SCHOOL OF EDUCATION

Teaching a Dilemma Story in My Science Classroom: Enabling Students to Make Ethically Aware Decisions

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Declaration

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

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

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #..SMEC-82-11.

Signature: 

Date: 26 January, 2017

ABSTRACT

The purpose of this research was to explore the experiences of students engaging with ethical dilemma story pedagogy in the context of education for sustainability. The study also investigated my experiences as a science teacher implementing ethical dilemma story pedagogy and gave rise to new understandings and insights about my teaching. This thesis records my reflective journey as I used ethical dilemma story pedagogy with two of my Year 10 Science classes.

The research was based on interpretive action research methodology with students from the two Year 10 Science classes, one in 2012 and the other in 2013. The research site was a coeducational independent P-12 Christian College situated in a large regional city in Queensland, Australia. The classes comprised male and female students with mixed academic abilities, aged between 14 and 16 years. Data generation methods included student journals and responses to worksheets, class observations of group work, student assignments, semi-structured interviews and my personal reflections. Online platforms were used for students to record personal journals and served as a resource repository.

The ethical dilemma story presented to the class, 'Torn at the Genes', described a family's debate over the acceptability of producing and consuming genetically modified (GMO) food. The story was the focus for a science unit based on the topic of Genetics, and provided opportunities to satisfy the Australian Curriculum requirements for Science Understandings, Science as a Human Endeavour and Science Inquiry Skills.

The research revealed that ethical dilemma story pedagogy increased student engagement in science. Students' struggle to resolve the ethical dilemma of GMO food involved considering their personal values, engaging in critical reflective thinking, and negotiating with their peers. Most students valued collaborative learning, in the form of group discussions, which enhanced their engagement with the ethical dilemma story. However, some students were frustrated with their experience of group work and many were reluctant to take advantage of thinking tools designed to help them develop evidence-based argument. Students also had varied success with personal reflective writing.

Through this research I developed innovative ways of improving my teaching practice. Ethical dilemma story pedagogy enabled me to move away from a predominantly teacher-centred approach to delivering content-based lessons to facilitating students' inquiry-based learning. Further, I came to understand the importance of (i) ensuring that the social dynamics of group

work do not disadvantage individual student participation, (ii) enabling students to understand the origin of their personal values, and (iii) ensuring that students understand how to use 'thinking tools' for developing their general capabilities.

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My Year 10 Science classes of 2012 and 2013. Thank you for being so gracious and allowing me to conduct my research using you as participants. You did not complain, you were helpful and interested. This, I think, speaks to the calibre of students at the College who are not only great students, but brilliant people.

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INTRODUCTION

Why Science?

I remember enjoying the science and mathematics subjects when I was in high school. I recall enjoying some classes more than others. I recall Mrs Andrews, my Year 11 Biology teacher drawing a food web on a chalkboard with coloured pictures. I have memories of dissections in Biology with Ms Johnson who was my Year 12 Biology teacher. I remember accidently setting ethanol on fire in chemistry after my classmate had told me it was water: I vividly recall the colourful green flame! I have memories of Physics practicals such as demonstrations with light bulbs that still fascinate me today. I absolutely loved the Biology camp at the Bunya Mountains, which are part of a national park north of Dalby in Queensland: we collected little creatures from the small creek, looked at even smaller creatures under the microscope and tried to match the creatures with the black and white pictures in the biology book. I enjoyed science at school so much that I chose to study it at university.

This thesis research records my reflective journey as a science teacher as I used the pedagogy of ethical dilemma stories with two of my Year 10 Science classes. I discovered that the ethical dilemma stories proved to be a strategy that allowed me to win over the science hearts of my students. Moreover, I found that ethical dilemma stories helped me to move from my well-used toolkit of teaching resources for content based delivery to the beginnings of a new toolkit where students are challenged to think beyond 'What should I know,' to 'What should I do with what I know?' Ethical dilemma stories provide a platform where students are required to make a decision based not only on their science knowledge, but also on their personal values and through the assessment of issues of sustainability.

Contemporary educational perspectives emphasise the provision of a secondary school education that is becoming increasingly holistic, ethical, and wide-ranging in its ability to address issues of local and global importance (Quittner & Sturak, 2008). According to Saavedra and Opfer (2012), the transmission of knowledge using traditional methods of lectures and textbooks has not been the most effective way to teach twenty-first century skills such as collaboration, communication, and critical and creative thinking. The Review of Science Teaching and Learning in Australian Schools 2001 highlighted the conundrum that traditional science education has promoted a rather limited content-based approach that has detracted from opportunities to explore topical subjects through inquiry (Goodrum, 2006).

The challenge for science teachers like myself — and consequently also for science teacher educators — is to provide students with a structured and age appropriate environment in which they can discover what is known about their local and global environment.

This introductory chapter provides the reader with an overview of this interpretive action-research study. The chapter opens with a narrative description of why and how I became a science teacher. The next section highlights the tension between content based and inquiry based teaching and I peruse curriculum history in Australia and Queensland. I then introduce the reader briefly to concepts of values education, socially responsible science, critical thinking and reflection, education for sustainability, and socio-scientific issues, all of which frame the approach of this research. Finally, I outline the research problem, the research aims and questions, and discuss the significance of the research. I conclude the chapter with an overview of the thesis structure.

FROM YOUTH WORKER TO SCIENCE TEACHER – HOW PLANS CAN CHANGE!

During my time at high school, I felt I 'got' science. I was fairly sure that I understood most of it, but my assessment results did not reflect that. I was able to get good marks in Biology, but my Physics and Chemistry marks were not so good. I passed, but I always felt that I should have been able to achieve higher marks: at some level, I believed that I only achieved a pass with the help of a good friend whom I was privileged to sit beside in class. Needless to say, my love of science was the main reason I enjoyed studying it at university. Despite that love for my science subjects, I did not pursue a science career. Initially, I told myself that my goal of studying science was a means to an end: I wanted to work with young people as a youth worker. My plan was to get a teaching qualification, teach for some time and then find a job as a youth worker.

The question arises now: why did I not want to be a scientist, since I enjoyed science so much at school? I believe the reason for my decision was that on leaving school I did not believe that I was ‘good enough’ — at least in terms of academic achievement. I considered myself lucky that my grades were more than sufficient to gain entry into university, allowing me to work towards my goal of teaching and ultimately move into youth work.

However, my goal of becoming a youth worker was not achieved, as I have never stopped teaching since leaving university. What, the reader may wonder, were the reasons for this change of heart? I came to see that as a teacher I could be — and in fact was — a part of

teenagers' lives in a pastoral care role. Another reason was that I rebuilt my scientific self-esteem at university: I found that I could actually 'do' science. I finally understood that it was my experience of science in school that had contributed to the impression that I was not 'smart' enough to pursue science as a career. I found that I first needed to achieve at university at a favourable level to overcome that deep-seated belief.

I Want To Be a Scientist
Phoebe, Student at Redlynch State College

I want to be a scientist
Observe the world around
I want to be a scientist
Not a boring old clown.
I want to make smart guesses
Hypothesising things
Doing cool experiments
And wearing lab-coat strings.
I want to be a scientist
That studies Earth or Sky
Recording all my data which
Will answer what and why.
I want to be a scientist
Who has a famous name
Receiving Nobel Prizes
So that will be my aim.

I Want to Be a Scientist
Adele O'Driscoll, Year 6 Student at St. Peter's School, Rockhampton

I want to be a scientist
I want to own a lab
I want to be a specialist
You might think I'm mad
I want to use a laser beam
I want to win awards
I want to measure gravity
And study different laws
I don't want to be a circus clown
I don't want to be a nurse
I don't want to be an undertaker
And drive around in a hearse
I don't want to be a fireman
And battle fires all day
I want to be a scientist
A scientist of today!
(Science Rhymes, 2015)

I discovered these poems on a website called Science Rhymes (2015). These school students

illustrate perfectly the reasons why I teach: I wish that every student of mine had a similar desire to be a scientist. Of course, this may not be realistic but at the heart of this wish is my hope that each student has the opportunity to enjoy and love science – as did I when I was at school. I believe that science allows students to try to work out how things work or behave the way they do, and to ask questions as to 'what would happen if…'? I have noticed over the years, through my own observations and those of colleagues, that students seem to lose the wonder of science when they reach high school. I have often wondered if that could be partly because students have a similar story to mine: they enjoy science at first, but assessment and high school science routines dampen their enthusiasm, and success in the subject comes to seem unattainable: enjoyment and success become almost mutually exclusive.

In the next section I explain developments in science education and in education in Australia in a more general sense.

MY CURRICULUM HISTORY

The first decade of the twenty-first century in Australia saw the advent of the Australian Curriculum, which prompted teachers of science, like me, to reflect more deeply on the content and processes taught in the science curriculum. In the past, content was the primary driver of the science curriculum (Ennis, 2002). This describes my practice as a novice science teacher in country Queensland in the early 90s. I do not recall consulting documents such as a syllabus to guide the development of my work programs, unit and lesson plans. The main sources of guidance regarding the content that I taught included the previous teacher's notes of the particular subject and the textbook. I taught the content via the textbook, mixed with 'recipe' style practical investigations; sadly, this was considered normal practice during the 90s.

Certainly I was not the only voice in the dynamic world inside and outside of the classroom wondering what I could do to help students engage in and like science. Perhaps the guilt I came to feel during those years for focusing primarily on covering the required contents was due to the professional development I received over the course of my years in teaching. Outcomes Based Education was introduced in Queensland in the late 1990s, and professional development became vital for science teachers (Holden, 2002). All current, beginning and pre-service science teachers were to be enabled to move from a content based, didactic teaching style to a new curriculum model of "student-centred inquiry and [an] outcomes-based approach" (Holden, 2002, p. 3). The concern of education researchers at the time was that a didactic teaching style was a contributing factor to the decline of the number of students choosing to study science in their senior years of high school and later at university (Lyons,

2006). Didactic teaching had been the primary choice of pedagogy of most traditional teachers, whereby students were instructed and facts were presented with authority as either right or wrong (New learning — Transformational Designs for Pedagogy and Assessment, n.d.). It was a teacher-centred pedagogy where the student virtually had no input regarding the learning in the classroom, accepting themselves to be passive learners and the teacher as the authority (Austin, 2013).

Australian science teachers were not alone in being caught up in the trap of perceiving didactical teaching as efficient. Lyons (2006) reviewed teaching practices and student experiences from England and Sweden, where he investigated concerns that the decreasing numbers of students interested in studying science was a significant pointer to the decline of science education. Lyons drew on several studies of student interest in science in other countries, including Canada, Denmark, France, Germany, India, Ireland, Japan, Korea, Netherlands, Norway, New Zealand, and the USA. He identified three themes drawn from two major studies he had reviewed and a third study in which he had been an investigator: "(1) transmissive pedagogy of school science; (2) personal irrelevance of much of the curriculum; and (3) perceived difficulty of school science" (Lyons, 2006, p. 595). In a similar vein, Holden (2002) researched the context of science teaching in Australian schools, focusing on the potential tensions for science teachers between a curriculum that encourages transformation in science teaching practice on the one hand, and the realities of grassroots science teaching on the other. Holden cited a publication by Hackling, Goodrum, and Rennie (2001) which confimed that science students find science "rarely relevant and engaging and [it] does not connect [students'] personal interests and experiences" (Holden, 2002, p. 6). Holden concluded that science teaching practice remains too "often traditional, discipline-based and dominated by content" (Holden, 2002, p. 2), especially at secondary level.

Reading the research of Lyon and Holden helped me recognise that these traits have characterised my own teaching practice, which explains why my students did not particularly like science. Acknowledging that some of my students do not enjoy science pushed me to reflect more on my teaching practice as I prepared my lesson plans, making sure that the content was covered, the lesson was interesting, and students were enabled to engage with science knowledge and skills. Yet I often asked myself why my science teaching was so content driven, with a majority of didactic lessons, for the majority of my professional practice? Although I did not consistently and exclusively teach didactic lessons on many occasions I tended to revert to the old habit of standing in front of the classroom, using PowerPoint slides and requiring students to take notes. My reflections resonated with Hackling, Goodrum, and Rennie (2001) who explained that teachers' perceptions of factors

that limit the quality of school science include: (1) inadequate resources and budget; (2) insufficient time for preparation, collaboration and reflection; and (3) large class sizes.

Based on my own experience, I agree with Tytler's (2007) proposition that additional factors could be responsible for teachers' tendency to default to traditional science teaching style: (1) a curriculum that it is inflexible; (2) inexperienced teachers who require guidance; and (3) conservative attitudes of many parents, teachers and university academics (Tytler, 2007, p. v). I can relate to some of these factors, particularly to the need for more time for preparation, collaboration and reflection. There never seemed to be enough time, and preparation can sometimes feel like a bottomless pit, which has led me to feel frustration and concern and at times question my role as a teacher. Notwithstanding these challenges, I have chosen to make the best of a difficult situation by employing lesson strategies that seem most effective in helping the students learn while offering engaging lessons. Sometimes it feels as if there is no end to the preparation for a lesson or a unit of work, and I am constantly trying to balance the tension of preparation, marking and maintaining my personal health, family and life needs. Sometimes a basic PowerPoint is the most time efficient method.

Additionally, I agree with Holden (2002) that assessment tends to lock teachers into the teaching of content, as community expectations of assessment rarely match the curriculum reforms in secondary schools. I experienced the introduction of outcomes based education in a traditional school climate, and found it an additional challenge through the introduction of the requirement to explicitly teach values. When the Queensland Science Curriculum initiated values education in science classes, I had to negotiate the tension between the need to cover the content and the requirement to include areas for which I felt I did not have the necessary training.

Values Education in Science Classes - the Queensland Curriculum Experience

Saunders and Rennie (2013) argued that citizens, including current students, need to be scientifically literate and skilled in decision making to allow them to make informed decisions about socioscientific issues, such as the development of technologies, including nanotechnology (Mnyusiwalla, Daar, & Singer, 2003) and biotechnology (Yoshihiro & Kazuo, 2008). Australian governments, both at Federal and State levels, have long recognised the need for scientific literacy. Consequently, when the National Goals for Schooling in the Twenty-First Century were developed ("The Adelaide Declaration", 2000), the document indicated that government and education authorities finally realised that local, national and global communities would benefit from citizens who are: (1) scientifically literate; (2) able to

make socially educated decisions; and (3) critically aware of the impact of science research on legal, social and ethical issues in our society. For example, when students leave school, they should:

> - Have the capacity to exercise judgment and responsibility in matters of morality, ethics and social justice, and the capacity to make sense of their world, to think about how things got the way they are, to make rational and informed decisions about their own lives, and to accept responsibility for their own actions.
> - Have an understanding of, and concern for, stewardship of the natural environment, and the knowledge and skills to contribute to ecologically sustainable development. ("The Adelaide Declaration", 2000, p. 40)

Several additional national statements followed the Adelaide Declaration (2000). These included the Melbourne Declaration on Educational Goals for Young Australians, and the National Framework for Values Education in Australian Schools (2005), which highlighted the need for educators to enable students to explicitly make values-based judgments. In response to these guiding principles, agreed upon by all State and Territory Ministers of Education, curriculum documents increasingly included unambiguous guidelines regarding the teaching of ethical values and sustainability (Brady, 2008). As Jones (2009) explains, never before has Australia had such a detailed review and consideration of values education. She concluded that state schools either tend to ignore values education altogether or they include it in social, physical or civics education subjects instead.

I agree with Jones (2009); during my years (1991-1996) as a science teacher in the Queensland State Education system, values education did not feature in my curriculum development or teaching. During the time I spent in the Catholic System (1997-2000), I was not aware of values education in the subjects I taught at the time – science and mathematics. In the mid to late 2000s, the Queensland Studies Authority developed the Queensland Curriculum Assessment Reporting (QCAR) Essential Learnings Curriculum for Queensland Schools for the key learning areas, including English, Health and Physical Education, Languages other than English, Mathematics, Science, Studies of Society and the Environment, Technology and The Arts (Queensland Curriculum and Assessment Authority (QCAA), 2015b). The QCAR Essential Learnings Curriculum was the first document I recall that clearly required the teaching of values. While this curriculum document included content material similar to that of the 1999 Science Syllabus plus a focus on working scientifically, an additional learning

area was also included: Science as Human Endeavour. Science as Human Endeavour was presented as part of the Knowledge and Understanding curriculum strand, and included purposeful statements (or Essential Learnings) regarding values in science education. These statements were presented in documents developed for particular year levels, titled Science Essential Learnings (Essential Learnings by the end of Years 3, 5, 7 and 9) (QCAA, 2007).

