few more years, and then dying after.	Using Christian ethics I would pray about the situation, and be trusting in God. Meanwhile, I'd do my best to look after Kate. (Christian's understanding of what is natural or unnatural/ tap into spiritual disciplines)
5	I think it is better than just killing a child who has a disease. A designed person would have to suffer but it	Depends on the situation I'm in. But I wouldn't save the kid if the disease <u>was really</u> serious. If you make a designed

	would be beneficial to a child who has a disease. (interesting that some students are using killing and murdering)	baby. She/ He wouldn't have the rights to live like other people. And she/he would have to suffer a lot. If a child with a disease wasn't that sick, then I would make a designer baby and try to save her.
6	It wasn't really a good idea even if it helps the person that has the disease because it will ruin the other person's life and future.	I might design a baby just to help the child that has a disease but I would ask the baby that was designed if it was okay because if the baby was forced to help the child with the disease, it would only ruin the baby's life and future, not only that but when the baby gets older, he or she will think badly of the parents.
7	Yes and No. You could be saving (keeping) one baby at the expense of others.	I'd use the balancing rights because everyone has equal rights, including the zygotes, killing them to save another is not right. It is our duty to give everyone under our control, responsibility to a free will/ life. Also Christian ethical reasons state we shouldn't murder and killing for no real reason would be wrong! So I wouldn't make a designer baby for Kate.
8	I do not believe that it is ethically right to conceive a child just to meet a certain requirement. This is because the baby (child) has his or her own rights and cannot be used as spare parts for someone else.	If I was Anna's parents, I don't think I know what to do because yes to some degree I would have a designer baby. But I would still have the child to make his /her own decision. I am not in that position as I am not completely sure as to what I would do but I would try to keep my children alive and love them very much.
9	(left halfway through the course)	
10	No, I don't think it is right to conceive a baby for the use of its body parts. Because the baby might not want to give the parts away but they don't have a choice if their parents force them to.	I would try to find a donor to give my child what she needed. There are many people who donate. I would use the `leading a virtuous life' ethical framework and try to do as much as I would to help the child. But I would not go as far as making a designer baby to give parts away.
11	I don't think it is ethical to conceive a child that meets specific requirements because it is not fair to the child they have only conceived for a specific	Balancing Rights – Everyone has the right to live and if it is concerning a child, then the parents have the duty to take care of their child and ensure that

	purpose. Every child has a right to develop normally→ they have a right to their own body and it isn't fair to the child if their genetic make-up is changed for a specific purpose. `Everyone is made and designed by God for different purposes and to `design' a person `eliminates part of the uniqueness'. Genesis 1:27 (made in God's image.)	they have the best life possible. BUT every unborn child has the right to develop naturally and without interference of new genes in the child's life. If I were Anna's parents, I would obviously spend money on the sick child, but genetically engineering a child should be avoided because it denies the child's uniqueness, and there could be many complications, like those in the movie.
12	I personally do not think it is ethic though I can see the motivation behind it by watching My Sister's Keeper in which this occurs in order to keep Kate the child with leukemia alive. I do not think it is ethical as it it disregards the child's welfare and only takes account of your own as it is not the child's choice but your own. She should be able to make her own choice. It disregards the donor child's rights. Right to live – for Kate Reason for living should not be reduced to just fulfilling a function – providing spare parts for the other Moral dilemma – concerns about rights	I believe if I were in the position of the parents that I would have tried to keep my child alive at all costs as they have a right to live. I might have even done the same things the Fitzgeralds did though it is hard to say if you are in that position. But I think even if I did have a child for that reason of saving another, I would have made sure that they never felt like spare parts for the other.
13	No submission	
14	I don't think it is bad but I think it isn't ethical to conceive a child for someone's medical purpose.	No response.
15	Left halfway through the course	
16	I don't think it is ethical to conceive a child that never meet the specific requirements because we only want	If I were the parents, I would have Anna as a NORMAL human baby not a designer one because the way you are

	them for transplant and transfusions to save another family member's life, not to love (in some people's cases, not all). Have a normal Anna and not use her to serve the purpose of helping her sibling	not using them for something they don't want. If I were also them, I would pray to God to cure Kate because he loves us all and all that is possible through Him who strengthens us but if he doesn't want Kate to live, that is His will, not ours.
17	I don't think it is ethical. How would you feel if you knew you were made with specific genes, and weren't special? The child could have self-esteem or mental problems.	Maximising benefits If designer child was able to save her sibling's life and survive, benefits would be enormous. It is worth the effort as two lives continue living instead of one. Making decision for yourself If the parents were to make the decision to conceive a designer child, they would have to be willing to go through it.
18	No it is not ethical. It ruins human nature to produce a baby with a specific genotype. As soon as it happens, a human is no longer human. It is a scientific experiment.	If she was my daughter, I would probably use pre-implantation diagnosis. This would only be done because it is my child. I would never want my child to die, and I don't think anyone else would either.
19	No, I think that everyone has responsibility over his or her own body Balancing Rights – I believe that the child we want to make has the right to provide or not provide her body parts to Kate. Kate also has the right to have a say.	Rights – I believe the child we want to make has the right to provide or not provide her body parts to Kate. Kate also has the right to have a say. Virtues – We shouldn't make a child just to help Kate. She probably isn't going to live as long as most healthy people anyway so maybe we should just let her go.
20	NO, I do not think it is ethical morally – the baby has a right although it may	Maximising benefits: Anna's parents may have only seen the benefits that

	maximise benefits for others, it may not for the designer baby. A child may feel used, just like Anna did in the movie.	Anna would provide. Designing Anna would provide benefits for the whole family but they may not have realised the consequences caused. Leading a virtuous life – they may have thought it would be fair on everyone.
21	I don't think it is ethical as the child knows they were designed, and not conceived naturally. They know they were made for a reason, and if that reason didn't exist, neither would they. Designer babies are not naturally conceived – hence not ethical Use moderation approach	Appeal to the judge's authority ` morals are more important than ethics; and love is more important than law.'  Empathy for one's situation: `No one could make a decision like this for sure unless they had to face a situation like this themselves'. If I was Anna's parents, I would make sure that she would be 100% to do all that is needed to help Kate. I wouldn't begin giving Anna operations when she is small, and too young to understand, but wait until she is older. I also wouldn't do it in excess.'
22	No, from a Christian perspective, the child is made in God' image and should not be altered.	Uses all ethical frameworks Balancing rights – Anna has the right to the decision concerning her body Utilitarianism – It is more useful if Anna gives her kidney to save the life of her sibling Making Decisions – Anna needs to make decision for herself Virtue – It is more virtuous if Anna gives up her kidney to save her sister. We all must respect her decision. Christian – We must respect the rights

		of the child, both Anna and Kate. I believe it is Anna's decision, but she must be made completely aware of all the facts.
23	No it is not ethical because then the child is a product of man and not of God and that child will lose it uniqueness.	If I were Anna's parents, I would be killing child in love either way so I might as well give Kate the kidney. The thing is that even with the kidney, Kate still has cancer and will die anyway so why make her suffer longer at the cost of her own sister's quality of life. I would not give Anna's kidney to Kate and just let Kate go.
24	I don't think it is ethical to create a child with specific requirements because the child has been created in the image of God and has been created by God. The command is not to be modified to do specific things to a specific person. Brings in divine created order `The child should not be modified to do specific things or be a specific person.' Concern about rights and choices Concern about quality of life (reduced for the designer baby Concern about feelings of Anna	If I were the parents, I would choose to not have a genetically engineered baby because the baby has been made y God the way it is for a purpose and a reason and its genetic structure should not be modified in any way. I would also consider not having a genetically engineered baby because all of its life it would be going through painful surgeries to help Kate live but that would not be fair to the designer baby. I would choose to find other donors who can help Kate because it would mean that the designer baby would not have a reduced quality of life.
25	I do not think it is right because it goes against the rights of the child. The child has no say in what happens to them. This method is also unnatural and not how God planned it to be.	Rights – It would not be right to make another child suffer for the sake of another, especially if they do not want to. Virtue: It is unfair to force a child to suffer, if they refuse.

		Christian morals – if a child with disease was dying, God would have a reason for it. The parents should pray and ask God for strength and wisdom. The parents should not have a designer's child. (confused with designer baby)
26	No because it will impact the child later in life, like it did to Anna.	I would have asked the doctor if there was a bone marrow match anywhere in the world.
27	No, because even though a child is created to donate to his or her siblings, they are still a life. They still have feelings, emotions and thoughts. Therefore, I do not think it is ethical to conceive a child to meet specific requirements.	I would not have created Anna in a dish just to help Kate. God has given Kate this disease for a reason and she was born to have that disease. I believe it is very unfair for Anna if she was designed to help her sister and were forced to donate things from her body.
28	I do not think that it is ethically right to conceive a baby that meets its parent's requirements. A baby is a gift from God. It is designed in God's image. It is not for imperfect humans to `select' a baby's genes. From the Christian ethical perspective, I feel that it is wrong. It could be compared to being discriminative of a person because of the skin colour. So I feel in the same way, people who conceive a child to meet certain criteria are being discriminative. Baby – a gift from God – designed in God's image Discriminatory act- so it is wrong Balancing rights – everyone has rights	Using a Christian Ethical Framework In the Bible, it says we should love one another as ourselves. If Mr and Mrs Fitzgerald loved their child Kate, they would do anything for her. If I were the parents, I would definitely ask God what to do. While I wait for God's reply, I would try to make my daughter's life as happy and as pain free as possible. Loving one another and asking God to show (discernment)
29	No submission	
30	No, it would not be right because you are destroying cells just because they do not fit your needs or wants.	It would be balancing the rights of Anna. It is the parents' duty to protect the children, and not just Kate. If Anna doesn't want to go through any more

		operations, that is her right.
31	No response	Maximising benefits – getting a designer baby would help the whole family Christian Moral – It is not really ethical to design someone in order to use her. Decision for yourself – The parents don't want their daughter to die so they 'd better get a baby designed.

Appendix 5A SUMMARY OF STUDENT JOURNAL ENTRIES – COMPARISON GROUP

STUDENT JOURNAL ENTRIES

Student No	Journal Entries
32	Lesson on Biotechnology 3 Aug I think I have learnt a lot about biotechnology and what it can do for our everyday living and it is also very useful. I found genetic engineering quite interesting because it shows how much technology developed these days. I would like to know more about human cloning. Using Frameworks 23 Aug I found the human cloning topic very interesting, and would like to know more about in vitro fertilisation.
33	Lesson on Biotechnology 3 Aug I learnt more about biotechnology and genetic engineering, cloning and how this is done with different organisms. I found genetic engineering interesting. I would like to know more about how the human body works, especially the different systems.' My Sister's Keeper 13 Sept We watched `My Sister's Keeper'. I think it is wrong to use someone to fix someone. She can make her own decisions. I found that watching the movie actually made me learn something (aspects of biotechnology). I would like to know more about how biotechnology can benefit mankind. Genetics Incursion 21 Sept I learnt that science career is a very large area, with lots of options to get involved in.
35	Lesson on Biotechnology 3 Aug I learnt what biotechnology is, and the many forms of applications. Debate on Effects of Gene Technology 10 Aug I found debating and working on different opinions of surrogacy and transplants interesting. It helps me see how everyone viewed things. Using Frameworks 23 Aug I have learnt what biotechnology and its different applications. I have also learnt ethical strategies and how to have group discussion. I enjoyed the group discussion and finding out everyone's opinion. Genetics Incursion 21 Sept I have learnt that the more you r cells divide, the more likely they are to develop

	cancer. I learnt more about mutations.
36	Lesson on Biotechnology 3 Aug I have learnt what biotechnology is, including xeno-transplants, GMF and biotechnology in agriculture. Using Frameworks 23 Aug I found the issues in abortion, designer babies and surrogacy interesting. I found it interesting – how sick people can be? What are people doing to stop these from happening?
37	Lesson on Biotechnology 3 Aug I have learnt much about biotechnology including IVF, stem cells and cloning. I think cloning, gene splicing and stem cells are interesting topics. Using Frameworks 23 Aug I have learnt about IVF, the processes involved , what a blastocyst is, and how they use it to make stem cells. I also learnt more about cloning and the different ways to clone cells, and DNA forensics. I have found cloning and gene splicing interesting as there are a lot of arguments about them, and the possibilities they provide. I would like to find out more about gene splicing. Debate on Effects of Gene Technology 2 Sept I have found the debate very interesting and just how everyone had a different opinion. I would like to know about debate on ethical issues. Most of us in the class answered the question from our Christian moral values. My Sister's Keeper 13 Sept I learnt the processes of gene technology and the ethical and moral side of this technology. Genetics Incursion 21 Sept I learnt how cancer develops and more about DNA sequencing and the way gene works – switching on and off. Also that science as a career is a good job – you get to travel around the world.
38	Lesson on Biotechnology 3 Aug I learned some things on biotechnology. I learned about the risks and the process of transplants and IVF, and to see if it is good and if it works. I have found the IVF and abortion thing interesting. I would like to know more about surrogacy and transplants.

	Genetics Incursion 21 Sept To be honest, I didn't really learn anything today because I have already been taught that stuff/
39	Lesson on Biotechnology 3 Aug I learnt about genetic engineering, genetic manipulation and taking getting information and putting it other cells. The cloning of animals and the switching on and off of genetic information are all very interesting. My Sister's keeper 13 Sept I notice that that biotechnology has gone very far. Issues such as `designer babies', having control over the design of your baby, eye colour, etc, and features. Genetic s Incursion 21 Sept I found out what people do in jobs concerning genes and how long it takes. It is interesting to know how many genes we have in our human body.
40	Lesson on Biotechnology 3 Aug I learnt more about IVF and blastocysts. I find genetically modified food as a topic quite interesting. I would like to find out more on cloning. Using Frameworks 23 Aug I found out more about IVF. The idea of creating `designer babies' is interesting. I would like to find out more and how in our modern era, parents can choose `assets' they want in their babies. Genetics Incursion 21 Sept I learnt what it is like to be a genetic scientist and some of the things they do in different countries and place all over the world.
41	Frameworks and `My Sister's Keeper' 13 Sept Over the past couple of weeks, we've been learning about certain forms of biotechnology such as cloning, gene sequencing, IVF and that kind of stuff. Before. I didn't know anything about it or what sort of terms mean and the steps involved. Now, I know heaps of new terms, what they mean and the steps involved. Before we started looking at the stuff to do with biotechnology, I wasn't interested in it at all. Though I know we have learnt more about it, it is now way more interesting to me. I have found most of the stuff really cool like IVF, cloning, ethics, genetically modified organisms. To my own surprise, I have actually found biotechnology and bioethics really interesting and I would like to know about bioethics issues and dangers within the field of genetic engineering. (*This is one of the weakest students in the class. Her results showed a remarkable improvement at the end of the term. She is hoping to do human biology in upper school.)*

42	Using Frameworks 23 Aug We look at various issues – abortion – many views - bad, okay, good. Genetic diseases can be passed on through a family for many years. I would like to know more about genetic diseases. I have learnt quite a lot on biotechnology – DNA and all that stuff – interesting.
43	Lesson on Biotechnology 3 Aug I have learnt lots on biotechnology. I also learned the process of how a person can get a genetic disease (eg, cystic fibrosis, breast cancer, colour blindness). What I found interesting is the way and the chances a person can inherit the genetic diseases. The things I would like to know more about are xeno-transplants, leukaemia diseases and more about the immune systems and why it fails to stop the genetic disease. Case study and use of frameworks 3 Sept What I have found interesting throughout the past few lessons are the ethical question concerning biotechnology and all its applications. They interest me on how they apply this sort of questions to their experiments. I would like to know more about the cures the scientists are trying to make concerning fatal diseases such as HIV and AIDS that have dominated many countries that have poverty. My Sister's Keeper 13 Sept I learnt that a baby can be genetically modified to do certain things (My Sister's Keeper). I would like to know more about how people respond when they are older and found out that their genes have been tempered with. Genetics Incursion 21 Sept What I learnt was that scientists are involved in the broad sense of the topic. They look deeper in the subject they're on than normal people would. I would like to know why scientists in particular don't believe in something overall other than their own projects. I thought the talk was good except when he said he believed in evolution. *(interesting comment, some sentiment sensed in the others as well.)*
44	Lesson on Biotechnology 3 Aug I learnt different applications of biotechnology such as agricultural and fermenting. I also learnt different definitions of new terms such as selective breeding, xeno-transplants and genetic manipulation. Also, I learnt the difference between traditional and new biotechnology. Using Frameworks 23 Aug I have learnt the risks of the process of transplanting organs and some of the issues around the world. I found it interesting that even a small foetus after it has been fertilised, has the ability to sense danger when getting aborted. I would like to know

	more about designer babies and the process of abortion. <u>DNA Profiling 2 Sept</u> I found the DNA profiling lesson interesting. I would like to know more about forensic in biotechnology. <u>Genetics Incursion 21 Sep</u> I found out that resurrecting extinct species are probably not possible because you don't know the base sequence of their DNA. I have some questions: Why do we get cancer these days? Live longer, higher chance of finding a cure for cancer, environmental influence, higher chance of genetic disease?
45	<u>Using Frameworks 23 Aug</u> Recently, I have learnt a lot about GM, and we today I Iearned a lot of people have different opinions about these issues. When we went into our groups and read an article and discussed it, it was interesting. I would like to know more about biotechnology, understand it and go more in depth. <u>Date unknown??</u> I have learnt lots on biotechnology and GM crops, in my opinion, is acceptable. I found what we did in groups interesting. I also learnt more about applications of biotechnology. <u>Genetics Incursion 21 Sept</u> I learnt a lot more about genes and DNA sequencing. Today's talk was quite interesting.
46	<u>Lesson on Biotechnology 3 Aug</u> So, I have learnt quite a bit about biotechnology, and I have also looked at the advantages and disadvantages of genetically modified organisms. <u>Using Frameworks 23 Aug</u> I found a couple of ethical cases quite interesting. It was interesting to see what people think about ethics etc. I would like to learn a bit more about the legal issues involved with GMO. I would like to learn more about surrogacy. <u>My Sister's Keeper 13 Sept</u> I have learnt about some of the more complex issues created by genetic engineering, especially within a family. I found it quite interesting to learn about the legal age that an individual has rights over their own body. I would like to learn more about surrogacy. <u>Genetics Incursion 21 Sept</u> I have learnt about some of the things that scientists do on a daily basis. I found the

	amount of DNA in the human body quite interesting.
47	Using Frameworks 23 Aug In the last couple of weeks, we looked at areas in biotechnology: forensics, selective breeding, cloning, genome research and DNA mapping. What I have found interesting – the different animals and human beings cloned. You can clone another version of yourself? My Sister's Keeper 13 Sept Most people don't feel like they would like to donate their organs to others in need. It also has an effect on the donor . Organisms should be cloned for the people who need organs. They are much better and healthier than those donated by humans?? (*Student appears confused here.)*
48	Lesson on Biotechnology 3 Aug I learnt that biotechnology was already in use a long time ago. It is possible to change a person or organism's genetic make-up. Things I 've found interesting is that it is possible to create an organism with mixed genes, etc. Using Frameworks 23 Aug I 've learnt that there are problems that are debatable, to do or not to do. I also learnt that biotechnology may be a big help to us but could also have cons which affects us. I've found it interesting how we can manipulate the bacteria DNA to create what we want (eg, insulin). I have a question – is it possible to use biotechnology without creating any problems? Case Study and use of frameworks 3 Sept I find it interesting that there are so many different choices and consequences to one thing. What would scientists usually do in such problems? Ethically, problems would only be created from the actions of the person who is receiving the information on whether he has the disease or not. Date unknown?? Some issues: Problems in abortion, surrogate mums/surrogacy, how unnatural it is to have surrogacy. Is there a safe way rather than abortions Genetics Incursion 21 Sept I learnt that genes are created through different order of bases. Also there are about 60 billion of them. All cells contain the same genes, but turns them on and off to perform or grow into specific cells. I would like to know if it is ever possible to resurrect an extinct animal?
49	Using Frameworks 23 Aug I learnt that some genetic diseases can be cured quite easily and they can be predicted.

	My Sister's Keeper 13 Sept Some people have different views on biotechnology. There are ethical issues behind biotechnology including biotechnology and the environment.
50	Lesson on Biotechnology 3 Aug I learnt about several biotechnology applications such as IVF, gene splicing, gene modification, what stem cells are and how they are used, cloning, gene therapy and germ line genetic engineering. I found cloning, IVF and the use of stem cells very interesting. I never thought we would be able to change our DNA. I would want to learn more about genetically modified foods (GMF) and the side effects and risks about genetic modification. Using Frameworks 23 Aug I learnt about all the different issues and viewpoints surrounding certain aspects of biotechnology which included surrogacy and donor organ transplants. I found the viewpoints especially the ethical and religious viewpoints interesting and some made me think twice about my viewpoint and whether I was thinking the right way. My conscience sometimes told me what I was thinking wasn't necessarily ethically right. I would find other viewpoints about these issues interesting and would like to hear other viewpoints about cloning and designer babies. Case Study and use of frameworks 3 Sept We did a few case studies involving moral and ethical issues. It was really hard to choose which way to go because there are positives and negatives for each choice. Sometimes, the Bible gives you guidelines but then they contradict our society's morals or the laws we have in place. For example, you have to obey your parents but then you have your own rights and are allowed to know whether you have a disease or not. I found the ethical issues, people's opinions and their reactions very interesting. I would like to know about how our society use the Bible's guidelines in our modern life. My Sister's Keeper 13 Sept I learnt about a number of different areas of biotechnology and how these can be applicable in the world today. We also learnt to think more thoroughly and think about all the positives and negatives before we make a decision about something. We now know how to ethically make the right decision and while doing case studies, we realised that it is not a straight forward path to choose which choice is morally right. I liked the movie `My Sister's Keeper' because it showed us how biotechnology relates to issues that can affect a family and how you feel about it in that situation. There is nothing more at the moment I would like to find out more except perhaps

	applying biblical views in our world. <u>Genetics Incursion 21 Sept</u> I have learnt that the longer a cell lives, so if a human were to live to 150 years of age, they would eventually die of cancer because the old cells would create mutations which could cause cancer to develop. I learnt more about mutations and how they can cause cancer.
51	<u>Using Frameworks 23 Aug</u> Many people have some sort of physical problem and no one is a perfect human being. What I have found interesting: Many people have more than one transplant and are continuing to have more which blocks other people having it. (Referring to Claire Murray?) It is a question of struggle with money. I would like to know more about genetic diseases. <u>Case Study and use of frameworks 3 Sept</u> I found many facts on my research very interesting and got me thinking. <u>My Sister's Keeper 13 Sept</u> I would like to know more real life stories on the topic of science. My Sister's Keeper is a good example. <u>Genetics Incursion 21 Sept</u> I learnt that doing science takes a long process. It is very difficult and take years to do research. Science is sometimes interesting ☺!
52	<u>Date unknown??</u> I have learnt a lot of interesting things like genetics and a lot about the human body and its functions. What I found interesting in biology is genetics, watching videos and seeing how things are formed. I would like it if we learned more about muscles and bone because it will help me later in life (*student is a very athletic one; representing the state, perhaps national soon, in a particular sports).* <u>Case Study and Use of Frameworks 3 Sept</u> I found genetic research most interesting of all. Genes play a massive role in genetics. Finding out what type of genes someone has is researched in biotechnology. It is very useful because people can find out if they have a genetic disease or disorder. It is important for them to know. <u>Genetics Incursion 21 Sept</u> I have found out that Mr R is intelligent in arguing against evolution.
53	<u>Lesson on Biotechnology 3 Aug</u> In biology this week, I have learnt a great deal on biotechnology. The topics are mainly given in the Science Aspects text. I have found it all interesting. Cloning, stem

	cells and gene splicing! The three topics stated above- I mean you could create a superhero! <u>Debate on Effects of Gene Technology 10 Aug</u> In the past week, I have learnt a lot about the ethics involved with biotechnology. I never knew ethics can be this complex. I have a lot of this interesting, and the debate was one of the most interesting of all. I would like to know more about using biotechnology for good. <u>Using Ethical Frameworks 3 Sept</u> I would like to see some real ethical cases which have been resolved. I believe seeing others' opinions would help us express better our viewpoints. I found the debate and group work interesting. I've dealt with our ethical issues through discussions and by looking through Christian viewpoints and morals. <u>My Sister's Keeper 13 Sept</u> I 've learnt that biotechnology raises a lot more problems than I thought; namely, the ethical issues behind biotechnology and the real ethical cases – I meant in real life. <u>Genetics Incursion 21 Sept</u> I learnt a great deal about genetic diseases and science as an occupation.
54	<u>Lesson on Biotechnology 3 Aug</u> This week, I have learnt a lot about therapeutic cloning and the way it is used. <u>Using Frameworks 23 Aug</u> This week in biology, I have learnt how to make decisions on particular situations. The ethics behind each situation and how to decide which way to go. From the reading of several articles, I found the way people live and abuse their organs very interesting. I find the way people use biotechnology to please themselves, very interesting too. There is nothing else I would like to know more about; it has all been covered. <u>Case Study and use of frameworks 3 Sept</u> This week in biology, I have found the decision-making sheets very interesting. This helps me to make a choice about a specific topic. I would like to know more about real life applications in biotechnology. <u>My Sister's Keeper 13 Sept</u> From the film we watched last week, I learnt how important it is to make decisions independently. And I appreciate the factors that do affect the decision making process.
55	<u>Date unknown??</u> What I have learnt? That you can add DNA to a cell to get the desired effects.

	What have I found interesting? That you can make a mouse glow in the dark. What are some things I would like to know more about? Splicing genes safely and painlessly? <u>Using Frameworks 23 Aug</u> It is a big ethical issue to abort a baby. It is interesting that they use a suction device to get the baby out of the uterus. I would like to know more about using biotechnology for good. There are many ethical questions being asked and some are answered wrong.
56	<u>Lesson on Biotechnology 3 Aug</u> I have learnt that genetic diseases can be picked up from the baby when it was in the embryonic stage, and how there is the possibility of changing genes! I have also learnt about surrogate mothers and how this is done, some with IVF. I have found learning about cloning interesting because I didn't know how it was done and was surprised to find that they had successfully managed to clone animals before. I never knew that cloning actually happened. I would like to learn more about how babies with genetic problems might be able to change and get better through biotechnology advancements and how ethical this is. <u>Case Study & use of frameworks 3 Sept</u> I have liked viewing the ethical situations which some people have been placed, and the different options that are made available to them. How it is not always money based, you need to consider other facts. It is hard to know what you should use. The different ways of thinking, etc. I would like to know how they actually made these discussions in hospitals, not just how we think they should. What it is actually based on in real life? The way we have been taught is a good way of thinking through different decisions and how we should choose them. It makes sure we consider all the options available, and if we are chasing the best one. It makes it easier to evaluate. <u>My Sister's Keeper 13 Sept</u> An IVF child can lead a normal life but the reason they are born cannot always be in the best intention for the child. I found the movie interesting and the things that happened in it. Also I think the ethical problems are real problems. I would like to find out more about the legal rights a child has if the parents have complete control over the child. Who has the right to the body? <u>Genetics Incursion 21 Sept</u> I have learnt that you can travel as a scientist and meet lots of different people. Also, you can have help from lots of people in different fields.