In 2012, schools in Queensland began to implement the Australian Curriculum in Science, Mathematics and English. The Australian Curriculum, developed by the Australian Curriculum, Assessment and Reporting Authority (ACARA), consists of the eight learning areas previously outlined in the Melbourne Declaration of Educational Goals for Young Australians, and presented in the form of "…content descriptions and achievement standards, what students should be taught and achieve, as they progress through school" (ACARA, 2010a, par. 1). The curriculum includes key learning areas and, in addition to these, so-called General Capabilities and Cross-Curriculum Priorities, which aim to support twenty-first century learning (ACARA, 2010d).

Australian Curriculum – General Capabilities and Cross-Curriculum Priorities

General Capabilities are an important dimension and "are addressed explicitly in the content of the learning areas" (ACARA, 2010d). Figure 1-1, from the Australian Curriculum website, displays the General Capabilities in the circles around the perimeter of the diagram. The General Capability of Ethical Understanding is directly related to this research, as ethical dilemma stories have the key goal of raising ethical awareness among students (See Chapter 4).

The Cross-Curriculum priorities are to be embedded in all learning areas and were designed with guidance from the Melbourne Declaration on Educational Goals for Young Australians, which expressed a desire for students to "engage effectively with and prosper in a globalised world" (ACARA, 2010b). These are:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability.

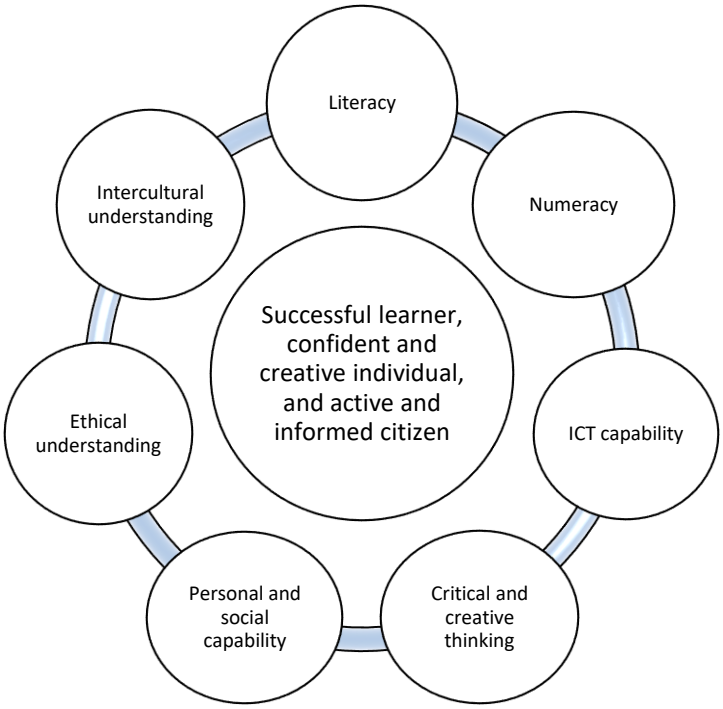


Figure 1-1: General Capabilities in the Australian Curriculum. Source: (ACARA, 2010d)

Ethical Understanding, which is listed under General Capabilities and the Cross-Curriculum Priority of Sustainability in particular, provides a clear mandate to science educators in the K-12 sector to consider the ethics and values associated with science education, and to foster:

> [a]n ability to solve problems and make informed, evidence-based decisions about current and future applications of science while taking into account ethical and social implications of decisions
>
> (ACARA, 2015a; King, Goodson, & Rohani, n.d.).

The Cross-Curriculum Priority of sustainability has direct implications for my research into using ethical dilemma stories, since, although ethical dilemma stories have been used in a variety of contexts with a variety of themes, the focus of the ethical dilemma story used in my research was specifically on science and sustainability. The story I told my students related to sustainability issues associated with genetically modified crops that are used as food for human consumpation.

Since its inception, the Australian Curriculum has undergone several reviews, during which it was noted that the Cross-Curriculum Priorities were of concern, and several recommendations were made. One of the recommendations was that the Priorities should only be embedded in the mandatory parts of the curriculum where educationally relevant (Wiltshire & Donnelly,

2014). Consequently, in Version 8.1 of the Australian Curriculum, the two Cross-Curriculum Priorities of 'Aboriginal and Torres Strait Islander Histories and 'Cultures' and 'Asia and Australia's Engagement with Asia' are no longer embedded in the science curriculum. The Cross-Curriculum priority of Sustainability is now embedded only in the Science area where it is seemingly most relevant. Interestingly, I note that it was not embedded directly in the science content descriptor for the unit I used for this research, even though it is implied, especially when considering the consequences of genetics. The content descriptor serving as the basis for the science unit with my Year 10 classes reads:

> Science Understanding: Biological sciences
> Transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)
>
> (ACARA, 2015c)

The Introduction of the Australian Curriculum into Queensland Schools

Schools in Queensland were directed to implement the Australian Curriculum in stages, starting in 2012 onwards. The subject areas of Science, English, and Mathematics were the first to implement these changes (QCAA, 2015a). However, there were notable differences between the Queensland and Australian Curriculum structures and how they address values education and sustainability. The Essential Learnings Framework placed the science content in a section called 'Knowledge and Understanding' (i.e., the curriculum that is taught), whereas the Australian Curriculum placed content knowledge in an area called 'Curriculum' which is subdivided into three fields – Science Understandings (this is where the traditional content is located), Science as Human Endeavour, and Science Inquiry Skills. A key difference regarding specific values education in Science is that in the Essential Learnings Curriculum, the descriptor of values education was included in the Science as Human Endeavour strand of Knowledge and Understanding. In the Australian Curriculum, however, values education is now included as part of Ethical Understanding, which is a General Capability, and Sustainability is listed as a Cross-Curricular priority, not unique to particular science strands or additional subjects, but encompassing, where possible, all aspects of science in the Australian Curriculum (ACARA, 2015b). I recall that at the time of the change in curriculum from Queensland to Australian, the general belief among colleagues was that we would keep on teaching how we have been teaching. The science content had not changed. Even though the Australian curriculum had made the treatment of values and ethics more obvious, we would consider them only if the opportunity presented itself. We believed, perhaps erroneously, that we did not have time in an overcrowded curriculum and felt ill prepared to

teach values and ethics with intent.

In the next section, I discuss moral development theory and the relationship between socially responsible science and ethical dilemma stories exploring the link between the Australian Curriculum and these stories.

MORAL DEVELOPMENT AND ETHICAL DILEMMA STORY PEDAGOGY

I introduce the next section by presenting contributions to moral development theory and the use of moral dilemma stories starting with Piaget (1932), Kohlberg (1981) and Gilligan (1982).

Morals or Ethics – What is the Difference?

When attempting to define the difference between ethics and morals, the distinction between these concepts quickly becomes blurry and definitions involve circular references. For example, the Oxford dictionary (Ethics, 2015, para. 1) defines ethics as "moral principles that govern a person's behaviour or the conducting of an activity." Another definition reads "the branch of knowledge that deals with moral principles" (Ethics, 2015, para. 2). Morals, on the other hand, are defined as being "concerned with principles of right and wrong behaviour" (Moral, 2015, para. 2). To Johns, McGrath and Mathur (2008, p. 8), "ethics is a system of morals of a particular person," enabling a person to distinguish between right and wrong, and to act in a manner that is consistent with what is considered right. Morals is thus defined as a subset of ethics. Haynes (2002) considers ethics to be the philosophical study of morality and, to her, it goes beyond the question of, "what should I do." To her, it is the study of moral questions in a manner that covers more than one particular situation. In my thesis I follow Campbell, who referred to morals as the rightness or wrongness of behaviour, and ethics as a "broader, more universal and all-encompassing understanding of such moral standards and principles" (2003, p. 17). I consider ethics as the ideas of the right or wrong that society upholds, whereas morals is more personal and may relate to culture and/or religion. Many authors appear to use the terms interchangeably (Campbell, 2003), as have I throughout this thesis. In the following section I discuss theories of moral development and morals education.

Theories of Moral Development and Moral Education

While Kohlberg is often credited with building the foundations of the current debate on moral

development amongst psychologists, he based his thinking on the work of Piaget. Kohlberg expanded on Piaget's theory of cognitive moral judgment (Nucci, 2014; Rich, 1994). For Rich (1994), moral development "relates to principles of right conduct in behaviour … complying with accepted principles of what is considered right, virtuous or just." Moral development can thus be described as the "growth of the individual's ability to distinguish right from wrong, to develop a system of ethical values, and to learn to act morally" (p. 6) and as "an attempt to explain how individuals acquire moral values and how such values help guide the way those persons treat other people" (p. 1). The question here is, how do people acquire morality, and can we teach it?

Moral education is the teaching of morality in order to develop students with good character traits and positive ethical behaviour (Rich, 1994). Moreover, "…the goal of moral education is to encourage individuals to the next stage of moral reasoning" (Murray, n.d., para. 7). Moral education approaches were designed to "guide" students into a state of disequilibrium, and the most common method of achieving this was through presenting a moral dilemma that required students to determine, with appropriate justification, a course of action that should be taken (Murray, n.d.).

According to Eysenck (2012) there are three components to the idea of morality: cognitive, emotional and behavioural. Piaget, Kohlberg and Gilligan focused their research mainly on cognitive factors, whereas researchers such as Freud studied mainly emotional aspects and social learning theorists such as Bandura and Mischel (1965) focused on behavioural components of morality.

Piaget (as cited in Shumaker, 2007, p. 4) studied moral decision making in children during the 1930s, when research was primarily focused on cognitive development in children who were, in his view, 'reasoning people.' He assumed that children used reasoning as the primary factor behind their moral decision making (Shumaker, 2007). Piaget observed children playing marbles to develop his theories about moral reasoning, which led him to the definition of stages of moral development. These stages according to Piaget (as cited in Shaffer & Kipp, 2010, p. 587), are: (1) the premoral period (0-5 years); (2) the stage of moral realism or heteronomous morality; followed by (3) the stage of moral relativism or autonomous morality. Piaget's basic idea was that at a younger age, children view the world from their own point of view (egocentric). As they grow older, that view moves towards an awareness that other people have different points of view, which leads to more responsible moral reasoning (Eysenck, 2012).

Moreover, Piaget used moral stories in interviews to investigate how children (male youths with a middle-class background) responded and reacted to moral challenges in the stories (Rich, 1994). He used responses from story interviews as evidence for his claim that children in Stage 2 (moral realism) judge moral actions by their consequences rather than the actor's intentions (Eysenck, 2012). The storytelling technique that Piaget used involved aspects of individuals working in pairs. He was interested in the following questions: (1) does the child recognise the moral intentions of the story; and (2) does the child foresee the consequences? The stories involved either/or choices (Rich, 1994), which is also the path that I followed when I used an ethical dilemma story with my students.

Kohlberg, building on Piaget's work, used stories to research moral development. He presented his research participants with stories containing moral dilemmas that required them to support or reject a moral principle in order to satisfy a human need (Eysenck, 2012). One of the most recognisable stories used by Kohlberg is the 'Heinz Dilemma'. In this story, a woman is near death and requires an expensive drug that her husband cannot afford. He tries to borrow money but fails to do so and thus resorts to breaking into a drug store and stealing the medicine. Participants were then asked whether the husband should have done that? Was it right or wrong to steal under these circumstances? (Kohlberg, 1981). The story was told to 72 boys from low- to middle-class homes whose age range was between 10 and 16 years. Later in his career, he also sampled females, younger children and children from other geographic regions. For Rich (1994), Kohlberg's findings "show culturally universal stages of moral development" and his stories were designed to challenge and cause moral development rather than teach the rules. The data gathered from these stories enabled Kohlberg to develop his version of a stage theory of moral development (Shumaker, 2007). His stages differed from Piaget's, as Kohlberg maintains that moral reasoning development is not limited to childhood, but continues to develop in adolescence and adulthood (Eysenck, 2012).

According to Eysenck (2012), Kohlberg assumed that all children progressed through the same sequence of moral stages. Later studies seemed to confirm this; for example, Colby conducted a 20-year study with 58 American males in 1983, in which all of the participants were found to progress through the moral stages in the same sequence as theorised earlier by Kohlberg. Snarey (1985) investigated 44 studies from 26 different cultures, and concluded that nearly all cultures seem to progress through Kohlberg's stages of moral development. Little evidence suggested that any participants skipped stages. Interestingly, Fleming (2008) noted that Kohlberg, after further research, dropped the sixth stage from his research, as very few people reached this stage. He also noted that the average person was unlikely to even reach stage 5.

However, the view that Kohlberg's stages are universal has been challenged, as there are cultural groups that do not seem to subscribe to Kohlberg's stages. For example, Cortese (1990) found limitations in Kohlberg's models based on his own research on moral judgment. He suggested that the literature seems to "view Anglo-American culture as universal in defining moral development" (Cortese, 1990, p. 1), pointing out that there is a methodological problem of using nearly all-white samples. Fang, Fang, Keller, Edelstein, Kehle, and Bray (2003) and Keller, Eckensberger, and Vonrosen (1989) asserted that morality was influenced by the cultural context, especially in the higher stages of Kohlberg's model. For Hing Keung (1992), the higher the stage in Kohlberg's model, the greater the cultural differences. There is an emphasis placed on the affective aspect of moral development which draws themes from the work of Gilligan (1982). Gilligan contends that the affective aspects of moral development were not sufficiently considered by Kohlberg.

Critiques of Kohlberg's Theory

Carol Gilligan was one of Kohlberg's former doctoral students who later became a leading researcher focusing on cognitive moral development. She disagreed with some aspects of Kohlberg's theories, suggesting that his studies were male dominated and hence biased against women (Nucci, 2014). Fleming (2008) suggested that Gilligan believed that boys and men progressed though different stages compared to girls and women. Gilligan developed the concept of a morality of care (human well-being, compassion for others to produce a moral world) by listening to the experiences of women. She contrasted this with the morality of justice (using laws and moral principles) that was the basis of Kohlberg's theory (Nucci, 2014). She proposed that males were drawn to a morality of justice, whereas females applied a morality of care. Nucci (2014) and Eysenck (2012), both men, argued that there was no evidence to support Gilligan's claims that the moral development proposed by Kohlberg was gender-biased. Eysenck (2012) cites work conducted by Jaffee and Hyde (2000) and Fleming (2008), who mentioned a study conducted by Turiel in 2006 that was not able to find evidence in support of gender bias in Kohlberg's theory. Their argument was that moral orientations towards care and justice exist, but they are not gender based. Orientations, however, may be gender biased, as it seems from these conflicting arguments that male researchers, in general, present a view that is not shared by female researchers. It seems probable that sometimes boys and men do use a morality of care, and similarly girls and women embrace a morality of justice. Researchers such as Belenky (1986) and Haynes (2002) - all women - do not reject Gilligan's findings as insignificant.

I now expound on the nature of ethical dilemma stories, which are designed to challenge students morally and encourage reflection on their personal values.

Introducing Ethical Dilemma Stories

The emphasis on values in science education in state and national curricula was the result of previous attempts at curriculum reform, such as the National Framework for Values Education in Australian Schools (2005), which was developed from the National Goals for Schooling in the Twenty-First Century (Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA), 2007). Based on national documents outlining the importance of values education and doctoral research (e.g., Settelmaier, 2009), an Australian Schools Innovations in Science, Technology and Mathematics (ASISTM) grant was awarded by the Australian Government to fund a project titled 'Socially Responsible Science' under the guidance of two professional consultants (Prof Peter Taylor and Dr Elisabeth Taylor (nee Settelmaier)) from Curtin University. The Socially Responsible Science ASISTM project was "designed to enable science teachers to attempt to adequately prepare young people for our crisis-ridden world by developing their critical scientific literacy skills" (Settelmaier, Taylor, & Hill, 2010, p. 1). A key aspect of this project was the use of ethical dilemma stories for moral development, specifically in a science education context.

Ethical dilemma story pedagogy involves teaching strategies that support the engagement of students in values learning in the science classroom (Settelmaier et al., 2010). Dilemma stories provide opportunities to develop and use the skills of critical and creative thinking for students in the learning area of science, and address the Australian Curriculum's General Capability of Ethical Understanding and the Cross-Curriculum priority of Sustainability. One of the outcomes of the Socially Responsible Science Project was the development of the 'dilemmas.net.au' website, which makes available to the public ethical dilemma stories developed by teachers for teachers as well as resources to help teachers with their values education efforts.

Dilemma stories are not just stories, but are a genre characterised by ethical dilemma situations (Settelmaier, 2009) with the goal of putting students in a situation where the story's characters have to make various ethical or moral choices.

Ethical Dilemmas

An ethical dilemma has been defined as "a situation in which a person must choose between two courses of action of (apparent) equal moral importance, so that the choice necessarily entails the transgression of an important moral principle" (Ethical dilemma, 2015). Ethical dilemmas in science education are dilemmas that have a perceived benefit to society or to further scientific research, but may have negative repercussions. Stories should be attention-grabbing and maybe even entertaining, but not at the expense of science concepts. Kokkotas, Pizaki and Malamitsa (2010) state that a story needs structure: a beginning, to capture the students' attention; a central part, where the concepts would be taught; and an end, where an ethical message or idea is conveyed.

While ethical dilemma stories always involve a storyline (with characters) they will also present one or more ethical dilemma/s to the reader. They are not designed to solve a problem or teach a concept, as case study stories do. They are used to engage students by challenging them to reflect critically at different stages in the story on the moral and ethical issues that the story poses. There will generally not be a clear answer, and the dilemma can cause students to investigate the science and the moral issues related to the story to try to resolve the dilemma that the story presents.

The main features of ethical dilemma stories are that:

- The language of the stories is kept simple, which allows for sufficient links to be made.
- The stories are open-ended.
- The stories are typically presented in several parts with dilemma situations at each interval.
- Most stories contain several dilemmas, with the central dilemma nearing the end of the unit of work.

The structure of the dilemma stories is adjusted according to the teaching topic, curriculum and class situation (Settelmaier, 2009).

Structure of an Ethical Dilemma Teaching Lesson

In a typical ethical dilemma teaching lesson, students are "confronted with one or more dilemma questions that are designed to initiate a cognitive disequilibrium and thus a reflective

process" (Settelmaier, 2009, p. 142). The students are required to put themselves in the shoes of a character and individually reflect about how they would respond if they were the person in the story. Students then share their ideas with other students, eventually joining in a whole class discussion. The phases where students work individually or in groups alternate. Figure 1-2 displays a description of the organisation of a dilemma teaching activity adapted from Settelmaier (2009, pp. 142-143):

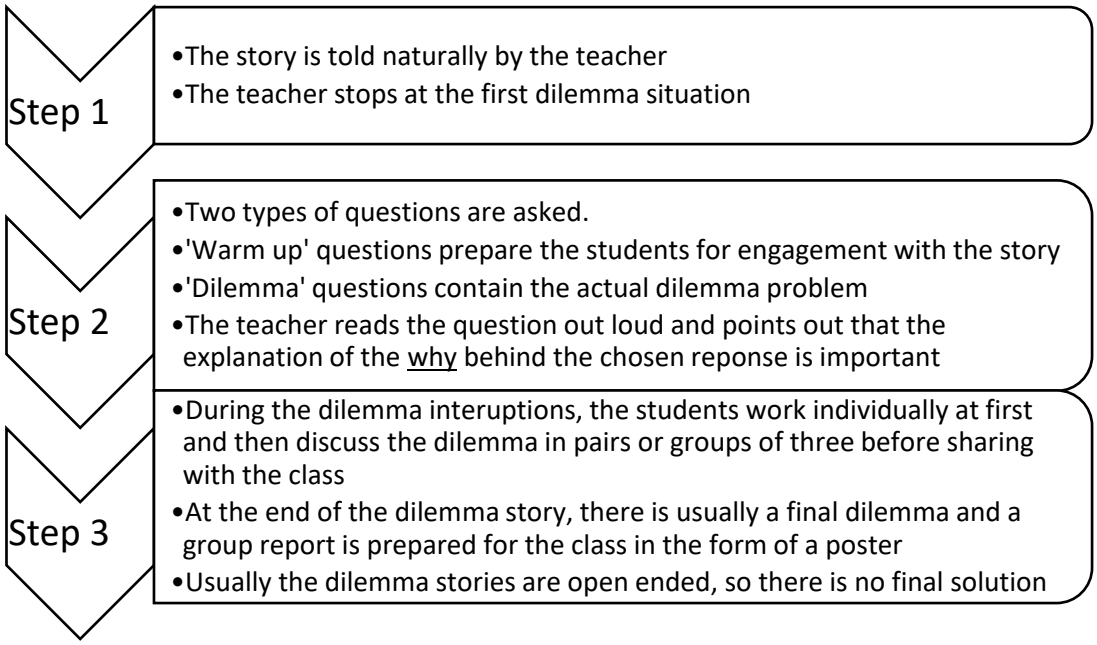


Figure 1-2: A description of a typical ethical dilemma story (Settelmaier, 2009, pp. 142-143)

During a dilemma story session, the role of the teacher is that of a facilitator of knowledge generation. The traditional role of the teacher as being merely a deliverer of content does not lend itself to dilemma story pedagogy. Rather, the teacher facilitates knowledge construction as the students grapple with dilemmas both individually and in group situations. The teacher's role is to manage the group interaction and collaboration skills of the students, to encourage critical and reflective thinking, and to promote a climate in which all opinions are valued and where there is no right or wrong answer.

In 1998, Elisabeth Settelmaier was part of an Austrian Youth Red Cross project that was to address concerns of Austrian teachers about how to approach moral issues in their then new curriculum. The project focused on how to improve moral and values education in Austrian schools (Gschweitl, Mattner-Begusch, Neumayr nee Settelmaier, & Schwetz, 1998; Settelmaier, 2009). The project team wrote dilemma stories and developed a teaching approach based on Kohlberg's theory of moral development in which dilemma stories were

used in a constructivist classroom environment (Settelmaier, 2009). In her doctoral research, Settelmaier used Kohlberg's dilemma stories as a foundation for the development of 'ethical dilemma story pedagogy' (Settelmaier, 2009). One of the main differences between Settelmaier's stories and those of Kohlberg was that the ethical dilemma stories in Settelmaier's work focused on science and issues of sustainability.

Ethical dilemma stories, according to the 'dilemmas.net.au' website (2013), have the following characteristics:

- Dilemma stories provide the foundation for a learning sequence that motivates students to explore the science behind the story and the factors that affect the decisions made.
- Students empathise with characters within the story that cause them to "think and reflect critically about the sequence of events" of the dilemma and to understand that science can be applied in a wide range of contexts.
- Dilemma stories allow students to develop an understanding of how ethical decisions are made.
- Dilemma stories allow for discussion of the cultural, ethical and value-laden issues that are a critical element of ethical decisions in science.

Studies of the use of ethical dilemma stories in the classroom have shown that they can provide an opportunity for students to self-reflect on their ethical assumptions and decisions, with increased use of critical thinking skills, and to reflect on the nature of science (Hill, 2008; Schaller & Tobin, 1998; Settelmaier, 2004). Keast and Marangio (2015) researched a dilemma story that was presented to pre-service teachers about the irrigation of northern Australia. The authors noted that the story caused students to reflect on "emotions and values and non-science domains" which they employed to help them make decisions (Keast & Marangio, 2015, p. 200). Similarly, Fischer (2004) argued that moral dilemmas in classrooms challenge "students to think critically," and that as teaching tools moral dilemmas encourage the affective domain of learning by causing students to activate intrapersonal intelligence (Gardner, 1983) and "wrestle with their inner selves as they contemplate moral issues" (Fischer, 2004, para. 4). Much of the research I reviewed posits a link between using moral dilemmas and promoting the use of critical thinking and reflection.

Critical Thinking and Critical Reflection

Ennis (2002, para. 3) defines critical thinking as "reasonable, reflective thinking that is focused on deciding what to believe and do." Others, however, such as Gunn and Pomahac (2008), are more cautious, and suggest that while there is no definite universal agreement about the definition of critical thinking, existing definitions have centred around common skills needed to demonstrate the action of critical thinking. These skills are evident in the Australian Curriculum, where critical and creative thinking is grouped into "four interrelated elements" (ACARA, 2015a) with each intended to contribute to learning rather than being a "taxonomy of thinking," implicitly referring to Bloom's (well known) Taxonomy (Anderson, 2013). Figure 1.3, sourced from the ACARA website, shows the relationship between elements found in Bloom's Taxonomy and the central idea of critical and creative thinking. The challenge for a teacher is to design units of work and/or lessons that can incorporate these elements while presenting engaging material to students. Ethical dilemma stories provide a structure for teachers to address these elements of critical and creative thinking in their lessons.

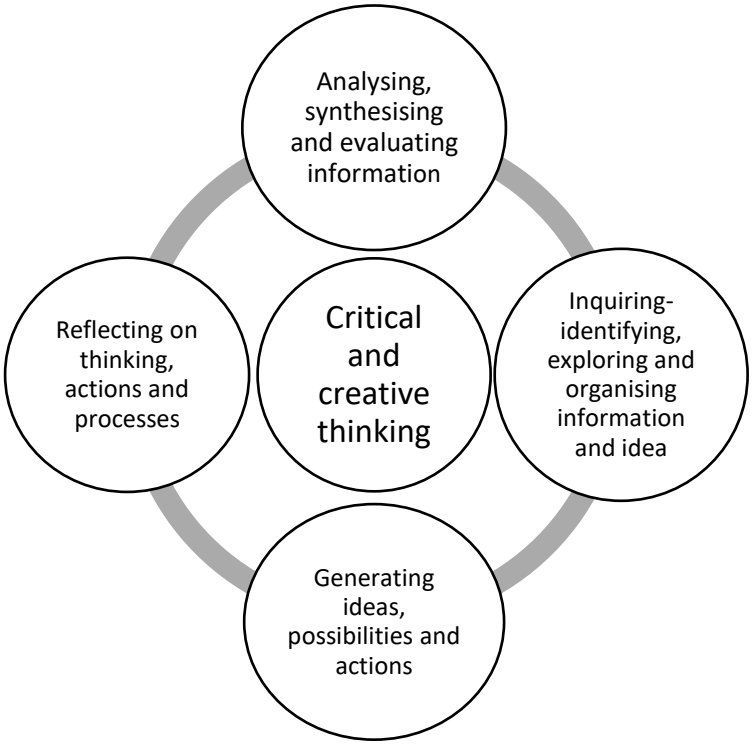


Figure 1-3: Organising elements for critical and creative thinking (adapted from ACARA, 2015a)

Carefully crafted ethical dilemma story pedagogy provides students with the opportunity to develop the attributes listed, such as reflective thinking and evaluation of information. Dilemma stories encourage students to suspend judgments by challenging their pre-existing ideas (King et al., n.d.). This is achieved through posing questions or dilemmas where there is

either not an obvious solution or where the solution challenges a moral or ethical belief. In addition, Leicester (2010) explains that moral dilemmas, especially in stories, can be used to develop critical thinking skills as they can cause students to attempt to resolve the internal conflict the story creates by reflecting on the best course of action required to resolve the dilemma. Beerman (2008) supports Leicester's ideas by suggesting that moral dilemma discussions that occur in the classroom can help students develop their ability to think critically. It is important, as Leicester points out, to ensure that students are guided by their teacher through various activities which help them to reflect on their thinking and beliefs, search for new information and generate new ideas and beliefs (Leicester, 2010). Herreid (2004, p. 13) concludes that in the use of case studies in education, reading, arguing and challenging are "hallmarks of critical thinking". I believe this can also be applied to dilemma stories; they provide a platform from which students can develop their critical thinking and "foster creative solutions to a dilemma" (Jones, Olivia, & Margarita, 2009, p. 33). Critical and reflective thinking are key outcomes for students encountering ethical dilemma story pedagogy. Education for Sustainability, one of the Cross-Curriculum Priorities in the Australian curriculum, requires both critical thinking and reflection, which makes ethical dilemma story pedagogy particularly useful for this purpose.

Education for Sustainability

Sustainability is a critical global concern, as indicated by the United Nations declaration of The Decade of Education for Sustainable Development 2005 to 2014 (Combes, 2005). As a result of this declaration, documents produced by the Australian Government, such as the Department of Environment and Heritage's 'Educating for a Sustainable Future – A National Environmental Education Statement for Australian Schools' (2005), and the Department of the Environment, Water, Heritage, and the Arts' 'Living Sustainably: The Australian Government's National Action Plan for Education for Sustainability' (2009), have guided the Australian Curriculum. Sustainability, according to the Australian Curriculum, is concerned with the continued ability to support and preserve life on our planet. The Australian Curriculum draws ideas from the Brundtland report titled 'Our Common Future', published by the World Commission on Environment and Development, Brundtland and colleagues explained that sustainable development involves addressing the needs of today whilst ensuring that future generations are able to meet their needs though individual and group actions that have mutual benefits to local and global societies (ACARA, 2010e; Brundtland et al., 1987). The Australian Curriculum describes sustainability in education thus:

> Education for sustainability develops the knowledge, skills and values

> necessary for people to act in ways that contribute to more sustainable patterns of living. It is futures-oriented, focusing on protecting environments and creating a more ecologically and socially just world through action that recognises the relevance and interdependence of environmental, social, cultural and economic considerations. (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010c, 2010e)

The use of ethical dilemma stories as a teaching strategy enabled me to incorporate the theme of sustainability in my science teaching (see Chapter 3). As students investigated ethical issues and values in relation to dilemmas associated with sustainability, they were guided by me to consider sustainable practices while developing appropriate solutions to the dilemma. In this way, socially responsible science education provided guiding principles for education for sustainability, as my students endeavoured to employ the skills of creative and critical thinking, self-reflection and group decision-making.

Ethical dilemma stories in the context of education for sustainability help students to develop the knowledge, skills, values, and motivation to respond to the complex sustainability issues they encounter in their personal and working lives (Australian Research Institute in Education for Sustainability, 2009). Rather than people being demotivated by an undesirable future that ignores sustainability issues, education for sustainability encourages a "futures-orientated" attitude that provides motivation for social action (Australian Research Institute in Education for Sustainability, 2009). A framework is provided for a context for teaching in a variety of subject areas and for growth in the use of twenty-first century skills, including critical and creative thinking, collaboration and communication (K-12 and Teacher Education Sector of the U. S. Partnership, 2014) which is similar to the focus of ethical dilemma story pedagogy. Ethical dilemma stories support the teaching of education for sustainability by encouraging students to understand the issue and investigate the fundamental problems behind the issue. Values clarification, the common denominator of ethical dilemma story pedagogy and education for sustainability, focuses on challenging values to enable students to realise a personal connection to sustainability. Ethical dilemma story pedagogy, through the use of a personal story, encourage students to consider a greater range of ethical values and enhance their personal connection to the issue, promote the idea of collaboration and reflection to solve problems, and make a decision. Since this study is based on ethical dilemma story pedagogy with values clarification, it could also be described as an education for sustainability study.

In the next section I focus on research-specific aspects, including the research problem, purpose, and research questions, the significance of the research, and the thesis structure.

THE RESEARCH PROBLEM

I recall a conversation I had with a student several years ago during a balloon releasing ceremony which was part of the annual Year 12 graduation activities. We were discussing the beauty of the maroon, blue and white helium filled balloons as they were released by the Year 12 students. The balloons drifted upwards and west, being carried by the breeze and finally they disappeared. The student and I pondered together about what happened to the balloons when they finally burst, or disintegrated. We decided that the plastic from the balloon would probably fall to the ground. We discussed how long the plastic would probably remain on the ground and its possible detrimental effects on the environment. I suggested it might be a good idea not to have the balloon ceremony in its current form and the student agreed but then changed his mind suggesting it was only a few balloons and the ceremony was important to the graduating student cohort.

This conversation caused me to consider my science teaching practice and whether I enabled students to effectively consider sustainability issues and their role in our society. At this time, the new Australian Curriculum was being introduced and I became more aware of the importance of some of the focus areas that I had not previously considered within the context of my teaching. These included ethical awareness and sustainability education. I had some limited experience with teaching these areas. Discussion in class about ethics or sustainability often occurred at the end, rather than as part, of a unit of work.

I became increasingly aware that we as science teachers should seek to empower students to make evidence-based and ethical decisions for the future. Particularly as our society navigates the exponential development of technologies and innovation in our local and global community such as biotechnology, nanotechnology, artificial intelligence, robotics, DNA mapping, and more recently 3D printing. The tension I experienced was related to whether I could effectively provide students with the skills to explore ethical and sustainability issues concerning scientific innovation while still ensuring that I covered the content of the science curriculum.