57	Lesson on Biotechnology 3 Aug I have learnt about traditional and modern biotechnology, the genetic engineering, the risks from gene technology and the biotechnology and medicine, and the environment. I also learned more about stem cells, the IVF, etc. What I have found interesting? Selective breeding. I did not personally know that most breeds nowadays were cloned by selective breeding as the whole time, I believed they were pure breeds. Another interesting subject is stem cells. It would be nice if we are able to learn more about biotechnology and look at different subjects similar to biotechnology in biology. Case study and use of frameworks 3 Sept The raised ethical and moral questions and issues regarding biotechnology were really interesting. I found that biotechnology can be very interesting because it involves many different things such as genetic testing, selective breeding and many others. I would definitely like to find out more on genetic testing, the ethical and moral issues of biotechnology and many aspects of this field. My Sister's Keeper 13 Sept I learnt that babies can be genetically `modified' to help someone. That watching movies is actually learning. Genetics Incursion 21 Sept What I learnt is that many scientists desire to know and look deeper into the subject than normal people do. I want to know why scientists don't believe in anything except evolution and their work? I fell asleep halfway but overall, I was not interested in cancer.
58	Using Frameworks 23 Aug I learnt that biotechnology can help us all. It comes with both good and bad points. Biotechnology can benefit people who suffer from certain diseases and gene disorders. I believe it will be a big breakthrough in science. I found gene technology interesting. I also found breeding interesting mixing certain sub-species and having a new species. I would like to know more about genetic cloning. My Sister's Keeper 13 Sept There are ethical issues in biotechnology. We need to look at human rights (the control we have over our bodies, for example. I also learnt that we can identify the faulty genes for a disease.
60	Date unknown? I learnt what biotechnology does and how it is applied. I found it interesting that there is a lot of things that can be manipulated. Using Frameworks 23 Aug I learnt about some issues with surrogacy, abortion and other stuff such as gene

	splicing, etc. I found it interesting how the egg and sperm can be brought together outside the human body. <u>My Sister's Keeper 13 Sept</u> I learnt some things about gene modification, gene splicing and gene therapy. I would like to know more about genetically modified plants and animals and why people think they are good for the environment.
61	<u>Lesson on Biotechnology 3 Aug</u> I have learnt about IVF which is artificially fertilising the egg and the sperm in a laboratory and stem cells that can divide and grow into specific cell types such as nerve, heart, muscle or bone. It is also interesting to find out more on cloning which is making copies of existing cells or person. We have also learnt about gene therapy and gene splicing. Everything we have learnt this week, I have been interested in. <u>Using Frameworks 23 Aug</u> I have learnt all the different things that involve when a woman gets an abortion, the mental and the ethical side to it. What I have found interesting is that people think there is a right and a wrong time to have an abortion. Some say it is a human after fertilisation; others say it is a human when it starts to look like a baby, but to me, even if it is just fertilised, it is still a living thing, a human and it has a right to live and not die. Just because the mother doesn't want it, maybe someone who can't have kids, might like to have them, so than it can still live. <u>Case Study and use of frameworks 3 Sept</u> I found the ethical points of some case studies interesting. We can see what some people would do and how they would react to each case. It was hard to choose because there were positives and negatives of each case. <u>My Sister's Keeper 13 Sept</u> We have learnt the ethical points of biotechnology. We also learnt that it is unethical for an IVF child in some situation to live in the movie. I found the ethical and moral points raised very interesting. I would like to know about what scientists are trying to do about diseases and cancers and how they solve such issues. <u>Genetics Incursion 21 Sept</u> I learnt that it is almost impossible to bring back an extinct animal because you wouldn't know the way to present them? I learnt that science is a group thing where all different people from different countries come together to work on something they are all interested in.
62	<u>Date unknown?</u> Before this, I didn't know what biotechnology was. I did know a bit about cloning and other things but not too much on them. Almost all my knowledge of biotechnology has come from the last few weeks.

	I enjoyed the debate we had on effects of gene technology. I have also enjoyed the lesson on ethics. I would like to do more ethics. I would like to do more practical work and experiments. <u>Date unknown? My Sister's Keeper 13 Sept possibly</u> I learnt all about ethics in biology. In the movie, we watched and learnt all about ethics involved in donating organs. I found the move interesting; I found all the stuff on ethics interesting and it made me think. I am happy with what I've learnt over the term. If I had the opportunity to study in future, I would. <u>Genetics Incursion 21 Sept</u> I have learnt about what people who study genes do. I find it interesting to know how long it takes to find a mutated gene and how cool it is when they find it. It is very cool. I thought it was cool when they travelled.
63	<u>Date unknown?</u> I learnt about certain biotechnologies that are productive and helpful. I found it interesting that you can make a mouse glow in the dark. I would like to know how to do gene splicing safely and painlessly. <u>Date unknown?</u> I learnt that breast cancer can be inherited; and some other cancers do. I would like to know how to get rid of these genetic defects before birth without terminating pregnancies. <u>Date unknown?</u> Some types of cloning are alright. I find it interesting that you can clone parts of your body but not the whole thing. I would like to find out more about biotechnologies that can save people's and animals' lives. <u>Date unknown?</u> I learnt that resurrecting an extinct species is possible. I would like to find out more about this.

Appendix 5B SUMMARY OF STUDENT JOURNAL ENTRIES – EXPERIMENTAL GROUP

STUDENT JOURNAL ENTRIES

Student No	Journal Entries
2	Debate on Effects of Gene Technology 6 Aug Today I learnt about the views of people concerning the benefits and downfalls of gene technology which were shown in the content of a debate (which I had not prepared for). I hope the opposition side team really do not think that way of gene technology. I would like to know some of the risks of gene technology which do not concern gay offspring and terrorists. I think we cannot presume that people in research positions are irresponsible. Class on Argumentation and Reasoning 11 Aug Today I learnt about the deductive and inductive reasoning by Dr T. He explained the reasoning process and the ethics of scientific study. We also discussed several articles on biotechnology in groups. Ethical Frameworks 17 Aug Yes, I think it is useful in helping me make decisions. I found the exercise interesting as it showed other opinions. Case study on Clinical Trials 20 Aug I learnt about the issues of clinical trials in medicine in the context of people needs and got a chance to apply the ethical reasoning process. I also learnt about how people may alter embryos for certain characteristics. Use of Ethical Frameworks 31 Aug Today I was able to use what I had learnt about the ethical frameworks to help support my decisions and viewpoint on the subject of embryo use. My Sister's Keeper 3 Sept Today, I saw `My Sister's Keeper' which concerned about many ethical issues such as rights of your body and genetically engineered life. It opened up a lot of questions and issues in the way concerning our topic of biotechnology. It was also a good break from class. Role-Playing Session 10 Sept Today, I was able to role play in front of the class and noticed that everyone is afraid of any risks involved with gene technology. I enjoyed role-playing and debating. DNA Profiling Lab 15 Sept

	Yesterday, I learnt about DNA profiling and was surprised at how relatively simple it was and how laid back the guy(the presenter) was. I would like to ask him why he chose to do what he does and whether or not he still enjoys it. <u>Genetics Incursion 21 Sept</u> Today, I got to see what kind of prospects a biological science career could lead to and the kind of people who get into this.
3	<u>Lesson on Biotechnology 2 Aug</u> I learned interesting facts about DNA and also some uses of stem cells. I found group activities interesting and helpful. I would like to learn more about selective breeding and its current applications. <u>Class on Argumentation and Reasoning 11 Aug</u> I find it interesting to learn how arguments are constructed and the section on ethics also. I also found out how to see different approaches at work. I want to know more about organ transplants. <u>Lesson on Genetics and Clinical Trials 20 Aug</u> I learnt about the different types of genetic diseases which can be passed on. I think the lesson was very interesting and informative. I would to learn more designer babies and its implications. <u>Lesson on Genetic Screening 24 Aug</u> Today, I learned more about ethical issues on pre-natal screening. I found it interesting how people approached the issues. I would like to find out more about ethics and their implications. <u>Use of Ethical Frameworks & Christian views on biotechnology 31 Aug</u> Today, we learned more about the Christian viewpoint on biotechnology. It was interesting how biotechnology can be tied in with Christianity. I would like to learn about the viewpoint of Christians towards biotechnology. <u>My Sister's Keeper 3 Sept</u> Today, we see how diseases affect not just the person, the family and friends as well. I found it interesting to see how much struggle a family goes through when affected by such a dilemma. I would like to know how much pre-implantation screening actually occurs. <u>Role-play 10 Sept</u> Today, I learned more about the applications of biotechnology and more views people have from the panel. I would like to learn more about the economic effects of biotechnology. <u>DNA Profiling Lab 15 Sept</u> I learnt about DNA extraction and found it interesting the way DNA is extracted. I

	would like to find out more on gel electrophoresis. What is your opinion on the future direction of biotechnology?
7	Class on Argumentation and Reasoning 11 Aug I learnt that ethics are very important and they enable us to have decent discussions in class. I would like to listen to Dr T more about this in future. Case Study and Debate on Organ Donation 11 Aug I learnt the ethics of organ donations as we discussed the example of a young mother who was addicted to heroin and even after a liver transplant, she still used the drug and needed another asap because the liver had failed her again, and she was thus denied having another. So we had fun debating on how we should treat her. It was quite an enjoyable session. Ethical Frameworks 17 Aug We learnt about the scale of where ethics belong in biotechnology/ genetics and after a range of subjects, I agreed mostly with the greater good, the more personal benefits! Yes, about the use of ethical frameworks, it helped me to understand how it works. It was a fun exercise today because the class was involved and so was their opinion. Lesson on Genetic Screening 24 Aug Having an activity to be able to use or express our own opinion is a lot better than just reading and answering questions/ comprehension type. I look forward to more ethical (ours) activities in the future ☺ My Sister's Keeper 3 Sept After ethical activity was interesting, and getting a bit repetitive, I am glad to see the slide show. Role Play 10 Sept Role-playing was very fun, and I enjoyed it- note the part that I wasn't too serious but serious enough to make my point across.[This student actually dressed up for his part, and very well indeed.] If everyone did not go just for one guy, we would have more time to listen and understand and then may be more people would have put their hands up. I enjoyed this and wouldn't mind doing this again. I talk a lot, I talk without shame. I don't care if everyone is sick of me. I just want to have a good time. DNA Profiling Lab 15 Sept The experiment was a very good experience. I think we use really good quality equipment – not something we do every day. Now we are learning biotechnology, I enjoyed this very much. I hope we can have more guest talks! Genetics Incursion 21 Sept Today I had a good time listening to the presentation given by biology university student. I learned that genes can be switched off. I was surprised by it but it is

	very interesting as I did not the presentation could be so very good.
8	Lesson on Biotechnology 3 Aug We have learnt about different things that are involved with biotechnology. For example, cloning, gene splicing, genetically modified foods, selective breeding and genetic engineering. We have learnt how to take DNA out of strawberries. I find it interesting learning about how cloning and gene splicing is done. The procedure of doing it and also the reasons behind doing it. I want to learn more about organ transplants, how it works and what it all works out for. Debate on Effects of Gene Technology 6 Aug Gene technology was the topic, and I was for it. In our opposition, there was a question raised about what would terrorist do if they got their hands on the technology. What if they create a disease that will kill us all? The matter of cloning also came up. Is cloning only about the outside appearance or do you also get a personality? I want to know more about cloning and what it is that you clone exactly. Class on Argumentation and Reasoning 11 Aug I learnt how to start an argument in a good way. How to reason properly? What are the type of questions that needs to be asked when research. Reason has to relate to conclusion/ Inference Ethical Frameworks 17 Aug Yes, the ethical frameworks help me to think more in-depth about the question that is asked. It helps with the understanding of the question and it is a natural way of thinking so it is easier. When a question/issue does not seem to relate directly to any of the ethical frameworks, then it is harder. Lesson on Genetic Screening 24 Aug I learnt that the ethical issues involved with genetic screening, such as the results are positive for genetic diseases, then it can lead to abortion. Designer babies can be made with the technology of genetic screening. We learnt how to work through the `problem' of genetic screening and see how the five ethical frameworks can be used to think through the problem. Use of Ethical Frameworks & Christian Views on Biotechnology 31 Aug Today, we did two case studies and also discussed some Christian views on biotechnology. As a Christian, I believe that biotechnology is not bad because it can help us but if we misuse it, then it can be dangerous.

	Role-play 10 Sept Our role-play/ debate on GM food was successful and very enjoyable. Most of the class was against GM food for now. More research needs to be done. I was representing a group of concerned farmers who did not really know if they want to support GM foods or not. I think more information to be discovered before GM food should start to be produced. (*Student has forgotten that WA is no longer GM free.)* DNA Profiling Lab 15 Sept We did a practical with Gary C, the scientist who ran the workshop. It was so interesting and we learnt how to be accurate in measuring small amounts. It was hard not to break the gel but it was really fun. We learnt lots about DNA and the profiling process. Genetics Incursion 21 Sept Today in biotechnology, two medical researchers gave their talks. There were lots of interesting facts on biotechnology and how to get into the field. DNA all put together will reach the moon and back 1500 times! We also found out how being a researcher can take you all over the world.
11	Lesson on Biotechnology 3 Aug I have learned the definition of biotechnology and how it involves using living things to create products and do tasks for humans. There are two main branches of biotechnology. Old/ Ancient and new biotechnology (I found it interesting that biotechnology has actually been practised for many years.) I have also learnt a lot of modern biotechnology and how it involves altering genes, eliminating the gene or adding new genes to the organism. I have also learnt that there are many applications of modern biotechnology in industry, food, agriculture and medicine. It can be used to help economy by altering the genes of a sheep, for example, to provide better quality wool, thus improving the economy on a gradual scale. Genetic Engineering/ modification of food is a topic of great debate which shows some promise but we don't know enough about it. Yes, it has advantages, such as speeding up the process of things and improving the nutrition and quality of a plant, and it doesn't always include introducing a new gene, but sometimes just changing one of the existing genes, changes the genetic expression. I find the process by which foods are modified interesting, for example, being able to silence a gene completely. I would like to know more about how GM foods would solve issues of the world – such as poverty, and if using genetically modified food was completely necessary, and if any other methods could be used. I would like to know more about ethical dilemmas of cloning as well, and why cloning has become of such interest to our society. Debate on Effects of GM Food 6 Aug It was interesting today to see the views of others about why or why not gene technology would be beneficial. I still think that we should be cautious about gene technology because while it may show promise, I think that we should be aware of the health risks especially. Today it was said that God gave us wisdom to change things. Well, didn't God say that what he had created was good?