My journey into reviewing educational research literature raised my awareness of educational reforms in Australia in the area of ethical and environmental responsibility. I became conscious of the growing social awareness of sustainability and ethical issues, and of the need to enhance student engagement with them.

I also had become increasingly aware of the problem of didactic science teaching and wanted to better deliver science teaching in my classroom. But I felt ill prepared to embrace values education, especially topics such as ethics, sustainability and socially responsible science, without losing focus on the relevant science based content. The teaching of ethical and moral awareness and of sustainability issues had especially been the catalyst for much personal reflection on my teaching craft.

When ethical dilemma story pedagogy was introduced to me it immediately sparked my interest. After discussions with my supervisors, I concluded that trialling ethical dilemma stories in my classroom might provide an opportunity to combine new ways of developing scientific knowledge for my students, while at the same time challenging them to reconsider their preconceived ideas and values. It appeared that the ethical dilemma stories could provide an avenue for my students to explore ethical and sustainability issues and to develop higher-order thinking skills through confrontational dilemmas and collaborating with each other.

Consequently, I decided to focus my doctoral research on using ethical dilemma stories in my science classroom. Ethical dilemma stories seemed to have the potential to provide an incentive for improving my teaching and to encourage me to move away from traditional didactic content delivery. They also could provide a mechanism by which to address the Australian Curriculum requirements of sustainability and ethical awareness.

Having focused my research on the use of ethical dilemma stories as a teaching strategy to make science learning less teacher-centred and didactic and more engaging, I designed an 'interpretive action research' study not only to develop my own teaching practice, in terms of planning, implementation and personal reflections, but also to involve my students as research participants. Details of the research design and the methodology are presented in Chapter 2.

RESEARCH GOALS AND QUESTIONS

As a teacher-researcher, I had the overarching goal of improving the teaching and the student learning that occurs in my classroom, especially engagement in science learning, collaborative learning and higher-order thinking. My reflective journey was designed to develop new understandings about the teaching of science to confidently employ innovative teaching strategies in my classroom, and to share my experiences with my colleagues, about what benefited my students and helped to improve their learning outcomes. This project was intended to enable me to move away from content-based and value-free lessons by engaging with ethical and sustainability issues of socially responsible science.

Based on these goals I formulated the following research questions.

1. How did the students experience ethical dilemma story pedagogy in the context of education for sustainability?

The second and third research questions focused on my self-reflective practice as a teacher and action researcher.

2. What were my experiences, as the science teacher, of putting ethical dilemma story pedagogy into practice?
3. What new understandings and insights did I discover about my teaching?

SIGNIFICANCE

Ethical dilemma story pedagogy has the potential to benefit the education community, especially curriculum developers, science teachers and students by providing enhanced opportunities to engage students with the General Capabilities and Cross-Curriculum priorities outlined in the Australian Curriculum that can be taught explicitly, rather than be treated superficially as in the past (Tytler, 2007). For teachers, heads of departments and school administrators who are keen to identify pedagogies that are beneficial for the learning experiences of students, ethical dilemma stories have potential to provide pedagogical strategies that enable teachers to cover the required curriculum content efficiently and effectively. Ethical dilemma stories are not restricted to science classes, but can be used in all curriculum areas. Therefore, the outcomes of this study could benefit other learning areas, which can be valuable for the broader education community.

The research was designed to develop my pedagogical skill set as a secondary science teacher. If successful, this professional skill set would include innovative methods of engaging students in learning about science through dilemma storytelling and through encouraging students to consider the ethical and moral aspects of a key science curriculum topic. My successful professional learning would serve as an example for other teachers to explore the use of ethical dilemma stories in their classrooms — even in other curriculum areas — in order to engage students in learning how to resolve ethical issues of sustainable development.

STRUCTURE OF THE THESIS

The remaining chapter structure of this thesis is briefly described below.

Chapter 2 - My Role as Interpretive Action Researcher

In this chapter I describe the context of this research, the research methodology in terms of the research paradigm of Interpretivism. I outline my adaptation of interpretive methods to generate, analyse, interpret and represent my data. The ethical implications of conducting this study with students in my classes are discussed.

Chapter 3 – My Ethical Dilemma Story Teaching

In this chapter I describe the development of the ethical dilemma story, Torn at the Genes. My attempt at implementing the ethical dilemma story with the first cohort of students is described. The context of the second ethical dilemma story study is explained, and changes that resulted from my experiences during the previous year's experiment are described. Finally, I discuss my plan to encourage my students to undertake higher-order thinking.

Chapter 4 – Engagement of Students in Ethical Dilemma Learning - 2012

In this chapter I analyse the data gathered from this study and discusses my impressions of how students engaged in the ethical dilemma story. The experiences of two students, Jye and Kylie, chosen purposively from the first Year 10 class, are analysed.

Chapter 5 – Engagement of Students in Ethical Dilemma Learning - 2013.

In this chapter I describe my second attempt at teaching the ethical dilemma story, with my Year 10 Science class, one year after the first class studied. The experiences of Amanda, Wade, Harry and Hayley are analysed in terms of collaboration, higher-order thinking, values, and the pedagogy of the story.

Chapter 6 – Towards Ethical Dilemma Thinking.

This chapter outlines my impressions of how well I managed to engage students in science by using ethical dilemma stories in terms of values-based decisions, reflective and dialectical thinking, collaborative learning and higher-order thinking. The results are reviewed in terms of the research questions guiding this study. The chapter presents new understandings gained from the research.

Chapter 7 – Post-script: Reflecting on my Teaching and Looking Forward

I review how the new understandings that I have gained have affected my teaching, discussing my shift from content-driven delivery to using a variety of teaching strategies to help student learn through inquiry. I explain my position on GMO foods and finally, I consider my future use of ethical dilemma stories and suggest how they could be developed further for implementation across the curriculum and expansion into other schools.

SUMMARY

In this chapter, I have provided an introduction to my doctoral research, outlined a rationale for the research, and demonstrated my desire to add an array of hitherto unfamilar teaching strategies to my teacher's toolbox of content-based delivery, which represents a major paradigm shift for me. These skills purposely address the key parts of the Australian Curriculum related to values education, ethical considerations and sustainability. I then discuss moral development, briefly explaining the contributions of significant researchers of moral development theory. I have discussed how ethical dilemma stories may provide a pedagogical tool that can enable students (and teacher) to move from a concern with content only to the inclusion of values inherent in science issues. I have emphasised my hope of improving the engagement of students, their higher-order thinking skills and collaboration, through the use of ethical dilemma story pedagogy. I have highlighted the significance of the research and provided an overview of the structure of the thesis. The next chapter continues the narrative by introducing the reader to how ethical dilemma stories are designed and to the ethical dilemma story that I used in this research.

CHAPTER 2
MY ROLE AS AN INTERPRETIVE ACTION RESEARCHER

INTRODUCTION

The purpose of this chapter is to describe the methodology of my research, starting with the research context. I reflect on my shift in perspective from a positivist to a constructivist worldview. This shaped my epistemological position and placed me on a path of seeking understanding rather than absolute truth, through the lens of an interpretivist paradigm. The chapter continues with a discussion of interpretive inquiry and action research methodology that guided my research. As a teacher-researcher, I was able to situate myself in the context of the research, searching for an understanding of how my students experienced ethical dilemma story pedagogy. Furthermore, I outline in this chapter the quality standards of my interpretive inquiry, highlighting how the standards of trustworthiness and authenticity were applied to my research and analysis. I then discuss the methods used to generate data. These methods included interviews, the VLES (Values Learning Environment Survey), student reflections, worksheets, assignments and my personal reflections. The chapter continues by explaining how the data were analysed with a software package called QSR NVivo, when identifying related themes that emerged from the data. I used the themes identified to generate an understanding of the experiences of my students. The chapter culminates with an explanation of the ethical issues related to this research.

THE RESEARCH CONTEXT

The research was conducted in a private, co-educational, P-12 college located in Toowoomba, which is a regional city approximately 125 km west of Brisbane in Queensland, Australia. Toowoomba is the major centre on the Darling Downs, which is an agricultural region west of the Great Dividing Range. The city supports the agriculture and mining industries in the region. The students of the College live mainly in Toowoomba and would be generally regarded as urban students, with only a handful living in a rural or farm setting. The College is a church school, owned and managed by a local church who are part of the Christian Outreach Church denomination in Australia. The College has a strong Christian foundation, and the day to day practices of the College reflect its Christian heritage. Staff that are employed by the College are required to have a Christian faith and live a lifestyle that is consistent with the College values. Staff have regular devotions, usually before the school starts, and students attend a vibrant, relevant chapel each Wednesday. While the school is regarded as a private school, it operates as a community school which supports a diverse

student group. Families are not required to have a Christian faith for their children to be enrolled at the College.

The College aims can be summarised in three statements: (1) learning, (2) faith and (3) life. Learning is considered to be the core business of the College, and occurs from Preparatory through to Year 12. A real faith in Jesus Christ is part of all that the College does. The College hopes that all students (and staff) will experience the joy of having a vibrant relationship with Jesus Christ. This faith leads all to love all people and to value relationship. The College aims to enable students to be well equipped for the world in which they live, realising that the world is challenging, complex and always changing.

I had been teaching Science and Mathematics at the College for two years at the time the research commenced, having previously taught in a variety of schooling systems over the previous twenty years. My main teaching areas were Physics and Science, but I also taught senior and middle years Mathematics. The research was situated within two of my year 10 Science classes. The first class consisted of 20 students, 9 female and 11 male. I knew this class fairly well, having taught most of them Science and Christian Studies in Year 8 and Mathematics in Year 9, as well as attending Year 8 and Year 9 camp with them. The second class consisted of 16 students, 9 female and 7 male students. I had taught Mathematics to most of this class in the previous year. Both classes studied the genetics topic that was the basis for the research in Term Two, having studied Astronomy in Term One. I taught one of the three Year 10 Science classes in both years; the other two classes were taught by another teacher.

Both classes participated in the ethical dilemma story, Torn at the Genes. One class completed the ethical dilemma story in 2012 and the second class in 2013. Both classes completed the unit during Term Two, which was from the Easter holidays through to the semester break in June. The demographics and class situation were similar for both classes. I had been teaching the classes since the beginning of the year, and as a result I was familiar with the students and their learning styles. I had also well developed relationships, to varying degrees with most of the students from previous years, through events such as the Year 9 camp, sport and my Year 9 Pastoral Care class. The classes were mixed gender with a broad range of abilities. The class did not have a science textbook, but we had access to a pod of laptops where students could access the internet and other resources when required. The classes were heldin a ‘standard’ science class laboratory with a bench at the front of the classroom, fixed position desks that were in rows where students sat during lessons, and six benches that were mostly at the back of the room; these were designed as a space where students could conduct practicals. I also used these benches as a location for group work, as I could not rearrange the everyday desks

in the middle of the classroom.

The next section of this chapter provides an overview of my shift from a positivist to an interpretive paradigm which guided my research methodology.

MY RESEARCH METHODOLOGY JOURNEY

This research project introduced me to a method of inquiry that I had not encountered previously. My first experience with university level research was nearly 25 years before with my final year undergraduate science project. Since then, my research had been limited to assisting my high school students with research required for their science assessments. It involved practical write-ups and research reports, which in Queensland are called Extended Response Tasks (ERT) and Extended Experimental Investigations (EEI). These research reports form part of the mandatory assessment types in the Queensland Senior Science Syllabus. Middle year (Years 7-10) science teachers tended to use the same types of assessment pieces for middle year science students to ensure they were familiar with this assessment prior to their senior science subjects (Physics, Chemistry, Biology, Science21) in Years 11 and 12. These pieces of assessment were based on the so-called 'scientific method' and a requirement to be objective.

With the idea that the scientific method acting as the universal guide for science investigations is common at all levels of science education (Windschitl, Thompson, & Braaten, 2008), I was unware that there were critiques of the scientific method. However, Windschitl et al. (2008) argue that the scientific method is not "scientific," and Tang, Coffey, Elby, and Levin (2010) comment that scientific method does not help with the scaffolding of inquiry, but distracts students and teachers from developing successful inquiry. Lederman, Antink, and Bartos (2012) point out that the scientific method does not represent scientific investigations that occur in science research, and hence the scientific method presented to students by teachers narrows and distorts their view of scientific inquiry. I was a teacher who believed that the scientific method was *the* guide to helping students with the design of their investigations. I recall being uncomfortable when some students' design process deviated from the accepted prescribed steps. I continued to help students pursue the scientific method when designing and/or conducting investigations. This belief guided me as I taught students how to write science reports. I recall explaining to my students that in their science reports they should write in the past tense, as they were reporting what they had done in their investigations, and that the report should be in the third person, keeping the personal out of the report, thus making it appear to be objective. Professional development and sample assessment items and

responses had contributed to my view of objective science report writing and objective investigations. Studying science in my science degree at university prepared me well for objective inquiries.

However, when I studied course work units for this doctoral degree, I was challenged for the first time to explore ideas behind qualitative research. I was beginning to understand that my experiences so far had been narrow and that there was a greater and fascinating world out there in relation to teaching and learning research. I realised that I had been locked into a worldview where absolute truth was an (all) important concept (Egbert, 2013), which may have sat well with my religious upbringing and possibly also with my experiences in science pedagogy so far, where an objectivist framework exists, and 'the truth' could be obtained through careful observation and experimentation. The framework or worldview wherein there is an absolute truth is the basis for the epistemological position called positivism (Scott, 2000). I realised that this was the worldview in which I had developed, being unaware that I had been in such a position. There have been times of conflict as I wrestle with disagreement between my religious truth and that of scientific truth. This has occurred mainly in the debate between creation and evolution. I believe that in terms of the big picture, such as how this universe came to be, there is one truth and people who believe in evolution or creation are on a path trying to discover it. I often struggle to reconcile this dilemma, and one of my comforting thoughts is the belief that science is our best interpretation of the observations and phenomena that are around us at this time. There are many examples when the interpretation of evidence has changed due to more data being collected or an increase in technological ability. However, sometimes someone just changes the rules, which was the case for the newly defined dwarf planet Pluto. When I was at school and university Pluto was regarded as a planet. I also believe that some evidence can be interpreted in a variety of ways, depending on the worldview of the person/s interpreting the data. This points to the idea that there can be multiple truths.

Identifying my Research Paradigm

It is appropriate to define what is meant by the term 'paradigm' in terms of research methodologies. Willis (2007, p. 5) states that paradigms are "world views about what research is and how it is to be conducted." According to O'Donoghue (2007, p. 8), "[p]aradigms are frameworks that function as maps or guides for scientific communities, determining significant problems or issues for its members to address and defining acceptable theories or explanations, methods and techniques to solve defined problems." A paradigm guides the theoretical position and methodology of the researcher (Holloway, 2013).

Epistemology can be defined in several ways: according to Scott (2000), epistemology is the "theory of knowledge and is concerned with the question of what counts as valid knowledge" (p. 21); for Willis (2007), epistemology "is concerned with what we can know about reality…and how we can know it." To Ernest (1995), epistemology deals with theories of knowledge growth and development, especially in psychology; whereas Airasian and Walsh (1997) view epistemology as an explanation of the nature of knowledge. Since I had been viewing the world and the nature of knowledge through a lens that employed an objectivist framework, my epistemological position was based within positivism. Positivism is the paradigm most commonly associated with quantitative research (Willis, 2007).

Positivism is a paradigm predominantly used in the study of science where there is a belief in universal laws. It attempts to present an objective picture of the world with a basis in the scientific method (Holloway, 2013; Scott, 2000). According to Willis (2007), a key assumption of positivism is that the scientific method is the way that truths about the world can be discovered. Positivists maintain that patterns of human behaviour can be obtained through the collection of facts and figures and careful and controlled observation. The researcher and the people being researched, that is "the objects," are independent of each other (Guba & Lincoln, 1994). The investigator can "study the object without influencing it or being influenced by it" (Guba & Lincoln, 1994, p. 110), thus, the study is objective and value-free.

As I continued to read more extensively about research in education, my worldview and epistemological position began to change. I started to realise that my objectivist worldview, that truth can be discovered only objectively, was being challenged. In the social context of the classroom, objectivity is not necessarily possible or even a useful ideal. The social reality of the classroom can be viewed as multilayered, and this complexity means that an event can have more than one interpretation, depending on the ontological orientation of the researcher (Egbert, 2013). From an interpretivist perspective, a student's actions can be interpreted according to the point of view of the student, and a different interpretation may occur from the perspective of the teacher. I realised that the positivist paradigm-was not appropriate for my intended research, since I was interested in investigating the complex social reality arising from students' engagement in ethical dilemma learning.

A Shift in Perspective

My reading led me to consider which paradigm would be the most suitable for the type of research I was planning to carry out. I had moved from the worldview that universal truth was possible to obtain. I was beginning to understand that human behaviour was not governed by

a set of universal laws or generalisations (Cohen, 2011) as would be posed by positivists. As my research was situated in my classroom, I did not believe that the positivist purpose of generating laws would be possible, as I, being the teacher in the class, would be part of the research. I would not be able to explain the phenomena that would occur in my class because an action by participants in the study could be viewed in different ways. For example, I may have observed students talking loudly in a group work task, and explained this by concluding that the task was not engaging and the students were off task. However, another view may have been that the students were indeed engaged by the task and were talking loudly because they were passionate about what they believed. I had to convince myself that I would not be able to seek a single objective truth. This led me to a dilemma; I had to shift away from my positivist background and search for a paradigm that would be appropriate for the type of research I was conducting.

I discovered that Willis (2007) identifies three major paradigms of social science research: positivism, interpretivism and critical theory. As discussed, my shift in perspective has led my worldview away from positivism. I had to decide which of the major paradigms would form the basis of my research. I found explanations by Taylor (2008) regarding these three paradigms enlightening. He explains that the interpretive research paradigm has a focus on developing an understanding based on the situation of the research. He comments that it has a basis in social constructivist epistemology, wherein, because of the multiple meaning perspectives of participants, understandings are subjective. Taylor (2008) explains that a critical paradigm has a primary concern with social justice, moving to make the world "more fairer, more equitable, more inclusive and more harmonious." He suggests that this paradigm moves further than interpreting the situation, and addresses the social injustices that may be present. The next section will discuss why I decided that an interpretive paradigm was the more appropriate for my research setting.

INTERPRETIVIST PARADIGM

Willis (2007) lists several key features of the interpretivist paradigm. These include: (1) the nature of reality is socially constructed; (2) the purpose of research is to reflect understanding; (3) subjective and objective methods of data collection are acceptable though objectivist methods could serve as a back up; (4) the meaning of data collection is based on understanding rather than generating universal truths; and (5) research and practice guide each other and are integrated. I will use these features to explain why I chose the interpretivist paradigm for my research.

As a teacher, a major assumption of mine is that knowledge in my classroom is based on the epistemology of constructivism, assuming that people can "create knowledge from the interaction between their existing knowledge or beliefs and the new ideas or situations they encounter" (Airasian & Walsh, 1997, pp. 1-2). Ethical dilemma stories provide opportunities for students to work in groups to discuss and generate a decision regarding a particular ethical dilemma. In my project, the students were constructing meaning and shared understandings with other members of their group and the class. The construction of knowledge was a result of the social interactions between the students and the teacher's experience.

The interpretivist approach relies on social interaction as the basis of knowledge generation. The skills of the researcher, as a social being, are used to try to understand how other humans understand their world (O'Donoghue, 2007). Chinn and Kramer (2013, p. 70) discuss the three fundamental human interests that are central to Habermas' critical social theory, developed in the 1960s: the technical, the practical and the emancipatory. The technical interest refers to the ability of humans to understand the physical world and create things. This interest requires that humans offer scientific explanations. However, Chinn and Kramer (2013) comment that Habermas believed that not everything could be reduced to scientific explanations and that people needed the ability to communicate and understand social meanings. Holloway (2013) suggests that interpretive methods are suited to the practical interest, which is the second of Habermas' fundamental human interests. The third fundamental human interest is the emancipatory interest. This is the ability of a person to recognise that a change needs to occur and to have the desire to make the change happen (Chinn & Kramer, 2013), in order to "achieve freedom and autonomy, overcome social problems and change power relationships" (Holloway, 2013, p. 236). This interest relates to critical theory, and while it is an important area to consider, especially in a classroom situation, as a researcher I have chosen to focus on the practical interest, attempting to understand the social interactions between students and myself as we work through the ethical dilemma story.

As interpretivist teacher-research, I no longer agree with the positivist belief that it is possible to discover an objective social reality using the scientific method in my classroom. As a teacher-researcher, I can construct a version of reality that is based on my interactions with my students as well their preferences and biases (Schutt, 2006), on my worldview as a researcher, and on pre-existing theories (Willis, 2007). The social realities of my classroom are constructed by understanding the social behaviour of my students, which is related to the way in which I define and interpret the social situation. This is much like Vygotsky's zone of proximal development, where students are moved from what they can accomplish on their own to what they are capable of accomplishing when they are helped by a more capable peer

through social interaction (Jones, Rua, & Carter, 1998; Kapon, 2016; Mestad & KolstØ, 2014).

Willis (2007) states that for interpretivist researchers, an understanding of the context of research is necessary for interpreting the data generated, which means that the interpretivist researcher has the goal of understanding the situation rather than trying to develop a universal set of laws or rules. The research that I conducted in my classroom did not have a goal of generating universal truth (laws or rules) that necessarily could be applied to other classroom settings. My goal, rather, was to develop an understanding regarding how students and I, as their teacher, experienced an ethical dilemma story. Since I was situated within the context of the research as a cultural insider, I had an ideal opportunity to live the experience of teaching the ethical dilemma story pedagogy, and to investigate the lived experiences of my students.

Interpretive Inquiry

The epistemological framework of interpretivism guided me to design a methodology to seek the understandings that I required. Methodology, according to Egbert (2013, p. 115), is "a reasonable plan for gathering and analysing information that responds to a line of research inquiry. Methods can be defined as the specific procedures that accomplish the task of gathering and analysing the data in a research study." The methodology of this research draws on the interpretive grounded theory approach of participatory action research (Chevalier, 2013). The methods of generating data, which I discuss later in this chapter, included interviews, student journals, personal reflections, and a survey.

Interpretive inquiry involves the interpretation (or understanding) of the "meanings, purposes, and intentions (interpretations) people give to their actions and interactions with others" (Smith, 2008, p. 3). The research questions ask how the students and teacher experienced a dilemma story, and interpretive inquiry provided a methodology for me as the researcher to apply meaning to students' experiences of the dilemma story as a teaching strategy. These understandings are unique to individual students and thus are subject to the students' own interpretation of the process. Interpretive inquiry methodology also allows students – the co-participants in the research – to make their own meanings during the ethical dilemma story experience, and students who were interviewed were able to express their meanings.

Interpretive Action Research

A key goal of this research was to improve my pedagogical practice as a teacher. What understandings could I develop through the inquiry of how to improve my teaching practice and develop appropriate ethical dilemma story teaching strategies that would enable my students to learn more effectively? As I generated insights in relation to these questions, it become obvious to me that some questions would not be answered in one easy stage, but that several steps were required: at each stage, I would ask questions, implement strategies and reflect, building with each step upon the knowledge and skills gained from the previous step. I realised that I needed to investigate the suitability of a strategy by implementing that strategy and then reflecting upon this action. If needed I would start the process again, depending on the interpretation or the understandings gained previously.

This type of cyclic inquiry is referred to as 'action research'. In the literature, action research is performed by people situated in a research context (practitioners) who become researchers in their own contexts (Holloway, 2013). I was the teacher in the classroom, the practitioner, and subsequently I became the researcher. Action research methods would allow me to generate understandings of the experiences of my students as they engaged in the ethical dilemma story, in accordance with the interpretive paradigm. These methods would also enable me to develop an enhanced understanding of my practice as a teacher.

Action research is usually characterised by a systematic process. McNiff and Whitehead (2006, pp. 8-9) suggest a 'typical' action research process:

- Take stock of what is going on
- Identify a concern
- Think of a possible way forward
- Try it out
- Monitor the action by gathering data to show what is happening
- Evaluate progress by establishing procedures for making judgements about what is happening
- Test the validity of accounts of learning
- Modify practice in the light of evaluation.

Tomal (2010) proposes a similar action research model derived from the previous work of Lewin, including six stages:

Stage 1: Problem statement

Stage 2: Data collection

Stage 3: Analysis and feedback

Stage 4: Action planning

Stage 5: Taking action (implementation)

Stage 6: Evaluation and follow-up

One disadvantage of such lists is that they cause the process to look linear, where as an action research process is cyclical in nature, which is indicated by the last point in McNiff's list – modifying practice. Authors have described the action research cycle in a variety of ways. McNiff and Whitehead (2006) discuss an action-reflection process shown in Figure 2-1 as a cycle, because as researchers reach a point where they have found satisfactory responses to their questions, new questions will arise, and thus the cycle begins again.

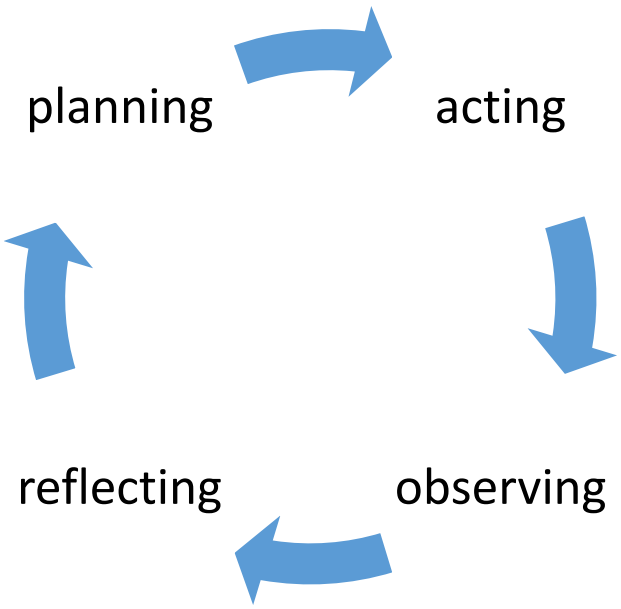


Figure 2-1: An Action-reflection cycle (McNiff, 2013, p. 57)

The process of action research is frequently displayed as a diagram that highlights its cyclic nature, as in Figure 2.2.

This cyclical model was useful for my research. Dilemma story pedagogy uses stages to present increasing complexities of the dilemma story that the students are experiencing. I planned lessons using the cycle of action research, presenting opportunities at each stage of the story, and as I worked through the inquiry process with students, further opportunities for action and reflection became available.

Action research, as a cyclical process, describes the "systematic application of problem-solving strategies to an authentic question at hand in order to achieve understanding of or resolution of the situation" (Egbert, 2013, p. 121). It is conducted by practitioners who are in a social situation (Cohen, Manion, & Morrison, 2007) and can be referred to as practitioner research, where the researcher is part of the social context, systematically undertaking critical self-reflection (McNiff, 2013). I was in an ideal position, as a teacher, to undertake action research, which should be distinguished from my normal everyday activities as a teacher. Cohen et al. (2007) commented on several daily actions of teachers that do not constitute action research. (1) Action research does not refer to the daily, regular thinking and planning teachers do about their teaching. Action research is purposeful and systematic in collecting evidence and reflecting on practice. (2) Action research is not (just) problem-solving, rather it is the identification of a problem, the seeking to understand a social situation, and the

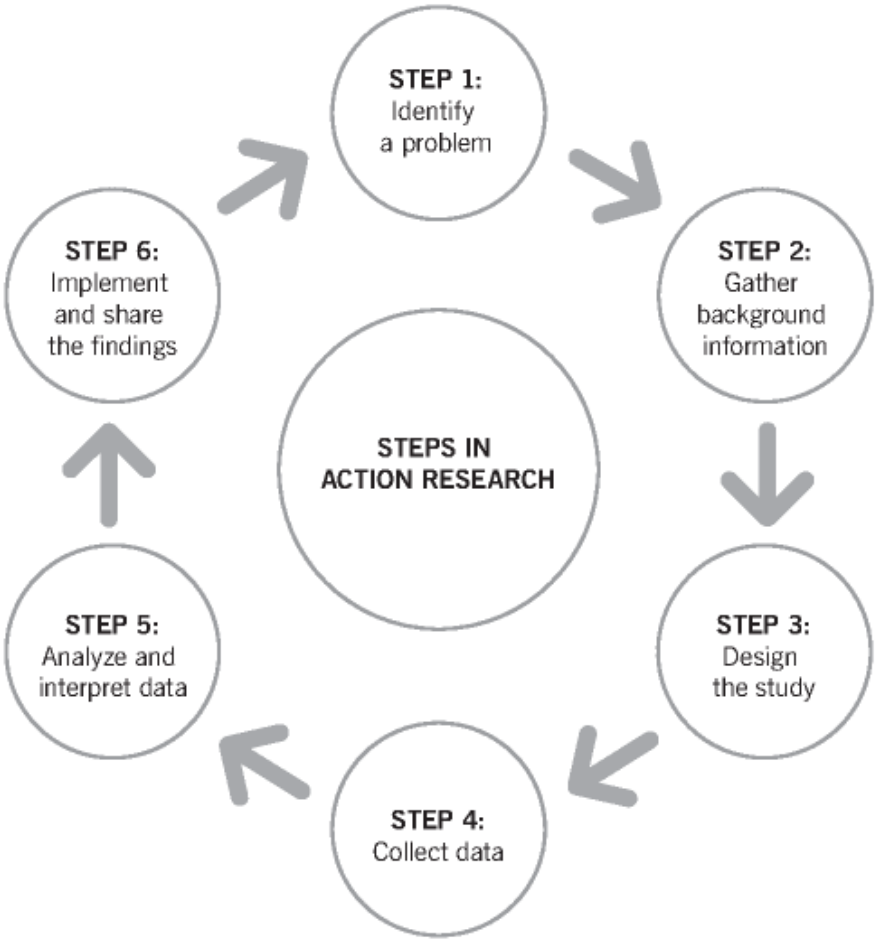


Figure 2-2: A typical action-reflection cycle (Efron, 2013, p. 8)

learning of how to improve it. For example, in my context, I was seeking to understand how I could assist the dynamics of group work activities when students collaborated in decision

making during the ethical dilemma story. Furthermore, I sought to improve the collaboration and involvement of individuals within their groups. Cohen et al. (2007) emphasise that action research is not carried out “on” people, but rather researches people doing their work, helping them improve what they do, and how they work with others.

Teachers who conduct action research are often referred to as reflective practitioners, committed to improving their methods of instruction. Tomal (2010) explains that action research is a simple, logical process of finding solutions to problems and making improvements. He suggests that action research is more concerned with making improvements within the situation being studied than with conducting an elaborate statistical analysis. This was empowering for me as the teacher-researcher, since solving a problem in a timely and doable manner is a practical process. Stringer (2007) reports action research as a means by which to improve the effectiveness of the work in which one is involved. Action research is often used in workplaces such as a classroom, where there is not a generalised solution to the problem in question, but where the process of action research allows for generalised solutions to be modified or adapted to suit the particular context of the practitioner-researcher (Stringer, 2007).

For McNiff and Whitehead (2006, p. 5), action research is “about practitioners creating new ideas about how to improve practice, and putting those ideas forward as their personal theories of practice”; they highlight two key themes of action research. These themes are: (1) improving practice; and (2) assisting practitioners to develop theory based on their own practices in the workplace. Action research is a type of inquiry where the “I” as a practitioner-researcher analyses and evaluates his or her own actions in the classroom. As I asked questions of my students’ practice, engaged in reflections and constructed data analysis, I identified ways of improving my own learning and the learning of my students (McNiff & Whitehead, 2006). One advantage of action research methods for a practitioner-researcher such as myself is that the investigation was of my own practice, and accordingly, I guided my research through personal practice rather than through being told what to do by external authorities.

QUALITY STANDARDS OF THE RESEARCH INQUIRY

As I considered how the quality of the research could be ensured, the suggestion of employing the strategy of ‘triangulation’ came to the forefront. Triangulation involves using "multiple methods, data sources, and researchers to enhance the validity of research findings" (Mathison, 1988, p. 13). In triangulation, multiple sources help confirm findings when searching for a conclusion (Willis, 2007). However, these ideas tend to lead to the notion that

the research attempts to reach generalisations or searches for universal truth. I found that this method of optimising validity and reliability did not match the chosen paradigm of my research, which was interpretivism.

Since interpretivist inquiry is more concerned with immersing oneself in the research with participants while attempting to understand the social constructs and meanings, rather than generating a universal truth, triangulation does not, as Willis (2007) points out, provide a good fit with the interpretivist paradigm, which is based on socially constructed reality which comprises a variety of perspectives. Triangulation, on the other hand, tends to direct researchers into a pattern of convergent thinking, looking for evidence that supports or verifies a theory (Taylor, 2014).