	Shouldn't we be taking responsibility and actually caring for the earth? I think that we are playing with fire when it comes to cloning and designer babies. What good can come out of this and how will cloning help us in the future. There was mention on how GT would be disastrous if fallen in the wrong hands of the terrorists, but how would they be able manipulate if there are no specially trained scientists? <u>Class on Argumentation and Reasoning 11 Aug</u> Today, we learnt about the reasoning process from Dr T. We learnt about inductive reasoning which starts at the specific and moves to the general and deductive reasoning which starts out generally and moves to the specific. Inductive reasoning is most commonly used in science. He taught us about the basics of ethics and what they were used and what we had to be careful of when we are working in an experiment and what ethical standards we had to be aware of. This afternoon, we also looked at a case study of Claire Murray and why or why is she not deserving of a new organ transplant and some of the policies that the government would try to put in place. <u>Ethical Frameworks 17 Aug</u> EFs are helpful, I think, in making decisions, because behind every decision, we used reasons to justify them. So using ethical frameworks, would come naturally to most people, because don't we use ethical frameworks in all decisions that we make even if we don't recognise it? Using ethical frameworks is an effective way of dealing with case studies, because they provide a reason to justify the answer. The case study exercise was interesting although slightly confusing because of the new terms used. <u>Lesson on Genetic Screening 20 Aug</u> We watched a video on genetic screening and discussed some ethical issues raised. If you found out that your unborn child had a genetic disorder, why would you have an abortion? If you see a child with a disorder in the public, you wouldn't kill it? It is unfair on the unborn child. Obviously, designer babies are a concern because they would provide unfair advantages to people who are rich, and eventually it may create a race of superior people and I don't think it is fair that genes would be selected- it is an unnatural process. <u>Use of Ethical Frameworks & Christian Perspective of Biotechnology 31 Aug</u> Today, we looked at the Christian perspective of biotechnology. I think I agreed with most of it, but I am not sure about using biotechnology to solve problems that have been caused by humans or other causes such as disease because the view could be biotechnology becomes a way of salvation for people when man is not able to offer salvation, only the divine power of God could. We looked at a case study about using embryos for research which I don't think is right because an embryo ends up being killed and they shouldn't be considered as something to play with and men discard this when research is over. We should speak up for those who cannot speak for themselves, and in this case, this definitely applies to embryos –who have no voice.

	Role-play 10 Sept I think that role playing is an interesting way to learn more about the views of other people as they step into the role of another character. The role play was entertaining and it was interesting to see other's views and the information they found as well as mixed with their own opinions. I did learn quite a great deal on GM and the pros and cons from this session but some aspects are a bit confusing. DNA Profiling Lab 15 Sept Yesterday, we had a scientist came in to do a DNA profiling with us. I had a good time because it gave us the opportunity to see how biotechnology actually applies to science – so instead of just learning about DNA profiling, we see how it was done and do it ourselves. It was fun to be able to use the micropipette. Watching and performing the application of biotechnology makes it more interesting and relevant to the course because we can see how it applies Genetics Incursion 21 Sept Today we had two medical science researchers coming in to present to us. They showed us how science is a global discipline and involves lots of collaboration to succeed. We saw how far the technology has advanced, the equipment they used for their experiment and research. I learnt some interesting facts about DNA and how our DNA was long enough to stretched to the moon and back 1500 times.
12	Lesson on Biotechnology 3 Aug I have learnt a lot from Biotechnology this term and I think that learning about biotechnology has put things into perspective for issues such as genetics, ethics and religion and made me realise how important little things are. What I found interesting in this unit so far has been the fact that you can splice and mix species together to make different species or that organisms can be genetically modified. However, I believe this is wrong as well as the idea that people will be able to choose what their child looks like and what they will be good at. I do not like this as people should be allowed to be who they want to be and not what their parents choose for them. I would like to find out more about their areas of genetic manipulation and forensics in DNA profiling. Debate on Effects of GM Food 6 Aug I found the debate today interesting as some people didn't say very much while others said a lot and nothing at the same time. Though I don't think the debate has changed my view on biotechnology (GM food?) because there were still a lot of questions they didn't answer and topics they didn't address. However, I think that as the course continues and the more I know and understand about biotechnology, the more these questions will be answered. But today, you could see how much people jump to conclusions by not having the complete picture. This was seen when people based their conclusions on nothing but an idea or concept which was pretty funny as some of them couldn't get to the point they were getting to and went too far. Class on Argumentation and Reasoning 11 Aug The class did not help me understand ethics too much. However, it helped me

understand how to structure arguments and why scientists used inductive reasoning when investigating things. Though I did find the slideshow in today's biology lesson a bit more interesting because they were information that really interests me.

Ethical Frameworks 17 Aug

Using EF in anything (in any case study?) , I think there is no right or wrong answer and so many different answers that coming to a conclusion can be difficult. So I don't think using ethical framework was useful as it seemed to give me even more possible answers to choose from then just my own ethics and point of view. Though the exercise was interesting looking at how pharmaceutical companies use ethics committee to decide on some issues. I think this is effective as it is independent to the drug companies.

I also have a question. Can an already transplanted organ be donated again?

Lesson on Genetic Screening 20 Aug

Genetic screening can be a good or a bad thing depending on the circumstances in which it is used. This is the case as some people have abortions if the child has a genetic disease which can be detected through genetic screening – which is wrong as everyone deserves a chance of life. However, these that aren't aborted are often at a disadvantage due to their genetic disease which can shorten their lifespan. So it is hard to determine whether everyone should use genetic screening or not as there is always the chance that people will be influenced by the result or keep their baby because of it.

Use of Ethical Frameworks & Christian Perspective in Biotechnology 31 Aug

I found the Christian ethics and objections to biotechnology interesting as they seem quite relevant to today's society despite the Bible being written some two thousand years ago.

Role play 10 Sept

Today, I would have to say the best biology lesson! It was so much fun. The role play was the best. It started off calm and a little boring but it get better when people started debating the issues brought up. The person whom everyone wanted to stop bring up facts probably was Daniel as he almost wanted to object to everyone. Though Vass seemed a little stiff which was kind of funny. I would like to do another debate if it is possible to give people a chance to express their beliefs and understand other people as well as listen to them. I also find it makes people question their beliefs more.

DNA Profiling Lab 14 Sept

The DNA profiling experiment was probably the one I was looking forward to the most as I think it is interesting the way they do it. I found the presenter Gary C. from UWA helpful as he explained very clearly to us what we were supposed to do. Also I realised how this could be used in different situations – in paternity

	testing, in forensics, etc. <u>Genetics Incursion 21 Sept</u> The talk by Richard A. and Karina P. was rather interesting. They explained where you can go with science and the different career options. It was a very helpful session, and I would like to hear more from people who are involved in different areas of biotechnology.
13	<u>Lesson on Biotechnology 2 Aug</u> I learn about DNA, more about stem cells and areas of uses and applications. I found interesting the part about stem cells and selective breeding. I hope we can delve more into selective breeding and examples of them. <u>Debate about Effects of GM Food 6 Aug</u> I learnt about how a debate works. There were lots I learnt about gene technology. Although there were some illogical comments during the debate. I hope we can do more debates. <u>Ethical Frameworks 17 Aug</u> Yes, the EFs are useful because I now have a reasonable framework from which to base my decisions on. I found today exercise far more interesting than usual. I love debating and forming opinions. Yes. <u>My Sister's Keeper 3 September</u> I learnt about the ethical dilemma (in real life situations) that families face. This situation in the story was extremely difficulty –quantity or quality of life I found interesting the almost impossible situation and conclusions drawn by all the characters – Kate, Anna, the judge and Mrs Fitzgerald. Pre-implantation diagnosis is a very big issue in gene technology and also the ethics of it – very interesting and relevant topic.
14	<u>Debate about the Effects of Gene Technology 6 Aug</u> Today, we debated if gene technology is good and it is because it saves people's lives and also consider how we should use the technology. People should stop being afraid of the unknown and experiment because it has already saved lives in third world countries. <u>Argumentation and Reasoning 11 Aug</u> Today with Dr T, we talked about ethics and reasoning. There are two types of reasoning – inductive and deductive.
16	<u>Lesson on Biotechnology 6 Aug</u> Today, I learnt that genetic engineering has both positive and negative points in the world today. What I really want to know is how will the future turn out and what will the future look like?

	Argumentation and Reasoning 11 Aug I have learned about ethics in science and organ transplants, and how to tell if a person is really dead. I found it interesting to know the difference between an argument and an explanation. Ethical Frameworks 17 Aug I have learned about the 5 ethical frameworks and how they affect people's views on things such as drugs, etc. I would like to know how people use ethics in very tight situations. It is interesting that there are five ethical frameworks and not one. Lesson on Genetic Screening 20 Aug I have learnt about genetic screening and some information about designer babies. I would like to learn what God think about cloning and designer baby. What I found interesting is the people's choice to kill a baby (or embryo?) with a defective gene and not love them for who they are and what they' ll be. Use of Ethical Frameworks & Christian View of Biotechnology 31 Aug What I found interesting were the views of Christians such as C S Lewis and the discussion that followed. I would like to know what God has to say about the use of biotechnology. My Sister's Keeper 3 Sept I have learned that only You can make your own choice, and not anyone else. I admired Kate's bravery. She is not scared of death. Why are we all scared of death when it is where we all end up? Role playing 10 Sept I have learned about the rightness or the wrongness of using GM crops. It was interesting to hear all the different views on GM crops. I can't decide which speech was the best. I wonder what life would be like without biotechnology? Genetics Incursion 21 Sept I learnt more about genetics and the different fields of biotechnology. What I found interesting was the royal family inbreeding. I found out more about staining cells, etc.
17	Debate on effects of Gene Technology 6 Aug I think the debate was a great way to address some of the key issues in gene technology today. It was a good way to voice some of our own opinions concerning gene technology as some people brought up side effects such as terrorism and cloning for gay couples. The debate has given me a deeper understanding of gene technology and it helped me see the issues through other people's eyes or in a different perspective. Lesson on Genetic Screening 20 Aug I think that it is amazing how advanced today's technology has become eg

	designer babies. But I also think that before we rush in to take advantage of the technology, we should look at the implications, mental and religious of using GM technology. <u>Role play 10 Sept</u> I think that instead of putting billions of dollars into GM food research, the government should make sure that the money has currently been put into solving world hunger is used properly and effectively. <u>Genetics Incursion 21 Sept</u> The presentation was very informative. It showed how intricate and broad genetics is. It has improved my knowledge on the different career pathways involved with genetics.
18	<u>Debate on Effects of Gene Technology 6 Aug</u> Today in biology, we had a debate. We each had 4 speakers on each term. My team speakers were VA, JM, RVA and I. I spoke about how gene technology will benefit us all, and how we need to think of new ways to tackle new problems that our world is facing each day. The opposing team mentioned a few good points but I think the benefits outweigh the problems of gene technology. I think we need to confront the problems of our time with whatever solution is possible, including gene technology. We need to think of the future, and not dwell on the past. <u>Class on Argumentation and Reasoning 11 Aug</u> Today we had two periods talk on ethics and the way we think (reasoning). Dr T introduced two new terms to us – inductive and deductive reason. Both are complete opposites of one another. We learnt how with each statement, there must be a reason. He also told us about the `Holy Grail of Science'. In the last two periods, we argued whether Claire Murray deserved the second liver. I don't think she did. <u>Ethical Frameworks 17 Aug</u> The use of ethical framework is very helpful because it gives a caring and informative decision on important medical decisions. Although at times, it may not be the most well-informed decision if the ethics committee is not made up of a panel of different backgrounds and moral, with religious views. <u>Lesson on Genetic Screening 20 Aug</u> Today in biology, we talked about ethical committees which made decisions about important medical problems. We also learnt about prenatal screenings which can detect disabilities and disease in a baby which isn't even born yet. We also argued about it being right or wrong for healthy people to take part in clinical trials if given a certain amount of money. I think it is ok as long as the person is aware of the danger and it is their decision. <u>Case Study Analysis 31 Aug</u> Today in biology, we did Case Study 5. I went against the use of healthy embryos

	for scientific purposes. <u>My Sister's Keeper 3 Sept</u> Today in biotechnology, we watched the rest of `My Sister's Keeper' which tackles the issue of pre-implantation diagnosis and the rights of one to their own baby. <u>Role-play 10 Sept</u> Today in biotechnology, we had a role-play. I was the Speaker no.1 – Jeff Bitstryp. I stand for the production of GM foods. Our society is already struggling with the concept of food rations in many countries. Every day, farmers struggle with producing healthy crops in large numbers. If GM foods will solve this issue, why is not being used? I found the role-playing exercise very useful and would like to see it used more frequently in the field of science. <u>DNA Profiling Lab 14 Sept</u> Today in biology, we did DNA profiling with Gary Cass from UWA. He showed us how gel electrophoresis works. It was very nice and educational and I liked it a lot. We had steady hands and it was easy to use the micropipette to inject dye in to the gel wells. <u>Genetics Incursion 21 Sept</u> Today in Biology, Richard A. and Karina P. came to talk to us about genetic mutations and diseases. I found it very interesting and helpful as it taught us things we didn't know yet. I would like to see more of these discussions become available for us students.
19	<u>Debate on Effects of Gene Technology 6 Aug</u> Today, I learnt what different people's ideas are on gene technology, and whether or not the benefits of it outweigh the negative points. I am still unsure of whether GM food is completely safe even with the tests in labs being done on them. <u>Class on Argumentation and Reasoning 11 Aug</u> Today, I learnt how to give valid arguments and to reason. I learnt about inductive and deductive thinking and how ethics are different all over the world. <u>Ethical Frameworks 17 Aug</u> Yes, the use of ethical frameworks was helpful to a large extent. I found the exercise helpful in explaining how we should make ethical decisions. Yes, it is. <u>Lesson on Genetic Screening 20 Aug</u> Today, I learnt some of the advantages and disadvantages of designer babies and different types of genetic diseases. I also learnt different issues about genetic screening.

	Use of Ethical Frameworks & Christian perspective on biotechnology 31 Aug I am aware that there are various Christian viewpoints on biotechnology. I also made my ethical decision on whether it is morally acceptable to do research on discarded IVF embryos. My Sister's Keeper 3 Sept Today, I learnt the ethical complications in the story `My Sister's Keeper'. I learnt that we should always listen to what everyone has to say before making an important decision. Role-play 10 Sept Today, I have heard many different views on biotechnology. I was interested to see that there are still some people against biotechnology. Genetics Incursion 21 Sept Today, I learnt about the different benefits of becoming a scientists and what sort of courses are required to become one. I learnt facts about genetics and cancers.
20	Lesson on Biotechnology 6 Aug In Biotechnology, I have learnt that genetically engineered products are not necessarily completely artificial as only the DNA structure is changed. There are other applications of biotechnology and also there are risks involved in GM foods. I found cloning and how it is done quite interesting. I liked reading about crime scene and forensics and how we could use so much biotechnology in our lives. Debate on the Effects of Gene Technology 6 Aug At the debate today, I learnt the huge effect that biotechnology has on the world. Although I was only on the proposition, I not only learnt about the good effects, many questions were raised about issues that I did not even think could happen. I learnt how powerful we are in this world. Biotechnology is starting to scare me a bit… maybe we should stop learning about it?? Class on Argumentation and Reasoning 11 Aug Today, I learnt about reasoning and ethical decisions in life and in science. I learnt about inductive and deductive reasoning and reflected on how ethical issues can cause dilemmas and problems in communities and culture. I learnt that ethics and biotechnology link very well with medical decisions in society. Ethical Frameworks 17 Aug Ethical frameworks have taught me how to make ethical decisions in an orderly way. I realised that using the ethical frameworks does not give you the answer, but guides you to the decision you want to make. I enjoyed learning about animal rights and pharmaceutical ethics because they are both points of interest to me.

	Lesson on Genetic Screening 20 Aug & 24 Aug The Clickview presentation showed the point of view of how wrong genetics can be. I really think that some things relating to biotechnology about babies are disturbing and wrong. Genetic screening and its link to ethics has made me realise how ethics is widely linked to science. Using the ethical frameworks, it has made me realise how difficult it can be to make a decision, and sometimes, I find myself linking to scenarios to ethics with none or all the frameworks. Use of Ethical Frameworks & Christian view on biotechnology 31 Aug Today, I did not really learn anything new. The debate we had weeks ago covered some of the Christian perspective on biotechnology and the case study was just one more practice of the use of ethical frameworks. Although I did find myself finishing in five minutes, it shows that I really understand how to use the frameworks. My Sister's Keeper 3 Sept I did not realise but now how much I have actually learnt on biotechnology. At the beginning of the movie, when Anna was explaining how she was a designer baby, I realised I understood every word. I think my understanding of ethics and biotechnology really made me understand and appreciate the movie better. DNA Profiling Lab 15 Sept The DNA gel electrophoresis workshop was quite enjoyable. I did enjoy learning about how forensic scientists did their work and doing a cool practical. Gary was pretty cool. I did wish we had more time. I would have enjoyed watching the electrophoresis kit a bit more.
21	Lesson on Biotechnology 3 Aug I have learnt a lot about biotechnology this past term as I hardly knew or understood anything about biotechnology beforehand. I find biotechnology quite an interesting topic. In particular, I find all the different branches of biotechnology interesting: selective breeding, application of micro-organisms, genetic manipulation, genome research, gene technology in medicine, DNA sequencing, fermenting, transgenic plants and animals, genetically modified food. Human Genome Project, stem cells and xeno-transplants. They are all very interesting. I would like to find out more about different branches of biotechnology. I could learn more about them individually and in-depth. Debate about the effects of GM Food 6 Aug Interestingly enough, I learnt quite a lot from the debate we did today. I didn't learn something `new' as such but I learnt to see things from different perspectives, in particular, genetic modification. I was able to see people's arguments; who were for, and who were against. It was also interesting to hear the reasons for the way they feel about the subject and how strongly they feel. Also, the angles and the sides in which they approached the subject, there was

	great variety. It was also quite fun. <u>Class on Argumentation and Reasoning 11 Aug</u> Today, I learnt all about reasoning and ethics. I learnt about deductive and inductive reasoning and thinking. I also learnt the difference between argument and reason. <u>Ethical Frameworks 17 Aug</u> Yes, the use of ethical frameworks was helpful. To what extent? It is the right amount of frameworks, enough to help me out. If there were less, it wouldn't be quite as helpful, and if there were more, it would be too confusing and too long. <u>Use of Ethical Frameworks & Christian View of Biotechnology 31 Aug</u> Today, I learnt about the Christian viewpoints on biotechnology. It was interesting as there were several different views on different aspects of biotechnology. <u>Role-play 10 Sept</u> The role play today was very good. It was quite entertaining, and it was interesting to see people's opinions on biotechnology and how they expressed themselves through their debates and through their role playing. <u>DNA Profiling Lab 15 Sept</u> I thought the DNA profiling lesson was very interesting and enjoyable. Gary Cass from UWA taught us how to do the profiling. It was good having a professional come into our classroom and tell us all about it. It was surprising how easy the process was and the reality was anyone can do it, not just professional scientists. It was a great practical and helped us all get involved. I know and understand more about DNA profiling and how to do it. <u>Genetics Incursion 21 Sept</u> It was very interesting and informative having two more professionals come in to talk to us. They told us about their careers. Richard A. is a geneticist and Karina P. studies colon cancer (research student) and all that they do in their jobs. It was quite good.
22	<u>Lesson on Biotechnology 3 Aug</u> I learnt a lot about biotechnology and how we change genes. The process of sequencing and cutting DNA in lab is interesting. <u>Debate on Effects of Gene Technology 6 Aug</u> I learnt a lot about the different views on gene technology and how differently

	people see it. The debate was very interesting and the many views were actually rather funny. We need more debate time to finish the points. <u>Class on Argumentation and Reasoning 11 Aug</u> I leant how to present a good argument, about people's opinions, ethics and a lot about ethics in science. The speech by Dr T was interesting and so were the different opinions by others in class. I would like to know more about the chemistry of organ transplants. <u>Ethical Frameworks 13 Aug</u> It was helpful in presenting views and show how it works in one place. The exercise was very interesting and I thought it was rather effective use of ethical frameworks. <u>Lesson on Genetic Screening 20 Aug</u> I learned some more about genetic screening and how the technology really works. The different views presented on the abortion of sick babies were interesting. Perhaps, a more current video on the latest genetic screening technology can be used. <u>Use of Ethical Frameworks & Christian View of Biotechnology 31 Aug</u> The lesson was helpful in presenting different Christian viewpoint. The Christian viewpoints were slightly different from mine and certainly very interesting. A debate on this may be a good idea. <u>My Sister 's Keeper 3 Sept</u> The ending of the movie were both helpful and interesting….(student could explain more… maybe time a factor). <u>Role play 10 Sept</u> This was a very interesting, amusing and educational exercise. It was fun to see how some people argue their point (*we have some interesting characters in the class*). <u>DNA Profiling 15 Sept</u> Lesson was very interesting and helpful. It allowed us to use lots of different equipment. <u>Genetics Incursion 21 Sept</u> I learnt more about how science works and the courses offered at the university.
23	<u>Lesson on Biotechnology 3 Aug</u> I learnt about what biotechnology is and how it affects us in our daily life. Before, I didn't know there existed such a thing like biotechnology through I knew some components about it. I found the gene manipulation really interesting, and would love to learn more about it. What interested me was how you are able to manipulate a cell and how it could be used to help us in many aspects of life. I

	would like to find out more about gene technology. <u>Debate on Effects of Gene technology 6 Aug</u> There were quite a number of points raised that I don't agree with. Cloning is a bit strange because several times the point was raised about a big population. Why do we want to clone things and make an even bigger population? Also, we live in a changing world and these genes have to be tested in labs and in isolation, so will they stay the same or change with different environment. Also gene technology may be good, my worry is that with great power comes great responsibility. We have great knowledge and great power but do we take responsibility for something or will we when something goes wrong? The interesting part was all the information given as part of the debate. I would like to learn more about the way food is modified, and animals and learn about superbugs and how they work. I have a question – does GM food affect our body and are they able to `place' themselves in our body and cause us to change? <u>Class on Argumentation and Reasoning 11 Aug</u> It was a very interesting lesson with Dr T. I think the session really helped me look at the way I think about an idea. The ethics he introduced were interesting but I don't quite understand how they apply to biology. I think I may understand how this may apply to life later on. In the afternoon, it was also a very interesting session. I learnt how to apply the ethics and reasoning taught me in the morning to real life situation. The newspaper story and article was also very interesting. I learn more about organ transplants and how it affects the body. <u>Ethical Framework 17 Aug</u> Today was very enlightening. The ethical frameworks are really interesting and represent the more popular ways of thinking. I don't quite understand how to use them for some issues, like the 2nd case study, for eg. <u>Lesson on Genetic Screening 27 Aug</u> I don't think that genetic screening is wrong in itself; rather the fact that it causes the death of so many children. We are able to manipulate bacteria so why can't we do something about this defective gene. Isn't it possible to use gene therapy to correct the gene or protein that causes it? <u>Use of Ethical Frameworks & Christian view of biotechnology 31 Aug</u> The session today taught me the Christian viewpoints on biotechnology. I found my beliefs quite similar to those expressed. I also found the two case studies we had to do, quite difficult. I can now understand the viewpoints of these people better. I also think that I now understand how to apply these frameworks in any and every decision I have to make. <u>Role play 10 Sept</u> I really enjoyed the session today as made me think about biotechnology from all points of view. In the past, I have always been against biotechnology but today,

	considering all the things I learnt, some areas of biotechnology are great – like the genetic disease research. I would love to learn more about this area, and there are areas that need to be considered a lot more – such as gene modification in plants and animals. DNA Profiling Lab 15 Sept The DNA profiling session yesterday was extremely interesting. I would love to be able to do that as a job in a lab somewhere. I was a little sad that we did not get to see the gel electrophoresis and it was unfortunate that there was too much dye and we could not see the banding pattern. Genetics Incursion 21 Sept The presentation today was very interesting. What I found most interesting is the talk about changing genes and cancer research. I would love to learn more about cancer and the mutations that take place. It is also nice that you get to travel around the world with science and that's something I've always wanted to do.
24	Ethical Frameworks 17 Aug The criteria are understandable and helpful and help you understand the area of ethics better. The exercise helped me understand the concept of ethics better. Lesson on Genetic Screening 20 Aug My view on genetic testing and babies had changed after I saw the documentary but I do agree with testing to get rid of diseased genes but I don't agree on designer babies. Use of Ethical Frameworks (Case Study – Genetic Screening) 20 Sept There was so much crammed in today and I couldn't process it all in my brain. (*JS is a special needs student; perhaps more time is permitted here for him).* Use of Ethical Framework & Christian Perspective on Biotechnology 31 Aug I haven't really learnt or changed opinions on anything today. Role Play 10 Sept I find that role plays are engaging to be a part of and to watch. Genetics Incursion 21 Sept I had insight today on what working on different fields of science would actually be liked and now I am a bit more interested.
25	Lesson on Biotechnology 3 Aug In today's lesson, I learnt about the benefits of genetic modification and also the bad points. I only knew of the bad points so it was good to find out some of the benefits as well. I also learnt why genetic modification causes such a debate. I found it interesting that different organisms use the same DNA code but have similar genomes and also genetic modification may have side effects. I would like to learn what Australia has done for the development of GM and how involved

they are. Also what other countries are involved.

Class on Argumentation and Reasoning 11 Aug

Today, I learnt about deductive reasoning and inductive reasoning and how we can use it in biology. I learnt all about ethics and what values people have in society. I also learnt the codes and policies in ethics. From the example given, I learnt that swans are found in every continent – there are black and white swans.

In the afternoon class, I learnt what transplants are, what types and who can be a donor. I also learnt how transplants take place.

Ethical Frameworks 17 Aug

The ethical frameworks were a little useful in discussing issues / cases because it showed what you need to think about when making an ethical decision. I found the exercise today helpful as it shows me about frameworks. It can base my decisions on when it comes to ethical issues. It also shows me what others might base their decisions on.

Lesson on Genetic Screening 20 Aug & 24 Aug

Today, I learnt about genetic screening and how you can predict if a baby will have a genetic disorder while still in the womb. I learnt about different genetic diseases and how they are formed.

Today, in biology, we continued with genetic screening. I learnt how to do a concept map to represent these issues as well.

Role play 10 Sept

Today in biology, we watched a role play that some students put on about GM foods. They were divided into two groups – farmers and consumers, who all had different opinions on the issue. I think the role play was an interesting way to discuss GM foods because it meant less work, and was at times, entertaining. *(So class work can be really `hard' work for some students*). I don't think people should be given such a long talking time because it got very repetitive and frustrating. I think we should do more role-plays in the future which is more of a story and less of an argument, as this would be more entertaining).(*We have a drama student speaking aloud here! On the record, this class is generally quite a well-behaved class!).*

DNA Profiling Lab 14 Sept

I think the experiment on DNA profiling yesterday was really good. I enjoyed being able to put our research to the test, by actually taking part in what we had been reading. I got to understand how DNA profiling actually works.