Given that my research was concerned with attempting to understand the interactions of my students as they engaged in an ethical dilemma story, rather than exploring generalisations, I decided that the 'parallel criteria' of Guba and Lincoln (1989) were appropriate to serve as a guide for determining the quality of this interpretive research. From the trustworthiness criteria, I have applied credibility, transferability, dependability and confirmability; and from the authenticity criteria, the idea of fairness (Guba & Lincoln, 1989). I will discuss how each of the criteria apply to my research.

Trustworthiness

Trustworthiness is also known as 'the parallel criteria' (Guba & Lincoln, 1989, p. 233). It was developed from the positivist criteria of internal and external validity, reliability, and objectivity. It assesses the quality of qualitative research especially the interpretive paradigm that frames my research. Guba and Lincoln (1982) posed four questions to be addressed. (1) Truth value – how can a researcher have confidence in the truth of the findings of study in relation to the context in which the study was carried out? (2) Applicability – how can a researcher be confident that the findings of a study can be applied in other contexts or with other participants? (3) Consistency – can the findings of a study be replicated with a similar study? (4) Neutrality – can the findings of a study be attributed to the experiences of the participants and the biases or motivations of the researcher? Guba and Lincoln (1982) renamed these criteria as: credibility, transferability, dependability, and confirmability. These criteria were useful as a guide while I was making methodological decisions.

Credibility

Credibility involves confidence in the similarity of the constructions made by the researcher and the reality of the participants (Guba & Lincoln, 1989). There are several techniques for establishing credibility. As a teacher-researcher, I established credibility through prolonged engagement. I had been working with both classes involved in the research for a significant period of time of at least ten weeks, and I had taught many of the students during the previous year. I was also immersed in the culture of the school, having two to three years of experience in that school (and more than 21 years teaching experience in total) before undertaking the study. I was able to consistently observe my participants as their science (and mathematics) teacher, which added depth to my narrative of the participants' experiences. As I was a teacher in the school, I could often debrief with peers, discussing various aspects of the research with my Head of Faculty and the other Year 10 science teacher. I was able to verify my representation of the data through 'member checks', using multiple sources of data to confirm and disconfirm my interpretations. I also discussed my interpretations with the students.

Transferability

Transferability refers to the degree to which the understandings gained from my research can be transferred to other similar contexts (Guba & Lincoln, 1989). I used thick description (Holloway, 1997) of key events, research participants and contexts to provide a detailed account of the research experience. I have included descriptions, examples, and quotations, attempting to be as specific as possible so that the reader has a rich understanding of the context of the research. I have also included sample materials used by the students, such as sections of worksheets and booklets.

Dependability

Guba and Lincoln (1982) argued that methodological changes can be expected within research that is emergent in nature, as was the case in my interpretive inquiry. They suggested that such changes indicate a developmental progress within the research, which needs to be trackable (Guba & Lincoln, 1989). I have, where warranted, described the development of the research process, and kept personal reflection notes and observation notes that have contributed to the study.

Confirmability

Confirmability examines how well a researcher's understandings are supported by the data generated (Guba & Lincoln, 1982), including any construction, assertion or fact. This implies that the data should be trackable to the various sources. The sources I have provided include excerpts of interviews, personal reflections, and coding, to allow links to be made back to the source material (see Appendix 2). For example, I have included references for direct quotes from the interviews, student reflections, and responses to worksheets and booklet questions.

Authenticity

I believe that fairness is an important criterion to ensure the authenticity of the project. Fairness, according to Guba and Lincoln (1989, pp. 245-246), "refers to the extent to which different constructions and their underlying value structures are solicited and honoured within the evaluation process." This criterion represents the "quality of balance" (Onwuegbuzie, Leech, & Collins, 2008) and reflects the idea that all viewpoints should be represented fairly (Wilson & Clissett, 2011). To achieve fairness in my research, I strove for the voice of a range of students to be heard. I did not focus on the academic students or even on the battlers; rather, I tried to represent the cohort of students in both classes in a balanced manner.

DATA GENERATION

Interviews

I employed a semi-structured approach to conducting interviews, which allowed some latitude with the questions, so I could ask other relevant questions depending on the progress of the interview and the responses of the students. A semi-structured interview is similar to a structured interview where there is a fixed set of questions; however, in the semi-structured interview, the interviewer is free to expand on any question in order to explore the participants' responses in greater depth. The interviewer can ask additional questions to follow up any interesting responses or unexpected answers (Mitchell & Jolley, 2009). Cohen (2007) suggests that using semi-structured interviews increases the flexibility of the interview, rather than having a fixed sequence of discussions; it also allows issues raised by interviewees to be more fully explored. I decided to use semi-structured interviews, as I believed that I would be able to reach a deeper level of understanding of the experiences of my students. I also felt more confident having a basic structure of questions to follow, to ensure that I gathered rich data and did not accidentally forget an important line of questioning. The set of questions that I used as a guide for the interviews is included in Appendix 2A.

There are disadvantages associated with conducting interviews, such as time constraints, possible misinterpretation of the student responses, and potential discomfort of the students being interviewed (Tomal, 2010). I chose to interview pairs of students so that they would feel less uncomfortable being interviewed by their teacher. It was difficult to find time during school hours to conduct the interviews. I had to find a time when I was not scheduled for a class, and when the students were also available. I held both sets of interviews for the two classes during the last week of school before the holidays, which meant that it was not a huge issue for the students to miss classes. To help ensure the credibility of the study, a variety of methods were used to collect data these included semi-structured interviews, student journals, Values Learning Environment Survey (VLES), student-produced material such as worksheets, and their assignment, as well as my personal reflections.

Values Learning Environment Survey (VLES)

The VLES survey was modified from a survey developed by Taylor, Settelmaier and Hill in 2010, and was not intended to be a primary source of data, but was used to generate an overview of the perceptions of the whole class. The VLES had three specific goals when developed, which were to promote, assess and monitor values learning (Settelmaier, Taylor, & Hill, 2010). It was designed to measure key factors of the classroom learning environment that research by Settelmaier (2009) found were helpful to encourage values learning, namely: (1) critical self-reflection; (2) empathic communication; (3) critical social thinking; (4) deep engagement; (5) collaborative decision-making; and (6) teacher support. The VLES measures students' perceptions of various aspects of learning science, such as how they experienced science as a subject, and their perceptions of the teacher and group work, using a five-item scale. The survey also asks students to consider how they listen and think within a science class. I conducted a post-survey for the 2012 class of students and a pre- and post-survey for the 2013 class. A copy of the surveys can be found in Appendixes 2B and 2C.

Student Reflections

A valuable source of data is student reflections. I adopted 'Wikispaces' and 'Moodle' to enable students to record online their reflections, which enabled them to enter their reflections at home. Reflections were recorded on Wikispaces, which is an online tool that I used as learning support for the students that provided resources and opportunities for collaboration. I outline how I used Wikispaces in Chapter 3. Moodle is an open-source online learning management system. I discuss how I implemented functions of Moodle in Chapter 3. I asked students to

record their reflections in the blog feature of the software. These were stored on Wikispaces and Moodle, where I could view and comment on their entries at times that were suitable for me. Thus I could see at a glance which students had or had not recorded their reflections. The medium for the reflections was different for the two classes. The 2012 class used the 'journal' feature of Wikispaces, which is a web-based social writing platform. The platform is designed to allow the creation of classroom workspaces where students can communicate and work on tasks individually or in groups. The instructions that I gave the students in this class can be found in Appendix 2D. This 'wiki-journal' was confidential for each student, although I could view the journal via a "teacher role."

Midway through the term (2012), I noticed that the reflection questions I had provided lacked depth. After some searching I came across an idea called 'A Taxonomy of Reflections' (Pappas, 2010), which is based on Bloom's Taxonomy. Figure 2-3 displays Pappas' Taxonomy of Reflections. I adapted the taxonomy, and subsequently developed a worksheet for students with reflection questions to be completed after their assignment. The reflection questions can be found in Appendix 2E.

A Taxonomy of Reflections
Creating: What should I do next?
Evaluating: How well did I do?
Analyzing: Do I see any patterns in what I did?
Applying: Where could I use this again?
Understanding: What was important about it?
Remembering: What did I do?

Figure 2-3: Taxonomy of Reflections (Pappas, 2010)

In 2013, instead of using Wikispaces for the journal, students recorded their reflections in a blog module called 'MYCOCT' that was part of the Learning Management System (LMS) used by my College and was based on the Moodle online learning platform. Students received similar instructions to the class of 2012. Both Wikispaces and Moodle LMS had a feature that enabled me to save permanently a copy of the student reflections, which became a source of research data.

Students responded to worksheets and, for the 2013 class, I created a student booklet (discussed in Chapter 3) which provided another source of data. Worksheets and the booklet asked students to record their thoughts and ideas regarding genetically modified foods and

what they thought about whether or not they should eat the genetically modified tomato, thus reflecting on whether or not genetically modified crops should be consumed as food.

Personal Reflections

I recorded personal reflections in my journal during both studies. Literature describes this as 'reflective practice', which can be considered as "learning and developing through examining what we think happened on any occasion, and how we think others perceived the event" (Bolton, 2014, p. 7). Reflective practice is more than just recording reflections; as Bolton has suggested, it involves learning and acting. In hindsight, I wish I had been more consistent when recording the reflections. Erlandson, Harris, Skipper, and Allen (1993) encouraged researchers to be consistent with reflective writing throughout the research. As a novice researcher, who was also working full time as a teacher, I was not as consistent as I would have liked. On occasions I recorded notes using my Ipad during class but generally, I wrote notes after each lesson or during the evening that followed the class. My insights and reflections served as an incentive to make changes in my practice.

ANALYSIS OF DATA

I was excited by the amount and richness of data generated through the implementation phase of the first ethical dilemma story, Torn at the Genes I. However, my excitement diminished as I started to reflect on how I was going to analyse the data. As I described earlier, my background as a science and mathematics teacher had positioned me in a positivist paradigm, and my experiences of data analysis were narrow, limited to guiding my students in the analysis of their investigations in the laboratory, and reading a limited number of scientific journal articles. My original view of data analysis was that it involved statistics and graphs, including standard deviation and normal curves. I recalled studying statistics, hypothesis testing, and chi-squared analysis at university.

I had a vague idea of what qualitative data analysis involved, gained from my supervisors and various readings: ideas such as coding and themes were discussed, yet they initially seemed an impenetrable barrier for me. This was to be the start of a steep learning curve. Fortunately, I was introduced to the software package QSR NVivo. As an external student, I relied on tutorials provided by NVivo and YouTube clips, and in the process, I developed a better understanding of interpretive data analysis.

I read about coding, axial coding, themes, nodes, matrix coding and grounded theory. I

watched several YouTube clips about grounded theory presented by Gibbs and the University of Huddersfield (Gibbs, 2010). As I watched, I took screenshots of images and copied them to my journal. These were helpful in part, but also caused some conflict, as I initially thought that because I was conducting an interpretive study, I was not focused on generating theory, but rather was interpreting and providing meaning from the data that I had gathered. As I continued to explore the relationship between grounded theory and interpretive study, I eventually realised that I was generating theory after all, throughout the process of interpreting data, and subsequently developing an understanding of those data.

I recall emailing my supervisors to seek clarification regarding what direction to take with the analysis. I was seeking a process or a list of steps to follow, but I had difficulty finding a process with which I was happy. My supervisor emailed back with comments that simplified my qualitative analysis life and helped reduce the doubts I had about how to undertake the analysis. She suggested that I:

- Work systematically through the codes and determine what they meant to me
- Code for meaning (open coding), taking notes of when the meaning changed
- Re-analyse my initial open coding to uncover what the codes were telling me, the interpretation of codes, or what people were talking about
- Check my codes for any hierarchies, that is, looking any overarching themes

My supervisor's email assisted me by placing the issues in perspective. I finally had some steps, a process, that I could understand. I also finally understood some of the literature about qualitative data analysis. I then set about coding the data. These data included interview transcripts, reflective journal entries made by me and the students, worksheets and the student assignments. As I coded, I revisited the initial research questions and created a mind map (Figure 2-4) which I placed on the wall so that I could refer to it easily. This mind map served as a guide. I purposely did not limit my coding to the research questions, but remained open to meanings that emerged.

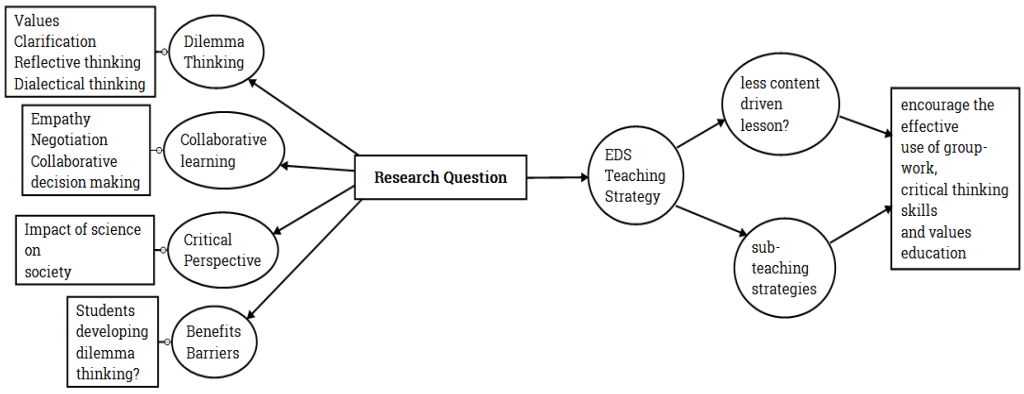


Figure 2-4: Mindmap of initial research questions

Fortunately, I was able to use the software package QSR-NVivo 10, which helped me with coding the data by creating so-called 'nodes'. A node in NVivo is another term for code. A sample list of nodes is shown in Appendix 2F, and an example of an interview that was coded is displayed in Appendix 2G. I found the coding interesting, as it provided structure for me as I explored the data. I found that I was looking forward to investigating the themes that became apparent through the coding, and I started to see aspects of the teaching and learning in my classes that I could investigate further. Subsequently, I developed my plan of attack, which I recorded in my journal:

- Keep in mind research questions
- Read through each node
- Memo thoughts about the node
- Note possible queries
- Options (for further analysis) – text and word frequency search
- Query combinations of nodes
- Work on nodes most related to research questions first

NVivo has a useful feature called 'Memo', which allowed me to write notes about a particular node as I read and reflected. Memos were linked to particular nodes and were therefore easy to find again. Appendix 2H has an example of a Memo from the second dilemma story. I investigated all the nodes freely which I had created as I read through the data, and where appropriate I grouped nodes into hierarchies. I ended up with two overall categories, one category based on the research questions, the other on the individual students, allowing me to analyse individual student experiences.

In addition, I explored some additional features of NVivo such as Queries', which are searching tools. NVivo provides a mechanism to explore data, such as searching for a

particular word or phrase. Queries also enable the researcher to search for content that may have been coded for a particular theme in the data. I was not very successful using the Query feature, as I did not set up the initial data attributes correctly. In hindsight, I believe it would have been a good idea to attend NVivo training, but at the time this was not an option because of my work commitments.

ETHICAL ISSUES

Research that involves the study of humans, in my case, students in my science class, raises ethical issues that should be considered carefully. Anderson (1998) explains that there are specific considerations and acceptable standards that should be adhered to when conducting ethical research. These are: (1) the risk of harm should be minimised and the general welfare of participants should be enhanced (AARE, 2016); (2) possible risks should be outweighed by the expected benefits for the participants; (3) the rights and the welfare of the participants should be of the highest priority; (4) the research should be periodically reviewed; and (5) participants should be given the opportunity for informed consent. As I was a practising teacher, choosing to undertake this postgraduate research to improve my teaching and subsequently my students' learning, my students became participants in my research. My research role , as an interpretive action researcher, allowed me to review and evaluate the impact of my innovative teaching practice on student learning. This implies that my students may have had difficulty identifying which practices in class were normal teaching practice and which ones were part of the research. I had an obligation to treat each student as an individual who had the right to not be involved with the research (Nolen & Putten, 2007), but as is the case with most action research with school-aged children, there is a blur between the teaching and research, and accordingly students may be unwilling participants in research as they are expected to undertake the normal classroom activities.