Genetics Incursion 21 Sept

Today's biology lesson, we had a presentation from Richard A. and Karina P. who are both medical researchers. I found the presentation interesting because I got to see how biotechnology techniques are actually used today and what careers can come from that. I learnt that genes can be turned `on' and `off' in different cells. I found it amazing that all DNA in a human can be stretched to the moon

	and back 1500 times!
26	Lesson on Biotechnology 5 Aug In science, I have learnt a lot about biotechnology. I have learnt about the applications of biotechnology and how it affects me and my future. I have learnt how biotechnology affects the society and about the benefits of the applications of biotechnology such as genetically modified foods. I have learnt that biotechnology can help cure sicknesses in the future and even change the genetic material to replace defective genes that carry diseases. I have also learnt about ethical and environmental issues associated with biotechnology. I have found it very interesting to learn about how cells are cloned or genes can be inserted into bacteria so it will produce human insulin to help people suffering from diabetes. I find it fascinating that there are so many ways biotechnology can help the society. Now gene technology can be applied to forensics and used to solve crimes. Everything I have learnt this term has been so interesting because up till now, I had never known biotechnology and how it affects us but now I have learnt so much biotechnology in this course. I am more aware of the things going around me and the issues going on in my society. I would like to learn even more about how biotechnology will affect me in the future and become more aware of the decisions I will face with in the future, for example, decisions concerning genetic engineering. I would like to learn more about the issues associated with biotechnology and its applications and I would really like to go into more detail on issues such as ethical issues. Debate on the Effects of Gene Technology 6 Aug Today the debate made me realise a lot about the issues involved with gene technology. I found that gene technology is such a broad subject and that it has the ability to not only help us, but it can also harm us. It was really interesting listening to everyone's view on gene technology and the debate helped broaden my view and opinion on gene technology. Gene technology has led to so many great discoveries but I don't think it is very natural because God created us the way we are – with the characteristics and genes that we have – for a purpose and reason and I don't believe that our genes should be modified when they have been given to us, and I believe the way they are – for a reason. I also don't like how gene technology can affect animals and how it is so unstable and it is not totally safe. I really enjoyed the debate because many of these views and opinions could be brought up and discussed. I enjoyed learning about whether gene technology is good or not. Class on Argumentation and Reasoning 11 Aug Dr T's talk was really helpful because it helped me understand how to reason and how to think about certain processes in science. The things I learnt this morning will really help me in biotechnology because a lot of reasoning and viewpoints need to be discussed and the issues involved in biotechnology. The newspaper article I read in science lesson today about Claire Murray and her second chance in having a liver transplant helped me understand how to apply reasoning because I believe that Claire shouldn't have been given a second

	chance because she abused her first transplant and wasn't responsible for it. The discussion about the article and listening to others' opinions and reasoning also helped me learn more about the issues involved in biotechnology. <u>Ethical Frameworks 17 Aug</u> Learning about ethical frameworks was really helpful today because I now know how to make decisions about the many issues we are faced with today or may face in the near future. The frameworks provided a basis on which I can hold my views and also a basis on reasoning with decision I make about the ethical issues brought up. I did not understand the case study about the pharmaceutical companies and what patents had to do with the ethical issues. I didn't understand what the medical ethics committee had to do and the decisions they have to make. Do they make decisions on who would be volunteers in the clinical trials? I read the case study again and I think I now understand a little better. It is really interesting because there are so many issues that we face in society and the decisions to be made. It is hard to know what's right and what's wrong to base our decisions on the frameworks. We need to understand why something is right or wrong and how our values affect our answer to the question. <u>Lesson on Genetic Screening 20 Aug</u> I learnt a lot through the lesson today. I enjoyed using the frameworks to view my opinions about the ethical issues involved in pharmaceutical companies and the medicines they are trying to develop. It was really interesting listening to the discussion and thinking of which in which pharmaceutical companies can develop to aid poorer countries instead of `fake medicines'. I also liked learning about genetics and reproduction because there were so many issues raised about preventing diseases while embryos are still developing and how using embryonic cells that are healthy and placing them back into the womb, can make the embryo develop normally and healthily. It was interesting to hear of real life cases in which mothers use tests to determine if their baby is healthy and the decisions they have to make. <u>Case Study 27 Aug</u> I learnt a lot about applying ethical frameworks in my decision making when it came to situations and cases that raised many issues today. I like how we are doing all sorts of different cases because it is so interesting learning about the many issues in our society and how we would make decision if we were in that person's shoes or in that situation. I also liked the task we did. We were to write a letter to Professor Cuckle because it gave me an opportunity to express my views on the issues and on the case about genetic screening which can lead to the abortion of the fetus. <u>Use of Ethical Frameworks & Christian views on biotechnology 31 Aug</u> Looking at the Christian viewpoints of biotechnology was really interesting today because it gave me a greater understanding of how God would view the issues of biotechnology and what he thinks of it. It also helped me consider things from a

	wider perspective and from a different point of view because many times I have looked at the benefits and risks of biotechnology to form my opinion on whether it is right or wrong. I am looking forward to doing more case studies because up till now, I had never really known what ethics was or how to make decisions if I was in someone's situation. I have learnt so much and I like learning new things which is why I am looking forward to the case study on `My Sister's Keeper'. <u>Role Play 10 Sept</u> The role play was really interesting because it helped me realise all the issues and risks that could come out of genetically modified foods. Even issues I didn't consider like companies who produce these plants and genetically modified foods and how there is the possibility of the plant being reproduced which will cause problems amongst companies and businesses. The role play helped me see how genetically modified plants affect not only the production of the plants and the consumers of the food but also the farmers who harvest the foods and use them as a profit to earn their living and money. (Greater appreciation for the different and diverse roles involved). Genetically modified food causes so much controversy yet it is only one part of the many applications of biotechnology. Imagine how many more issues arise if other applications of biotechnology are used. (getting a global picture of things!) <u>DNA profiling Lab 15 Sept</u> Yesterday's workshop was really interesting because I learnt how DNA profiling is done and how it is used in many things such as crime to determine the relationship between people. It was also a good experience because I haven't done DNA profiling before and it was interesting to work with DNA and to compare the barley that was modified with the standard barley. A question I have is what kind of work this person gets to do and how they got to where they are. How did they become a researcher for genetics? (Expanding to science career) *Another question is what is the most interesting part of what they do in their career?* *Who decides on whether applications of biotechnology will be used or introduced?* <u>Genetics Incursion 21 Sept</u> The talk today by Professor Richard Allcock and Katrina Price was so interesting because I got to hear about genetics and biotech from people who are experienced in it and who knows a lot about it. It was interesting because I would see the many issues that are going on right now, especially about the diseases that can be experienced that I hadn't heard of before. It was also interesting learning more about our DNA and how complex it is. Colon cancer was another interesting topic because I hadn't thought of that ever being that kind of cancer and it was interesting hearing about how Katrina (Ph D student) studies this cancer and the research they do to identify diseases and

	how they are caused. I liked listening to how they are helping many people through the research they do because they can help identify how diseases are cause and find treatments and cure in the future.
27	Lesson on Biotechnology 3 Aug During this class, I have learnt many things. At the beginning of the term, I did not know anything about biotechnology or what the definition was. But now, I am introduced to many more biotechnology terms and definitions. I leant what IVF, stem cells, cloning, gene therapy gene splicing, genetic engineering, selective breeding, GM foods and modern, traditional biotechnology meant. I found DNA sequencing really interesting because it shows us a bit about technology in the future and how we can possibly even pick our children's appearance and features. I would like to find out more about DNA sequencing. Class on Argumentation and Reasoning 11 Aug Today, I learnt that only black swans are found in WA. But during the last two periods of the day, I learnt many things about organ transplants. We discussed the newspaper article on Claire Murray and I learnt there is no age limits to donating organs. The heart, lungs, skin and bone can be donated. Ethical Frameworks 17 Aug I think the ethical frameworks are easy to follow and it covers all areas of making a decision on life. I think the ethical framework on virtue and Christian belief are the most important. The exercise today was easy to follow and effective. Lesson on Genetic Screening 20& 24 Aug Today, we learnt about reproduction and genetics. This area is really interesting to me, especially designer babies. There are so many ethical questions to be considered with genetic screening. I personally that this practice of altering genes is wrong. It is changing God's creation. Genetics incursion 21 Sept Today's presentation was really interesting.
29	Debate on Effects of Gene Technology 6 Aug I think the debate helped us get a better understanding of gene technology. It also lets us think in a different way on different view on how we should debate on gene technology, considering others and how we should treat others and have respect for their points of view on technology. Ethical Frameworks 17 Aug We use ethics in everyday life, and I did not know that. The purpose of ethical framework gave me and stretched my knowledge and potential of opinions and situations. I learn how to give or state my point of view. Next time, I would have to plot or offer my opinion, I can use the ethical framework as a `tool' to develop my point into a more understandable one (or relevant one?)

30	Lesson on Biotechnology 6 Aug So far in biology, we have looked at what biotechnology is and some of its uses. We also learned in what areas biotechnology has changed and also possible improvements. We also learnt that there are ethical issues behind biotechnology and possible dangers. I would like to know more about the ethics involved behind biotechnology before we continue further. Class on Argumentation and Reasoning 11 Aug Before the class on argumentation, Dr Y gave us a placemat activity. It was ingenious. I learnt that are so many different areas of biotechnology that I have not even considered. The lesson on deductive reasoning is a small part of ethics in biotechnology and that it can be implied for other areas of life. Ethical Frameworks 17 Aug Today, we learnt about ethical frameworks. This has been helpful and other people's views matters and not just your own. This has also strengthened my view on genetic manipulation. This is helpful as a guide but my decision should not be based on this entirely. Lesson on Genetic Screening 20 Aug & 24 Aug Today I learnt more about genetic screening and ethics. It was an interesting and a good lesson. I have a broader understanding about the ethical issues – thanks to the example given. There is more than one way to decide. These are very good examples – very useful. Use of Ethical Frameworks & Christian View on Biotechnology 31 Aug All we did today was some Christian viewpoints on biotechnology. I have been looking forward to this for a while. For decision making, this is helpful. Otherwise, we can do more case studies. My Sister 's Keeper 3 Sept We watched `My Sister's Keeper'. It is a good case study and once more, it is good to see another area of biotechnology. Role Play 10 Sept We did role play today. It was so much fun! It was really interesting – so good to see all the different views. DNA Profiling Lab 15 Sept Yesterday, it was a great session. It was good working with the micropipette. I really understand DNA profiling better. I have two questions – What areas are there in gene research? What subjects do I take to get into gene research? Genetics Incursion 22 Sept Speakers Richard A. and Karina P. have been extremely informative. It showed me another side of science that is so interesting. It showed me that scientists interact a lot with one another and from all over the world.

Appendix 6A NOTES TAKEN FROM INTERVIEWS – COMPARISON GROUP

Date	Teaching Strategy / Activity	Students' Observations	Teacher's Observations
10.8.10	Dr M T. Deductive vs Inductive Reasoning Logical progress of argument – process → conclusion Successful – how? To what extent did the students get it?	Engaged, Enjoyed the exercise	Need for more on ethics Will supplement with one more period How can different group of scientists come to different conclusions about evolution? Al Gore – climate change; global warming Use of graph in a balanced way Debate was a helpful way of engaging kids Think back over argument yesterday. Good to start with a debate prior to teaching ethical reasoning Build on an ethical basis in the 2nd debate
16.8.10	Relief Teacher (Mrs H) Don away Students were generally on task with the placemat activity Behavioural issues with some.	Collected students' work (PMI) Most of the placemats were half completed after the two periods.	

23.8.10	DR Christian Response to Ethics • Sanctity of life • Conscience • Golden Rule – love for God and neighbour as yourself • Others vs selfishness • Word of God • Justice/ Truth • Fear of God and Wisdom Newspaper article – My Bad Children don't deserve donated organs Drug crusader urges State to lend liver mum transplant cash Discussion – digital recording on Form D		Teacher's observations: DR – regroup the students – break the boys group mentality, facilitate discussion Student- speaking up against the general viewpoint (on forgiveness) Most convicted about reference to a girl with late term abortion (jailed) unrepentance ; justify because she is a party girl
24.8.10	Organ Transplant Committee Choice of 4 – based on age, family responsibility and limited means and no of dependants A,G,F,H DR noted there was none for E (Aids) and I. He commented on Hitler getting rid of Jews- old, sick and mentally retarded Second – Asthma -	Students' observations – see collected worksheets Need to establish some guide questions to facilitate thinking Students clamped in when teacher joined in the discussion Interesting comment; Assumption about Greek nationality, Aborigine (student said perhaps drugged out) Assumptions coming with certain stereotypes and categories	Note that for asthma activity; introduction was to find out how many had asthma in the class (6 out of 31) close to figure 1/6 of Australian population- highlight the importance of asthma and its effects Caesarean babies – higher risk of

			asthma Note that there was not much scaffolding into the activity due to time factor
26.8.10	**26 August Thursday** **Year 10 Biological Science DR's Class P7 and 8** Class did the case studies on Cystic Fibrosis and Genetic Population. Not very engaged as it was the last 2 periods of the day. Response was not as desired. Suggest mental activities best near the beginning of the day).		
30.8.10	**Monday Period 3 and 4** Completed Case Study on Huntington Disease Also completed DNA in the Football Field		
1 September Wed 2 September Thursday	Biotechnology on Line - Interactive		
6 Sept Mon	Watched My Sisters' Keeper DVD 1 hr 10 min		
7 Sept Tues	Watched the remaining of My Sister Keeper 30 min Work on Answer sheet	Questions posed by Researcher – refer to notes on Class Discussion	What kind of ending do you like? And why? What are some

	Class's discussion with Researcher – taped `D' Pizza Lunch		issues you gather? What is the core issue? Put yourself in the shoes of Mr and Mrs Fitzgerald, what would you have done? If you have the chance to use gene tech to improve your family genes, what would you do? If the quality of life has ceased, is it better to choose the way of death" Would you and why? Bringing God in – to wait and trust, is it necessarily the most loving thing to do in that circumstance when Kate is in dire need.
Lunch Interviews	Interview with three students	Most enjoyable was the DNA extraction and organ transplant committee exercise. Case study engaging because it has to do with real life situations, like Claire Murray. Debate was good. Student thinks biotech is quite separate from human biology. Point out the huge connections	

	Interview with three students	necessary Student used the pro and cons framework and found it useful. Easy to use or user friendly. Controversial issue – genetic engineering Conversation brought in God-gift – tampering with it. Christian values – significant in all case studies 2 students think that the Christian input is prevalent in all case studies. DVD presentation – most enjoyable; entertaining and presents a good ethics message? Student– issues to deal with in the future in a career Case study – best done in small group discussions 1 case study per period is good Studying ethics certainly motivating and engaging Fun	DR gave a short presentation on Christian values in ethics studies.

		Talking helps to memorise the facts KM discover his audio-visual learning style Yes, Christian values are strongly considered in all cases Important for parents to make informed choices Parents ignorant about stem cells and the technologies involved with Kate in the story Students seemed at a loss to talk about a range of ethics issues Need for more hands on and experiment sin biotechnology Refer to students' worksheets on My Sister Keeper	
9 September	Completed Biotech On Line Exercise		
13 September Monday	Completed Post Questionnaire Except for a student	Round 1 – Boys Most enjoyable activity – DNA extraction and yeast	My observation – generally quite quiet, perhaps time has lapsed since the

		activity	last activity
	Conducted Interviews with three students	Debate	
		Interest in agricultural – not covered as much	Preference for hands on activities for DR's class
		Student – keen on IVF and gene technology	
		Mentioned My Sister Keeper without prompting – DVD – relevant, engaging	
		Round 2 – Girls	
		Likes class interactive exercises, small group discussion, appreciate different view points	A little passive perhaps I don't teach them...
	Interview with three students	Student– ethical choices in ethical survey was good	
		Case studies – helpful personal views of others considered	
		More focus on genetic diseases and gene tech would be good	
		Not much on GM food	
		Nicole – wants to	

		know the legal side of things; ethics	
14 September Tues	Meeting with DR – reflection notes, etc. See Interview with DR's notes on 15.9.10		
16 Sept Thurs	Interview with DR's students Enjoyed the guest speaker G Cass; wants to see more incursion Hands on; interactive – vital debate Like conflict situations where resolution can take place through talking through and reasoning DVD – entertaining, engaging, less paperwork Small group – good – feedback and appreciation of everyone's point of view Figuring our problems together Increased level of interest – 7 – 8/10 Controversial issues – GM Food and Designer babies **Interview with Students** Most enjoyable – guest speaker G. Cass, Hands on/ interactive Debate/ conflict Controversial issues – opens a		

	whole new realm of seeing things Interest level 6 – 6 ½ and 7/10 Controversial issues – use of human life Creator/ GM food, weighing both benefits and risks *solving third world countries issues (Student– keen to want to talk about these issues) **16 Sept Thursday** **Interview some students** **3:15 - 3:25 pm** Most enjoyable – DNA profiling (take into consideration this is just what they have done two days ago) Student – marks has improved because of greater involvement / engagement with the biotech field. All three agreed that they thought biotech was going to be boring, but were surprised all interesting it has become. Engagement with the subject of Science has definitely increased - 8/10 Enjoyed the ethics part (felt that the biotech teaching session was just a bit too long; wants to engage a lot more ethics) incorporated in		

	the course (this is interesting considering the fact that this control group merely uses a simple template; and did not do the case study booklet like the experimental group did) These three students obviously would enjoy more case studies analyses. Enjoy the discussion and the sharing of opinions Even doing the gene technology in forensics would be fun Also recognise that bioethics has much overlap with psychology. Wished Dr T. had covered more on ethics (so students remembered what he said) Debatable issues – Genetic Modified Food ***Ends abruptly due to dismissal bell***		

21 Sept Tuesday	Geneticist Professor R. A. and C. P. 1 hour talk (pair presentation) Gave DR the teacher's evaluation questions to provide written response	Well received To read students' journals Interesting talk about IVF with speaker; had IVF with his wife and choose not to contribute embryos for research or for destruction but stored at cost of $600 per year – to follow up talk with DR	

Appendix 6B NOTES TAKEN FROM INTERVIEWS – EXPERIMENTAL GROUP

Date	Teaching Strategy / Activity	Students' Observations	Teacher's Observations
4 Aug Wed	**Preparation for Debate** Gene Technology is Good for Us 3 opposition teams, 3 proposition teams Time – 30 min	Excited Student 1– talks about genes altering one's attitudes towards Student 2 Possibilities of gene to influence consumer's thinking Students referring to teacher's or text notes in discussion. Scribe's notes collected – to be reviewed	
6 Aug	Preparation time – 20 min Getting into the role and structure *Let's Debate* – Greg Paul with Adrianna Phillips – LIFE SKILLS (2009) Pearson Education UK	Students are beginning to ask questions, and some really good questions. What does cloning really involve and what is it that you clone exactly. Appreciation for the variety of views and opinions and different perspectives. Appreciating pros and cons Factors – fear of the unknown	Keen participation Each round – 20 min Student uses understanding of cloning to rebut – still has a soul and spirit, person can be influenced by the environment (AP, VA) Imaginative – cloning bad people, social implications, propagating gay people progeny, Abuse in Olympics **Use of Scripture – God's given wisdom to improve mankind**

			and quality of life **Stewardship** **Uniqueness of God's creation** Terrorism – use in biological warfare Concepts of genes in isolation and interaction with environment awareness.
9 Aug	Plus Minus Interesting Chart	See student's work	
10 Aug	Good Parent Feedback on Biotechnology Project- Illustrated Booklet **Talk by DR M T (2 Periods)** Premise Reason -----→ Conclusion Argumentations - statement clear and concise and valid statements Valid argument Validity – is it true or balanced? Does my conclusion agree with my argument? Reasoning – Syllogisms Moon is yellow; cheese is yellow So moon is cheese **Deductive Reasoning – General to Specific** **Inductive Reasoning - Specific to General**	Students seem engaged. Will view journals	Ethical dimension is somewhat not targeting at controversial issues but on research and experiments. Next time – indicate to Tayler to focus on socio scientific issues Of relevance were social responsibility, animal care and human protection.

	Dialectic Inductive Rational Processing Bottom Up Approach – Inductive – Empirical – involves all senses Isaac Newton – Specific – General Ethics, Values, Scriptures, expectations What culture is good or bad> Polygamy, opposite ethics Cultural norms Ethics – grey area Meta-ethics (about ness) Ethical – social responsibility Animal care – vivisection – test of non-toxin products		
17 Aug Tues	Introduction to: Ethics in Biotechnology Powerpoint **Ethics and Ethical Framework** Case Study 1 Work in class Case Study 2 – Pharmaceutical companies	Student's Observations Animal Research Student– Use Virtue Framework to justify C. Student- Use Maximising Benefit to justify A Emma S –Use balancing right to justify B (5 min) Student– ethical framework seems to provide more options than one can cope with.	Student– natural guiding process in using ethical frameworks Student – better to use virtue and Christian character Point of choice of any five ethical frameworks – emphasised

		Student – Good point – don't we all use ethical framework to some extent without realising using them Student – framework enough to work around with Student – helps to focus more on the issue at hand Student– found the framework reasonable Student – easy to navigate around Student – understandable and helpful Student– help in making decisions; exercise enabled him to appreciate other opinions Student – useful to a large extent Student – useful & helpful Student– helps to think more in-depth about the question that is asked. It helps with the understanding of the question and it is a	So the next question is how a greater awareness of using them (meta-cognitively) enhance the thinking process

		natural way of thinking so it is also easier To what extent? Harder when a question does not seem to relate to any of the ethical framework Student –would like to know how people use ethics in very tight situations Interesting to find out five instead of one ethical framework Student - Ethical framework gives a caring and informative decision on impt medical decisions. Student– It has taught me how to make ethical decisions in an orderly way Topics on animal research and pharmaceuticals were of interest to me. Student – it helped me understand how it works It was a fun exercise today and the whole class was involved. Student– helpful as it	I wonder if this is linear thinking. Can we help student to relate and make the connections with ethical framework a little stronger

		shows other people view point and strengthen my view on genetic manipulation Student – easy to follow and covers all areas of making a decision. Also reliable? I think ethical framework on virtue and Christian belief is the most important. Exercise today was easy and effective Student– ethical framework stretches my knowledge; help to develop my point – render an opinion that is relevant and understandable.	Important to choose topics of interest to students It helps student to appreciate the breadth of frameworks and appreciate others' viewpoints.
20 Aug Fri	Review Case Study Obligations of Pharmaceutical Companies	Q1 Student– balanced view points from the community View of public opinion Legal aspects addressed Q2 Healthy individuals – Student– clinical trials require affected individuals Student– results caused by affected individuals	Students need more prompting to appreciate the wider context (include social, economic, etc.) Will be duly considered as part of research design the variables

			Prompted students on choice in ethical frameworks Maximise good or balanced right and duty Economic reasons – poor being vulnerable Require some prompting in using EF Prompting required for Questions 3,4 & 5 Time factor – rush through questions Perhaps good to review EF before asking them to use them
	CLICKVIEW – Genetics and Reproduction 21 min Explores revolution in genetic medicine and highlights the social and ethical implications of the		Generally, students were engaged with the CLICKVIEW and serves as a good starting base to explore ethical issues. Student – awareness of different types of

	emerging reproductive technologies. Personal stories of CF, DS, Potentially Cancer, Down Syndrome 16 year old genetic testing Tay Sachs Amniocentesis, Embryo Screening, PCR, Designer Babies	Students' Journal 20 Aug	genetic diseases that can be passed on Like to learn more about designer babies and implications, found clickview interesting Student – amazed by the tech but caution, need to look at implications Student– concern about aborting genetically defect embryos; intervention unnatural Plus many others – mostly positive
23 Aug	Genetic Screening – Concept Mapping on issues linked to genetic screening Discussed differences between * - **preconception counselling** **Pre-implantation screening** **Prenatal screening** **Adult screening** Probably half of the class did the concept mapping activity instructed last Friday Instruction to do ethical framework – not as straight forward Students realised that there could be more than two per framework Task took longer than usual 20	Would be interesting to see the concept mapping; perhaps time factor – it was not as extensive as biotech mapping Also issues - a little harder to	Students appear to take a while to engage with the topic; last left off was Clickview on Friday Needs as scaffolding exercise – introduce the topic; a little cold start Student – too crammed in Response a little hesitant today

	min Enjoyed the fun of cutting and pasting Apparently, engaging with the framework mindset takes a while Choices and decisions – awareness Needs more practice with the ethical frameworks Next reading the article from 2.21 Cystic Fibrosis Article –students Explain some of the issues involved Went through the template C And as homework to write a letter of response (3 days) hand in on Friday For discussion	conceptualise	Needs more structure and scaffolding
27.8.10	**27 August, Friday** **Year 10 Biological Science SY's Class P3 and 4** • Distributed the My Sister Keeper's consent for viewing forms – to be returned by the following Wednesday 1 Sept (viewing date) – 3 students who would be away will view at home with their parents • Discussed on the ethical issues surrounding some WA parents of same-sex marriages and the identity of the child – real issues confronting our people • Case study 1– Genetic Population Studies – questions twice raised was – what's the problem		

	with that? One student Carson P raised that it was a question of privacy of information; and I jumped in too soon to state the implications on health insurance and job employment opportunities • Case study 2 – Huntington Disease – majority of class agreed that Matt should go for the H testing, while one disagreed stating that Matt should be loyal to his dad and not put him to such grief; will need to look at written response to gauge ; class was a little tired due to lots of events happening in school; training for athletics, baby sessions (2 fake babies in the classroom), book writing competition and the usual winter ills/ virus • Only one third of the class has completed the previous task of writing a letter to the Guardian on cystic fibrosis screening. One student did not understand why it has to be directed to the journalist. Task was given on Tues, expected on Friday. Most students cannot manage within the time frame. Extend to Monday 9 am. • Needed time to review test papers, lab assessments and assignments; also subject allocation forms to be signed, interruptions of PA announcements; including a Deputy visit (term 3 unusually intense – staff relief issues, etc.).		
31 Aug Monday	Presentation on: Christian Response to Biotechnology Most students took notes	Christian view presentation was helpful and interesting – Student	

	Briefed on Role Play – a number of enthusiastic response except for DO who turned down one role (will need to find another student) Student complete Case Study 5 Some confusion about how to answer when ethical framework was not given, yet ask to response using framework. 20 – 30 min in class Forgot to collect students' work Will do so tomorrow No parent object to watching My Sister Keeper. So will proceed tomorrow Journal writing for last five minutes of lesson	Interesting hear what other Christians has to say about biotech Such as CS Lewis - Student Find Christian viewpoint presentation interesting; diff perspectives Find use of framework repetitive; Student I also think that I now understand how to apply these frameworks in any and every decision I have to make. Student Today I was able to use what i had learnt about the ethical framework to help support my decisions and viewpoints on the subject of embryo use. Student (missed one week of lessons) I want to know more about Christian perspective of biotechnology - Student I was looking forward to the Christian view on biotechnology and it was good. Student	(Interesting – this is after three weeks of lessons)

1 Sept Wed	Students submitted their case studies. Viewed DVD on My Sister's Keeper (1 hour) Asked to think of ethical dilemmas from the perspective of Mr & Mrs Fitzgerald, Anna and the lawyers.	I really understand the use of frameworks. Student (did in 5 minutes)	
3 September	Watched the remaining 49 min on the DVD – To answer worksheets Interview of select group of students In Period 8. **Interview at 3 pm with Students** Most enjoyable activity – open discussions; and case studies appreciation for different viewpoints' noting a student's constant utilitarian approach Thrown into ethics – good to build into the program from the beginning of the year; Boys – still prefer science hard core facts Student– ethics is a good way of introducing into the subject – engaging and connecting with		Conflict about extent of hard core concepts and the ethics portion Students enjoy discussion and interactive activities Appreciate the use of ethical framework to develop reasoning First time using ethics in science; value the applications Find using the ethical framework quite easy to use and took on board

	science Matching framework and issues – helpful; like the first exercise on prenatal screening; more of such activities will help. Issues of life and death most controversial/ abortion Newspaper articles – drug addict mum was interesting – media helps see relevance of societal issues with science Like to see more practicals, experiments in the biotech curriculum Interview with some students		rather easily
3 Sept	Most enjoyable – case studies – learning how to use the ethical framework, teach to justify things Make you think deeper, think of different viewpoints eg. Anna, Mr & Mrs Fitzgerald, My Sister's Keeper Think of what you would do in the situation. Liver Transplant – Committee interesting You can give your input, your ideas and make decisions to justify		

	Debate – fun, different opinions view, finding out everyone 's opinion Feel that study of ethics is important and relevant How has this helped your learning of Science? Applications Appreciate how much science is used in the world today		
7 Sept Tuesday	Complete Post- Questionnaire Ethical Framework Questionnaire Work on Biotechnology On Line		
8 Sep Wed	Complete Biotechnology On Line Role Playing Preparation Biotech Quiz Preparation		
10 Sept Fri	**Role Play and Debate** Participating students: Chairperson	Students totally engaged for about 30 minutes, forum format Dealing with perspectives from the farmer, consumer, scientist, businessman, political perspective Student addresses misconceptions about genes in food. It is not Eating a GM apple does not make u an	Wrote a note of encouragement for Student Student The point of the role play could be made clear from the beginning. Role play – make clear the stand of each role – consumer, farmer, etc.