The participants of this study were students in my Year 10 Science classes in consecutive years – 2012 and 2013. Both classes consisted of female and male students whose age ranged from 14 to 16 years of age. The average age of the students was 15 years. The recruitment of the participants for this research was in part determined by the teaching timetable given to me by the Director of Studies. My research required a middle year science class, and the Year 10 science class was chosen because they were the only timetabled science class given to me. I placed a special request to the Director of Studies to be timetabled with a second Year 10 science class in the following year. This meant I could repeat the study with a similar cohort of students. The names of students were changed in the study in order to protect their identity.

In the case of my research the dilemma learning activities were appropriate for the age of the students. These activities did not lie outside the realm of science class activities that students would typically experience. It is not unusual for a teacher to explore different teaching strategies with their classes with the intention of improving the teaching and learning, and I could have easily introduced the ethical dilemma story pedagogy without formally researching and reporting on the process. This means that my students were not disadvantaged in terms of their classroom experiences and learning of science. The science topic that was the basis of the research study was one that students would have learnt about even if the research had not occurred. This topic was genetics and genetic technology, which was described in the Australian Curriculum as part of the Year 10 Science descriptors for Biological Science. This means that students who were part of the research were not disadvantaged, as the curriculum that was the foundation of the ethical dilemma story used in the research was part of their normal Year 10 Science program.

However, even though the research activities were part of normal classroom practice, I sought consent from the students, as this is one of the fundamental principles for ethical practice in research (Anderson, 1998). Anderson explains that participants should be informed of the type and goals of the research, possible risks and the benefits. Participants should be able to give consent without coercion. I applied this principle of informed consent by giving students and their parents an information letter and a consent form to enable their participation in the study, with a suitable time frame for parents to properly consider the information. The Principal of the College and other relevant administration staff, including the Head of Senior School and Head of Science/Mathematics, also received an information letter, and their permission was sought for the conduct of the study. These staff were also available to address any issues raised by students or parents.

In my absence, the Director of Studies explained the purpose of the research to the classes, ensuring them of the voluntary nature of their participation in data collection activities, and their right to withdraw without prejudice at any time during the research. He also distributed and explained the Participant Information Sheet and Consent form, and collected them from the students. He made students aware that he was their “go to” person if they had any further queries or concerns about their ongoing involvement in the research component of the study.

Due to the action research nature of study, I had to resolve the issue of when a student might decide that they did not want to be part of the study. This would have been a difficult issue, as the teaching in class during the study was considered to be a natural part of the learning of science in those classes. I decided that if a student did not want to participate then I would

take particular care not to record specific observations about the student, and I would inform the student that I would not use any material from their reflections, journal, worksheets or assignment as a data source for the study.

The students in this study were in a dependent or unequal relationship with the researcher, as they were students from my classes. I, as their teacher, was more powerful than the participants, as students, due to the teacher-student relationship (Ferguson, Yonge, & Myrick, 2004). I was careful to ensure that students did not feel that they should respond in a certain way in order to please me as their teacher. Due care was taken not to force students to undertake interviews or surveys, and they were free to discuss their participation at all times with the Director of Studies, who was an independent third party within the school. The research activities were separate from the standard assessment of student learning, thereby ensuring that assessment of student learning would not be compromised by a student decision not to be involved in or to withdraw from the research component of the study.

Data Storage

The data, in the form of interview recordings and transcripts, journal entries, worksheets, booklets and assignments, have been stored privately on my password protected personal computer in a digital format and a backup is stored in a secure Microsoft OneDrive account. The only exception to this is that some of the journal data collected is also stored on an external site – Wikispaces. This data is secure. All data will be deleted five years after the submission of the thesis. In order to delete the data on the Wikispaces website, the account will be closed.

SUMMARY

This chapter begins with an explanation of the research context of my Year 10 Science classes. The methodological background to my research project is then discussed. Firstly, I consider the shift in my perspective, from my previous experiences with the positivist paradigm to developing an understanding of the interpretive paradigm, which is grounded in social constructivist epistemology. The chapter continues with an explanation of methodology within the interpretivist paradigm, explaining how action research was employed in this study. Further, I present a brief overview of the quality standards of my interpretive research, the trustworthiness and authenticity criteria. I describe various data generation methods, ranging from personal interviews to student reflections and the Values Learning Environment Survey. The process I used to analyse the data involved exploring and identifying themes, generating new understandings about the experiences of my students, and of myself as their teacher. I

conclude the chapter by considering ethical issues involved with the study. Chapter 3 follows, with my account of the development of the ethical dilemma story – Torn at the Genes – with the first cohort of students.

CHAPTER 3
MY ETHICAL DILEMMA STORY TEACHING

INTRODUCTION

The first section in this chapter describes my plans for the ethical dilemma story unit for both of the classes that participated in this research. I begin by explaining the development of the ethical dilemma story – 'Torn at the Genes'. I include a discussion about the way in which I attempted to develop higher-order thinking in the classes and a description of the thinking tools that students used. The chapter continues with a description of the implementation of the story in my 2012 Year 10 science class, followed by my 2013 class. I discuss how Wikispaces acted as a resource for the first cohort of students. The second cohort of students were introduced to MYCOCT (the College learning portal using Moodle as the software base) and a student booklet in which students could keep notes. The booklet also served as a tool that I used to gather information about students' experiences with the story.

TORN AT THE GENES – DEVELOPMENT OF THE STORY

As I considered my research needs and the requirements of the Year 10 Science Work Program, I decided that my first ethical dilemma unit would be related to a genetics topic. This suited me for two reasons. Firstly, the work program for the year developed by previous science teachers for Year 10 science classes indicated that genetics would be the main topic for Term 2. This suited the timeframe for completing one ethical dilemma unit. Secondly, genetics provides numerous ethical dilemmas such as genetically modified food, genetic testing, prenatal testing and predictive testing. My first decision related to choosing an issue to investigate with the students. Some practicalities needed to be considered before I could settle on a topic. The issue needed to be appropriate and accessible to the students; that is, relevant information could be easily found using a variety of sources; and the underlying theory had to be understandable for students at this year level.

I chose the 'safe' option of Genetically Modified (GMO) foods as the basis for my ethical dilemma unit. I considered it safe because there were a variety of issues to consider but it was not as controversial as some of the other ethical/moral issues in genetics. A safe topic seemed important to ensure the learning outcomes of the students were not affected by the research. But in hindsight, a more controversial issue may have caused students to struggle more with the various issues, and this might have meant there would have been a higher level of indecision. I also wanted their first experience of ethical dilemma stories to be reasonably

straightforward and satisfying, in that they could reach an opinion without too much confusion or ambiguity.

Genetically Modified Food

"Genetic modification (GM) is the use of modern biotechnology techniques to change the genes of an organism, such as a plant or animal" ("Information on genetically modified (GM) crops", 2015, para. 1). It is thought that genetically modified crops are able to help with safer food production. Food production around the globe is a growing concern, as the population of the world is increasing, and there are issues with food distribution in developing countries (Qaim & Kouser, 2013). The use of pesticides and herbicides presents health risks, and experts view genetically modified crops as a possible solution to address this problem (Gwin, 2001; Halford, 2011). However, others view it as a serious threat to human civilisation, with health and safety risks associated with genetically modified food as well as environmental concerns (Gwin, 2001) such as the production of 'superweeds' (Gilbert, 2013). There are two ethical issues in the statements above: (1) is it right to ensure that our global population has enough food? And (2) should society be using technology such as genetically modified food when there are health and environmental concerns? (Jefferson, 2006).

STORIES IN THE CLASSROOM

It is not uncommon to see stories used in our classrooms in various forms. One example of story-based teaching is the use of case studies. These have been deployed for a long time at Harvard University in their Law and Business schools as well as in the medical schools. The University at Buffalo, for example, has been a pioneer in the use of case stories in science, mathematics and engineering (Herreid, 2005). Cases are stories (Herreid, 2005; Jonassen & Hernandez-Serrano, 2002; Pimple, 2007) that are told and analysed in the classroom using a variety of methods. They are usually written around a problem to be solved. The case provides the history or background necessary for students to solve a problem. Herreid (1994) noted that the case study method "involves learning by doing, learning how to grapple with messy real-life problems… and often team work." The intended learning outcome guiding the case study method is that of learning how to problem-solve. Jonassen and Hernandez-Serrano (2002) argue that using stories with the case study method is an effective way to engage students in real life problem solving. They explain that stories are "essential to solving complex, everyday and professional problems" (Jonassen & Hernandez-Serrano, 2002, p. 76).

Ethical dilemma stories have some similar features to case studies. Both can involve solving

a real-life problem. The main difference is that an ethical dilemma story poses a dilemma with equally viable options. Students have to make choices based on their ethical understanding and values. Both case studies and ethical dilemma stories serve to promote engagement and critical thinking in the classroom. Some case studies can be adapted to become ethical dilemma stories since they contain values conflicts, as in the ethical dilemma story I used with my students.

Whilst the use of stories as a teaching strategy has many advantages, some authors point out several issues need to be considered when preparing stories for the classroom, such as: (1) the type of stories that are appropriate for the students; (2) the depth of knowledge; and (3) skills that need to be covered (Heering, 2010). Heering stresses that stories should be selected to ensure the integrity of the class and curriculum.

Considering all these benefits and caveats, I concluded that in science teaching using storytelling is not an easy process. It can be complex and challenging to get the meaning across in a concise manner. It requires the teacher to have the ability to make the story attractive and meaningful, which depends on the teacher's narrative writing experience (Kokkotas et al., 2010). When I first reflected on this statement by Kokkotas et al., I felt a bit daunted, as I was not confident, as a maths-science teacher, of my creative writing ability. Fortunately, a variety of guidelines were available to me throughout the story writing process.

TORN AT THE GENES – THE ETHICAL DILEMMA STORY

Given the program for the Year 10 science class that I was going to work with, I decided that the story should be based on genetics. My pedagogical challenge was that I was initially concerned it would be difficult to locate or write a suitable story for teaching Year 10 genetics. I considered writing a story from scratch but as I did not see myself as a confident story writer I continued searching for ideas. However, I realised that there were numerous socioscientific issues on which I could base a story. I did not attempt, at the outset, to write my story but searched for an existing story. The National Centre of Case Study Teaching in Science website (see http://sciencecases.lib.buffalo.edu/cs/) based at the University at Buffalo in the USA, had numerous case studies based on biology topics. This website is aimed at the undergraduate tertiary level, or so I initially thought. I also found another website that presented many topics that were of interest and possibly could provide a seed for a story. This website, NOVA – Science in the News (see https://www.science.org.au/nova-science-news), is published by the Australian Academy of Science. Its topics include Conservation Genetics, More Food, Cleaner Food (relating to genetic modification), and The Human Genome Project. I believed that any

of these would be great topics and could be interesting sources for potential stories, but I was not entirely confident in writing the actual story by myself — demons from the days when I was an English student in high school.

I decided to head back to the National Centre for Case Study Teaching in Science site and started to browse the case collection. Using the keyword search that was provided, I searched for 'genetics' and 'dilemma'. After reading through some of the case abstracts, I found the case 'Torn at the Genes' (Nelson & Herreid, 2000). It is a story about one family's debate over genetically altered plants. This case study was written by Jennifer Nelson (School of Medicine, University at Buffalo) and Clyde Freeman Herreid (Department of Biological Sciences, University at Buffalo). The abstract for the case study reads as follows:

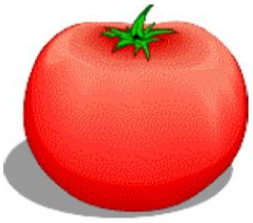
> The setting for this case is the family dinner table, where a heated discussion about genetically altered foods is taking place. Marsha Cumberland's brother-in-law has joined the family for dinner. Ed is an industry official whose job it is to decide whether or not new products need pre-market approval by the FDA. He has just returned from a conference on transgenic foods. When it turns out that some of the food on the dinner table is genetically modified, a debate ensues with different members of the family at different ends of the spectrum. Written for an introductory biology course, the case considers the scientific and ethical issues of genetically altered plants (Nelson & Herreid, 2000, par 1).

The story appeared to match most of the requirements I had set. It related to a topic that we would need to cover in Year 10 science. It seemed engaging and interesting, as it was based on a family debate which could quite feasibly occur within actual households, and it allowed sufficient breadth and depth of the topic. This story can be found in Appendix 3A. It also seemed to suit the requirements for an ethical dilemma story covering the genetics concepts required in the curriculum.

The story, I hoped, would encourage critical thinking and engage both sides of the brain (left/analytical and right/emotional). I was convinced students would have an opportunity to analyse the issue of using genetically modified (GM) crops in our food, investigating the advantages and disadvantages, and becoming emotionally involved in the story, as one of the story characters becomes quite emotional in her arguments and desires to protect the environment. In consultation with my supervisors, I created several questions at key points throughout the story to create an ethical dilemma story. (These questions, which are embedded

in the ‘Torn at the Genes’ story, can be viewed in Figure 3-1).

I hoped that the students would start to consider what they valued in terms of sustainability, both consciously and subconsciously, as they wrestled with questions posed by the story. The link between science and values was an area that I was remiss in addressing in my past science classes; however the new Australian Curriculum (at that time, 2012) encouraged teachers such as myself to understand that the study of science is not just a collection of facts but rather a subject that influences society, depending on the societal values. This is demonstated by the content descriptor in the Science as Human Endeavour strand for Year 10 science students: “The values and needs of contemporary society can influence the focus of scientific research” (Australian Curriculum Assessment and Reporting Authority (ACARA, 2014) (see Chapter 1).



Torn at the Genes: One Family's Debate Over Genetically Altered Plants

by

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Adapted by John Werth, Christian Outreach College, Toowoomba

It had been a busy day for Sonia Chamberland. She had spent most of it cleaning and running errands in preparation for her brother-in-law Jim's return, and now she was preparing a quick dinner for her family. Jim, an industry official whose job it was to decide whether or not new products needed pre-market approval by Food Standards Australia New Zealand (FSANZ), had spent the last two weeks in Victoria expressing his views on genetic engineering in food. He had attended a big conference with various members of the FSANZ, the Department of Health and business officials to determine what guidelines should be enforced regarding the regulation of transgenic foods—a controversial issue between several consumer protection groups and various government agencies. Jim was coming over later for coffee and to visit with the family.

As Sonia began dinner, she realized that in all the commotion she had forgotten to buy tomatoes for the salad. She knew that her daughter Amy would go for her, and so she called her into the kitchen. At 16, Amy had just gotten her driver's license and she jumped at the opportunity to drive anywhere, even if it was just to the grocery store.

About 10 minutes later, Amy returned and handed her mother the grocery bag. Sonia grabbed inside and pulled out a tomato.

"What's this?" she asked, as she began to read the unfamiliar label stuck on the

vegetable in her hand.

"It's a tomato, Mom. The kind that Uncle Jim was talking about. The label said that it was grown specially through genetic alterations so that it won't spoil or soften."

"Amy, you know how I feel about this," Sonia replied. At 45, Sonia was very conservative and had a general distrust of new technologies.

1. Warm Up Question
If you were Sonia how would you feel about the tomato? Would you eat it?

Think, Pair, Share
"What do you think/believe? And why do you think this?"

Need to come to a group consensus. Group to put together a presentation explaining their decision...paragraph or two etc

"Mum, Uncle Jim has told you over and over again that they're safe and, besides, he would want us to support him."

"Well, Uncle Jim is not your mother, is he? And I just can't accept his ideas without proof that they are safe. Now, where is my change?" Amy rummaged in her pocket and handed her mother some coins; considerably less than what Sonia was expecting. "That's it? I gave you three dollars."

"They were $9.99 a kilogram, Mum. Better quality means more money."

"That's another reason why I don't buy them, Amy. Now go get cleaned up for dinner. I guess we'll just have to have plain lettuce with dinner."

"Mum, you're being so old-fashioned. Genetically engineered foods are the new wave of the future. Wait until Uncle Jim comes over tonight and I'll ask him. You'll see!"

2. Question

Does genetically modified in your view equal better quality. Answer as Sonia, and as yourself.

Think Pair Share

Jim arrived at the house shortly after dinner and was talking to the entire family about his trip to Victoria. The conversation eventually turned to the business side of the trip, as Sonia had feared it would. For some reason, Jim's research had always been a bone of contention among the members of the Chamberland family. Everyone seemed to have different opinions for different reasons.

At one end of the spectrum there was Amy, who supported her uncle 100%. She wanted to see more genetically altered foods on the market, but Sonia believed that it was only because Amy thought of it as "trendy." It was the cool thing to have—next to a new car, of course.