		apple. Patenting issues Solving world problems Environment Profit making Refer to student Journals on 10.9.10	Issues were not as clearly defined. Those not in the forum found some aspects confusing. I think the entire class needs to be briefed on what the forum is all about. It may be better if each member of class is given a role to think about. That would facilitate involvement and better participation. When it comes to open forum, there were not many questions forthcoming as most were not quite in the topic itself. The role of the chairperson could be more sufficiently briefed so as to ensure the process is carried out smoothly. Success of role play also depends on the individual student personality, capacity to debate and willingness to listen to one another. More enthusiastic response; perhaps my class Would be interesting to hear from the rest of the

			class.
13 Sept	Interview over lunch with some students	Role playing most enjoyable 7/10 enjoyability 5 – 6/10 learning Josh L 9/10 enjoyability Ethical framework – good – consider a variety of viewpoints, more than one angle of looking at things Gives a better handle or grasp of issues Natural development of the course Ethical framework – could give more examples Want more practice on ethical frameworks And using better explanation of biological concepts Could cover all scenarios or cases such as environment, liver transplants, animals, mutations and gene tech	

14 Sept **Tues**	**DNA Profiling – G. Cass** **Introduce Arts and Science** **Using red wine to make a dress** **Robots and use of microbes to grow skin** WORKSHOP – DNA Profiling Interview with some students	Most fun – DNA extraction, hands on activities Student– knowing the theory behind gene technology Doing the Biotech booklet – good starting point Ethical issues – good 0 got us thinking Ethical framework – good in helping us think through the reasoning process Different viewpoints Awareness of some really difficult issues that people fact Ethical framework – confusion – don't have to use all Applies in some cases only Wants to find out more about gene manipulation	
15 Sept Wed	Review DNA Profiling Returned Biotech on Line Worksheet Review Journalling – DNA profiling	**Interview with some students (lunchtime)** Most enjoyable – role play and debate Appreciate both sides	

	Biotech Quiz Preparation	of argument Question beliefs, more critical Case studies interesting More info could be provided for decisions to be made Usually scientific view is presented; one sided; good to see other aspects Ethical side Relevance – important Overall gained a better understanding of biotech and applications Language used in EF complex; needs to figure out Christian framework– as a matter of fact to voice our Christian beliefs Practical – was good Wants to see more Relevance of ethics to science curriculum Engagement factor 7/8 of 10 Cloning – most controversial	

16 Sept	**Interview with some students**	Refer to comments in Student Journal on DNA Profiling Workshop Most enjoyable – DNA profiling and role playing Forum – why Can air your opinion Favourite topic – gene technology & cloning Ethical Frameworks – explore a few possibilities, options that aid decision making Christian framework as 5th – assumed to work; naturally considered Any improvement on EF? Adequate, could not see any alternative Case studies/ hands on could do more Role playing was most engaging. The role play actually showed much we have learnt (Week 7).	

	Interview with some students	The movie `My Sis' demonstrated all the ethical issues linked to the biotech concepts we have learnt. Student: DNA extraction Designer babies – future possibilities What would God have to say about that? Ethical frameworks Helps to analyse ; was confusing at first Once we used it, it was not that difficult. Creating the issues and matching the framework would have helped. Starting with concept mapping was confusing. Did not know what biotech is to begin with Starting with the power point on Biotech before the concept map would have helped. Issue was – I had to be away on the first lesson for Brain bee Challenge so relief teacher took over the first two periods. Gals felt that they did not know enough to do the concept mapping. They were	

		lost. Value of introducing the subject well even if concept mapping is used. It is quite a big step forward. Increased interest in Science about 8/10 Interest in Gene tech – quite significant	
17 Sept Friday	**Biotech Quiz** **4 groups – enthusiastic participation** **Recess Interview with some students** Most enjoyable – DNA profiling Role playing – interesting to watch, Learn different perspectives of one issue Small group discussion – good Use of ethical framework 8/10 Anatomy – more engaging than biotech; has this view that it is not morally right; so dismiss the subject as less important, or do not wish to engage more with it, Christian framework – helpful as it states her beliefs/ and provides the basis for her to work on **Lunch Interview with some students** Most enjoyable was DNA Profiling		

	Forensics application Use of micropipette – hands on Faith mentioned without prompting the use of EF helps made better decisions and helps give due consideration for all possibilities Engaging with biotech as a subject – FC 5/10. EC 4/10 Information overload Forensics – of interest, mentioned again Ethics – well integrated in Science this term		
21 Sept Tues	**Genetic Researcher Talk** **A Prof R. Allcock** **C. Price** Science and Medical Research in WA **Students Evaluation Questionnaire** **7 boys 7 girls (Lunchtime)**	Feedback in Student Journals Students ask questions about transgenics Is cancer purely hereditary? Breast cancer 10 minutes Mutations – various types Transfer of gene to salmon (from another fish) to produce bigger salmon Possible to transfer gene between animals	

	Post talk with presenters <u>Students seem to cover more ground than some schools they visited</u>	Given evaluation questions	
22 Sept	End of Term Test	Weak student SA shows significant improvement From 12% → 40% Student- increased participation in class Written responses in test shows more critical thinking Having completed marking End of Term Biotech test, it appears that some of the weaker kids have improved perhaps due to better engagement with the topic. The high end kids have demonstrated more ethical reasoning in their answers although that was not something that was asked.	
24 Sept Fri	Review Test and Complete Round 5 & 6 of Biotech Quiz		

Appendix 7 TEACHER'S EVALUATION QUESTIONS

Teacher Evaluation Questions

1. How effective are the teaching strategies of biotechnology used in this Year 10 Biological Science unit? You may cite specific strategies such as concept mapping, debate, role-playing, media articles, simple framework for decision making, Biotechnology On Line, hands on activities, incursions, etc. Explain.

   Rate the effectiveness on a scale of 1 – 10. 1 – least and 10 – most

2. In what ways has the use of a simple framework such as pros/cons and benefits/risk template improve student's ability to reflect critically and make decisions about their own ethical values?

   Rate the viability of a simple framework on a scale of 1 – 10. 1 – least and 10 – most

3. In what ways has the use of a simple framework increase teacher's confidence in teaching the socio-scientific issue (eg. organ transplant, cystic fibrosis screening, etc.)

   Rate this increase in teacher's confidence on a scale of 1 – 10. 1 – least and 10 – most

4. To what extent has the use of a variety of teaching strategies and the simple framework **enhance student's overall ability to handle ethical issues** using their scientific knowledge?

   Rate its effectiveness to increase student's ethical reasoning ability on a scale of 1 – 10.
   1 – least and 10 – most

5. What do you think were some factors that have affected learning in your class in this entire biotechnology unit?

6. Personal Growth – Reflection
   Please rate on a scale of 1 – 10. 1 – the least and 10 – the most

   i. Knowledge of the ethical reasoning process
   ii. Confidence in using the teaching strategies
   iii. Understanding of small group dynamics
   iv. Understanding how students process information
   v. Awareness of the important contribution that teaching controversial issues makes to science education

   Feel free to add your comments here.

7. Can you identify any unexpected learning that occurred while teaching this unit? Explain, and be as specific as possible.

8. If you are going to teach the biotechnology unit again, what features will you retain and what will you do differently?

Thank you.

Appendix 8 USE OF ETHICAL FRAMEWORKS IN BIOTECHNOLOGY QUESTIONNAIRE

Year 10 Biotechnology Unit

Use of Ethical Frameworks in Biotechnology Questionnaire

The objective of this questionnaire is to determine the level of usefulness of ethical frameworks to help you make decisions about controversial issues in biotechnology.

Place a tick in the column which best represents your answer.

	Agree	Disagree	Unsure
1. The use of ethical framework helps me identify the important issues involved in biotechnology.			
2. The use of ethical framework helps me understand the implications involved in the use and misuse of biotechnology.			
3. The use of ethical framework helps me recognise the moral effects of biotechnology on humans, animals and plants.			
4. The use of ethical framework helps me decide how we can best use biotechnology for the benefit for humans, animals and plants.			
5. I think the ethical frameworks provide some good guidelines in dealing with difficult issues in biotechnology			

Any comments or feedback please.

Thank you.

Appendix 8A LIST OF COMMENTS ON USEFULNESS OF ETHICAL FRAMEWORKS

No.	Initials	Comments of Experimental Group
1	SA	Agree – no comments given
2	VA	Agree – no comments given
3	NC	Agree – no comments given
4	RC	The ethical frameworks are very useful. It helps me to determine the more important issues. The Christian moral framework is a good framework to use because I am a Christian. It has helped me realise that everything should be viewed from a Christian perspective.[*a point that I have made clear at the beginning that it is not necessarily to use only one framework all the time; in fact more than one may be used - perhaps this point was not accepted by the student.]*
5	EC	I think using the ethical framework is important since it helps in many ways.
6	FC	It was really helpful because it helps me make better decisions for what is right and what is fair.
7	DC	It enables me to express my personal opinion and that's why I like the ethical frameworks.
8	EE	The ethical frameworks are an easy and effective way to think and help understand the ethical problems behind the situation.
9	HG	*Left the course halfway.*
10	EG	The ethical framework helped in situations that were hard to choose.
11	SG	The ethical frameworks provide an interesting view of looking at situations involving biotechnology. They help to justify decisions and help to understand the dilemmas involved.
12	RH	Unsure – no comments given
13	RJ	Agree – no comments given
14	JK	Agree – no comments given
15	IL	*Left the course halfway.*
16	JL	Agree – no comments given
17	LM	Agree – no comments given

18	KM	The ethical framework is a great guideline to making important decisions in biotechnology and has helped me a lot.
19	JM	Agree – no comments given
20	VN	I like using the ethical framework because it allowed me to see the problem from different views.
21	DO	The ethical frameworks are quite useful, and help with making decisions involving biotechnology easier.
22	CP	Agree – no comments given
23	AP	The ethical frameworks guided me through the case studies and I can see how effective it must be even though it can be cruel sometimes, it always does the best for the majority.
24	JS	Agree – no comments given
25	BS	The ethical frameworks help me to see the problem from a range of perspectives.
26	JS	The ethical frameworks really helped me to decide how to deal with the issues of biotechnology when we did the case studies.
27	IT	I thought the ethical framework was useful in helping me make decisions regarding biotechnology.
28	ST	The course has definitely helped me develop my reasoning skills and allowed me to understand some of the ethical issues which people face as a result of biotechnology.
29	RVA	Agree – no comments given
30	JVY	Agree – no comments given
31	E S	Agree – no comments given

Appendix 9 INFORMATION LETTER AND CONSENT FORM FOR STUDENT QUESTIONNAIRE

Developing, Implementing and Evaluating the Use of Ethical Frameworks in Teaching Bioethics Issues in a Year 10 Biotechnology Program

Science and Mathematics Education Centre

Curtin University of Technology

Kent St

Bentley 6102, WA

Dear Parent/Guardian

I am a doctoral research student in Science Education in the Science and Mathematics Education Centre at Curtin University. I am involved in research about ways in which student's critical thinking and decision-making skills can be facilitated through the use of ethical frameworks in dealing with socio-scientific issues related to biotechnology. To assist in the evaluation of these activities, I would like to invite your son/ daughter to complete a 30 minute questionnaire before and after study genetics in their science class. The questionnaire asks students about their understanding of genetics and also their decision-making about human genetics testing and genetic modification.

All information provided by your child will be confidential and no individual student or school will be identified. All questionnaire results will be combined as frequency counts to provide an overview of high school students' understanding of genetics. Questionnaires and electronic files will be stored securely and destroyed five years after completion of the study. Your child is free to choose not to complete the questionnaire or individual questions.

Any questions concerning the project entitled `*Developing, Implementing and Evaluating the Use of Ethical Frameworks in Teaching Bioethics Issues in a Year 10 Biotechnology Program*' can be directed to Siew Fong Yap on 92952688. I am most willing to discuss any questions you may have about the questionnaire. This project has been approved by the Human Research Ethics Office at Curtin University and if you have any concerns about the project or would like to talk to an independent person, you may contact the Research Ethics Officer, Dr Christine Howitt on 92662328.

Thank you very much for reading this information. If you agree for your child to participate in this study, could you please sign the consent form at the bottom of this page and return it to your child's science teacher.

Regards,

Dr Siew Yap

Doctoral Research Student in Science Education

Curtin University of Technology

PARENT / GUARDIAN CONSENT FORM

Project Title: **Developing, Implementing and Evaluating the Use of Ethical Frameworks in Teaching Bioethics Issues in a Year 10 Biotechnology Program**

I have read the information letter above and I agree to my child participating in this activity realising they may withdraw at any time.

Parent's/ Guardian's Signature: Date:

_____

STUDENT CONSENT FORM

Project Title: **Developing, Implementing and Evaluating the Use of Ethical Frameworks in Teaching Bioethics Issues in a Year 10 Biotechnology Program**

I have read and understood the information letter above that explains the research study and I agree to participate in this research study by completing the questionnaire. I understand that my participation is voluntary and that I may withdraw at any time.

Participant's Name:

Participant's Signature: Date:

Appendix 10 PARTICIPANT INFORMATION SHEET AND CONSENT FOR INTERVIEW

Curtin University of Technology

School of Education

Participant Information Sheet

My name is Siew Fong Yap. I am currently completing a piece of research for my Doctor of Philosophy of Science Education at Curtin University of Technology.

Purpose of Research

I am investigating the use of ethical frameworks in teaching bioethics issues in a Year 10 Biotechnology program.

My Role

I am interested in finding out if the use of ethical frameworks will facilitate students' ability to reflect critically and make decisions about their own ethical values with reference to socio-scientific issues in the area of biotechnology.

The interview process will take approximately 15 minutes.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without affecting your rights or my responsibilities. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number SMEC 08-09). If you would like further information about the study, please feel free to contact me on 618 92952688 or by e-mail siewfy@scea.wa.edu.au. Alternatively, you can contact my supervisor Vaille Dawson on 618 92667484 or e-mail v.dawson@curtin.edu.au.

Thank you very much for your involvement in this research.

Your participation is greatly appreciated.

CONSENT FORM

- I understand the purpose and procedures of the study.
- I have been provided with the participant information sheet.
- I understand that the procedure itself may not benefit me.
- I understand that my involvement is voluntary and I can withdraw at any time without problem.
- I understand that no personal identifying information like my name and address will be used in any published materials.
- I understand that all the information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
- I have been given the opportunity to ask questions about this research.
- I agree to participate in the study outlined to me.

Name: _____

Signature: _____

Date: _____