3. Question

Do you feel that all teenagers always want what's new and trendy?

Think, Pair, Share

Sonia's older daughter Karen, on the other hand, strongly opposed her uncle. A university student, Karen was actively involved in several environmental clubs and organizations. She was against anything that posed a potential threat to the environment and had launched several protests in the past for different environmental concerns.

Sonia's son Brian, also at University, really didn't have an opinion one way or the other. He was argumentative on both sides of the issue and liked to show off his intelligence by questioning everything and everybody.

Finally, there was Sonia's husband Ross, who didn't really know where he stood on the issue. He wanted to be supportive of his brother but at the same time he didn't want to take sides for fear of causing further dissension within the family.

4. Question

Who in the family do you most identify with? Why?

Think, Pair Share

Jim began to explain several ideas that were developed during the conference regarding the regulation of genetically engineered foods. Sonia hated when the conversation turned to this, as it usually did when Jim was over.

At this point in the conversation, Amy eagerly jumped at the opportunity to disprove her mother's concerns.

"Uncle Jim, will you please tell Mom how these genetically altered plants work?"

"Well, Amy, scientists have found ways of taking a good gene, say from a bacterium, and putting it into plants such as these tomatoes or beans or corn. The bacterial gene produces a protein that makes the tomato less appetizing to a pest. Or perhaps the gene allows the tomato to survive a heavy dose of chemical spray that farmers sometimes use to control weeds in the fields. Or maybe the scientists find a gene in one species of plant and they put it into another species to help the plant survive the cold better or taste or look better."

"That's all well and good, Jim, but what about the safety issues and the cost?" asked Sonia.

5. Question

Was Sonia over reacting by not using the tomato?

Think, pair, share

What information do we need to answer the question with confidence?

"Uncle Jim, will you please tell Mum that genetically engineered fruits and vegetables are safe!" interrupted Amy. "She doesn't trust them and won't let me eat them."

"Well, safety has been a key consideration in the approval of these products, and has definitely not been overlooked. There have been over a dozen tests performed on more than 50 engineered crops to evaluate the risk and environmental impact they might have. These tests were reviewed in detail by the U.S. Department of Agriculture and they show that such engineered crops present virtually no risk to the human consumer. That's why we concluded at the conference that genetically altered foods should be subject to the same standards of regulation applied to all other foods."

"But," Sonia tried to defend herself, "there is no concrete evidence for the safety of these products. It has never been proven that they are 100% safe. As a matter of fact, I read an article the other day that said just the opposite. It said something about making bacteria resistant to antibiotics. The genes that we put into corn or tomatoes might jump into bacteria in our stomaches. Then the bacteria will suddenly have genes that make *them* resistant to antibiotics. Where would we be without useful antibiotics?"

"Yeah," Jim replied, "that particular study was discussed and debated at the conference. What actually happens is genetic engineers have found that if they want to insert a new beneficial gene into a plant, it works better if you inject a second gene with it. The second gene is one that produces an antibiotic. It is called a marker gene because it is easy to test for its presence and see if both genes have gotten into the plant cell. In fact, the United Kingdom's Advisory Committee on Novel Foods and Processes has declared that this poses an "unacceptable risk."

Sonia nodded and smiled. She had thought for a split second that she had argued a good case, but as Jim continued to explain the process, she knew that he had a comeback for everything and that essentially it was useless to argue with him further.

6. Question

Do you agree with Jim who is saying that the GM foods are safe?

Think, Pair, Share

What information do we need to have to help us decide if GM food are safe?

Jim continued: "But after many tests this doesn't appear to be a problem. Robert

Beachy, head of the Division of Plant Biology at Scripps Research Institute, has written that "there is no scientific data indicating that DNA could jump from food to a microbe in the gut of an animal." He concluded that transgenic foods pose "no risk to the public, nor to the farm animals for which they serve as food." In fact, Abigail Salyers, a microbiologist at the University of Illinois, wrote to *Nature* magazine that this is a trivial problem and that researchers ought to be more worried about the fact that we routinely put vast amounts of antibiotics in animal food and overuse antibiotics on ourselves, which creates a much more serious problem of resistance."

Brian turned to his uncle. "But, Uncle Jim, in biology we just learned about mutations and natural selection. Suppose the DNA that protects plants against insects is injected into the plants and it works? Won't the insects eventually evolve a resistance to these toxins?"

"This has been a concern and problem among farmers for many years, but mutations in the insect population are not caused just because of transgenic crops. It happens all of the time. Pests evolve a resistance even to the chemical pesticides being sprayed now. So, yes, it seems likely that the insects might evolve resistance to the toxins in the transgenic plants, since it is all caused by the operation of natural selection. Some researchers have figured out how to slow down natural selection. If farmers planted a small area of traditional crops near fields of genetically modified ones, this would significantly slow down the rate at which insects could adapt. The two different kinds of plants would exist and the insects couldn't specialize for only one."

"See, Mum, I told you there was nothing to worry about," Amy stated proudly. "Genetically altered foods are safe to eat, and plus they taste better. I'm going to go cut up that tomato right now."

Karen, who had been silent until this moment, suddenly stood up and said: "I don't know how all of you can be so naive. The safety of the nation's food supply is being threatened by an eagerness to help companies bring new products to market. Lots of companies aren't even labelling these mutant foods so that we can avoid them. That's not ethical! And on top of this we're risking ruining the whole environment. Uncle Jim may be right that bacterial toxins pose no risk to humans directly, but what happens when insect resistance spreads to populations of plants, like the forests? This would cause sharp declines in entire insect populations, which in turn would lead to declines in predators that feed on these insects, like birds. The whole cycle of life would be disrupted!"

"How is it different from the litres of toxic fertilizers that people spray on plants now, Karen, to keep insects away? You can't tell us that that is safer," Brian argued. "At least with genetically engineered crops the only insects that are getting hurt are the pests. When you spray pesticides everywhere, everything gets killed or poisoned."

"Brian does have a point," Jim replied. "Much of the standard agricultural and forestry practices, like the heavy use of pesticides, have severe detrimental effects on soil fertility, whereas the direct effect of genetically engineered plants on soil may be relatively small. Proteins, the products of DNA, are quickly broken down by the environment. Pesticides, on the other hand, do not break down quickly and are often

harmful to beneficial insects and earthworms that are necessary to conserving a healthy soil biota. Pesticides, such as fungicides, have actually been proven to be carcinogens and account for approximately 70% of the human health problems associated with pesticide exposure. So, in general, genetic alteration methods are a lot safer than using the broad spectrum of pesticides being sprayed now."

"I never said that I was in support of chemical pesticides either," snapped Karen. "You just don't agree with anything, Karen. And you don't even have a clue as to what you're talking about. You and your little environmental buddies just go parading around campus with your Greenpeace views arguing about everything, thinking you know what's best for the world...."

"Oh, shut up, Brian. I know what I'm talking about. I've watched National Geographic specials, and even talked to Jane Rissler, a specialist with the National Wildlife Federation, so I probably know more than you." Karen continued to argue her point, "Uncle Jim, that still doesn't explain what would happen if the genes from these "super crops" jump into other species and become "superweeds." Australia will be taken over by uncontrollable weeds that have an unnatural resistance to everything. Weeds will spread everywhere, even to the wildlife preserves, causing drastic declines in the native species. What then?"

7. Question

Do you think that Karen is just being over cautious, or does she have a point?

Think, Pair, Share

What information do we need to have to help us decide if Karen is being over cautious?

Sonia looked at her husband for help. She really didn't understand her daughter's reasoning at all, but was glad that someone was on her side, even if it was for completely different reasons.

Ross felt his wife glaring at him and tried quickly to change the subject. He hated being stuck in the middle between the opposing views of his brother and wife. He knew eventually at some point down the road he would have to decide and take a stand on the issue. There was no getting around it. He just hoped that it wouldn't have to be anytime soon.

8. Question

What would you decide? Would you allow the use of genetically modified crops in our food?

Think, Pair, Share

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Figure 3-1 The Torn at the Genes Story

PLANNING MY ETHICAL DILEMMA TEACHING

My intention for this research was to use the ethical dilemma story approach of Gschweitl, Mattner-Begusch, Neumayr nee Settelmaier, and Schwetz (1998) as a guide on which to base my science unit. I ensured that the following key characteristics (Figure 3-1) of an ethical dilemma story were included and developed within the unit.

Key Characteristics of Ethical Dilemma Pedagogy

Open-ended stories
Ethical/moral dilemmas
Two or more possible solutions
Story is presented in several parts
Parts of stories contain several dilemmas with the main dilemma towards end of unit
Opportunities for students to experience:

- Values clarification
- Reflective thinking
- Dialectical thinking
- Opportunities for collaborative learning
- Empathy
- Negotiation
- Collaborative decision-making
- Opportunities for critical thinking

Figure 3-2 Key characteristics of ethical dilemma pedagogy

Initially, I planned to run the unit for two different Year 10 science classes, one in 2012 and the other in 2013, over the course of a term that was approximately 7 to 8 weeks. This depended on the term plans and the material to be covered. Alternatively, the plan could have been for a 3- or 4-week unit. In any case, I intended to use a similar process modified to suit time constraints. I incorporated additional depth into the planning of the unit by using a modified inquiry focus that has been described in the Queensland Science21 Syllabus (2007) produced by the Queensland Studies Authority (QSA). This was used as a model to direct the unit and, at each appropriate stage to implement suitable critical thinking skills strategies based on the Thinking Skills Framework published by ITC (Innovative Teacher's Companion) which is based on Bloom's taxonomy.

Phases of learning with an inquiry focus	
Phase 1 **Teacher immersion**	Teacher becomes familiar with inquiry Learning goals selected 'Hook' selected Map ways inquiry could unfold
Phase 2 **Introduction**	Present inquiry to students Stages of inquiry documents Brainstorm — organising information into useful categories
Phase 3 **Information gathering and sharing**	Groups read, discuss Groups evaluate the information Sharing occurs with other groups 3-4 items deemed most relevant recorded
Phase 4 **Rephrasing the problem and mapping**	Rephrasing the problem – develop an 'angle' on the inquiry Map inquiry (concept map) – what has been considered, deficiencies, reflect on scope of inquiry
Phase 5 **Re-evaluating the 'KND'**	'KND' chart organiser reassessed
Phase 6 **Further information and gathering**	Re-evaluate progress Address shortfalls Decide on priorities for information gathering
Phase 7 **Refining the problem statement and re-mapping**	In light of more information – problem may need more refinement Mapping eliminates redundant information
Phase 8 **Generating possible solutions**	Students generate several solutions
Phase 9 **Reconciling the solution with the conditions of the problem**	All material, information used and gathered Discuss and evaluate value of each position Consider constraints, stakeholders, costs, benefits etc Generate solutions and determine which comes closer to inquiry statement Make the best decision under circumstances Consensus within group
Phase 10 **Assess student learning**	Students report and defend their position – report, presentation etc.
Phase 11 **Debriefing (evaluation)**	Students reflect on the whole process

Figure 3-3 Science Inquiry Cycle. Source: Queensland Studies Authority, Science21 Syllabus (2007)

The science content that students need in order to engage meaningfully with a dilemma story can be presented before the presentation of the story itself (Chow, Taylor, Taylor, & Hashim, 2011). However, I planned to organise the unit using an inquiry approach, where students would discover and apply information required to provide an informed response to the dilemma. The science inquiry cycle produced by the QSA provided strategies for students and teachers to gather relevant information, and is summarised in Figure 3-2.

Higher-Order Thinking Skills

In order to develop students' critical thinking skills for reaching a decision that is mindful of consequences (see Chapter 1), the Thinking Skills Framework was deployed. There are two main reasons that I chose to use this. Firstly, the administration at my workplace indicated, at the time, that they supported teaching staff using that framework in their classrooms, and encouraged all teachers to place the Thinking Skills Framework poster on noticeboards in their classrooms (see Appendix 3A). Secondly, the College provided three professional development sessions for teaching staff relating to improving students' thinking skills. Thirdly, the teacher diary that was usually supplied by the College to staff was an ITC publication that contained information about the framework and strategies with examples for implementation in the classroom.

The framework provided teachers (and students) with helpful guides for each of the levels in the Bloom's framework, suggesting useful verbs, starters and tools that can be used. A significant number of the tools were in circulation. The advantage of the framework is that the thinking tools are placed into appropriate Bloom levels. These levels include: (1) remember, (2) understand, (3) apply, (4) analyse, (5) evaluate and (6) create (Marzano & Kendall, 2006). Appendix 3A displays an image of the Thinking Skills Framework poster.

The use of so-called 'thinking tools' was an integral part of this project. One of the research questions related to higher-order thinking skills (HOTS), and these tools were designed to help students develop higher-order thinking and to encourage collaboration. Higher-order critical thinking has been defined as "reasonable, reflective thinking that is focused on deciding what to believe or do" (Norris & Ennis, 1989, p. 3) and as "artful thinking" (Barahal, 2008, p. 299), which includes "reasoning, questioning and investigating, observing, comparing and connecting, finding complexity, and exploring viewpoints" (Brookhart, 2010, p. 4). I followed Brookhart's (2010) definition of higher-order thinking in terms of (1) transfer, (2) critical thinking and (3) problem solving. In identifying the first two types, Brookhart draws on the

work of Anderson, who divided learning into learning for recall and learning for transfer (Brookhart, 2010, p. 5). Learning for transfer involves students in not only retaining what they have learned but also applying what they have learned to situations they have not encountered or considered before. Through the ethical dilemma story, I hoped that students would not only recall the genetics information they had learned but could also apply it to a new situation, that is, understanding the science of GMO. My teaching goal is to enable students to make sound decisions on their own without relying on guidance from the teacher. The story, 'Torn at the Genes' provided opportunity for my students to think critically as they engaged with the dilemma of whether or not they should eat the GMO tomatoes.

The third type of higher-order thinking that Nitko & Brookhart (2007) identified is problem solving.

> A student incurs a problem when the student wants to reach a specific outcome or goal but does not automatically recognize the proper path or solution to use to reach it. The problem to solve is how to reach the desired goal. Because a student cannot automatically recognize the proper way to reach the desired goal, she must use one or more higher-order thinking processes. These thinking process are called problem solving (Nitko & Brookhart, 2007, p. 215).

As my students encountered the 'Torn at the Genes' story a problem was exposed that students had not encountered before, and in order to develop a meaningful response to the problem students were given the opportunity to transfer knowledge that they had retained to apply critical thinking skills to reason, question and explore viewpoints in relation to the problem.

Table 3-1 Description of thinking tools employed in this study

PCQ (Pros, Cons, Questions)	**PCQ** is an attempt to apply objectivity when considering proposals, ideas or suggestions. The simple table will assist students to make sense of their deliberations. *Pros* equates to benefits, strengths, plusses, advantages of the idea, from as many points of view as possible. *Cons* deals with all the negatives, opposing points of view, disadvantages and weaknesses of the idea. *Questions* offer an opportunity for questions, curiosity, probing and "what ifs?"
KWL (Know, Want, Learned)	This is a metacognition tool that requires students to think about what they know (K), what they want to know (W) and what they have learned (L)

The thinking tools that I planned to use included: Alpha Ladder, KWL, Round Robin, Double Bubble Map, 321RIQ, Think Pair Share, PCQ, Jigsaw, Decision Making Matrix, PCQ extension and SWOT Analysis. However, due to time constraints I was only able to use the KWL and PCQ regularly. A description of the thinking tools I used is given in Table 3-1.

Think Pair Share Teaching Strategy

As I described in Chapter 1, ethical dilemma story pedagogy involves pausing at key stages in the story where students engage with a dilemma question. All pauses in my telling of the ethical dilemma story involved the Think Pair Share strategy, which is typical (in a variety of forms) of dilemma story pedagogy (Taylor, Taylor, & Chow, 2013). As the story progressed, I increased the complexity of the Think Pair Share strategy. Parts 1-4 of the story contained 'warm-up' questions designed to encourage the students to think about the issue. The procedure was the same for each subsequent part of the ethical dilemma story. I read the story and at the appropriate point I stopped to ask a set question. For each question, I asked the students to think about their answer individually, and take individual notes without talking. After one to two minutes I directed the students to discuss their individual answers with a partner. I then directed each pair to share their thoughts with another pair who were part of their team. The team was required to generate a 'team' response which every member of the team was comfortable with. Ideally, dilemma story pedagogy would have students reach consensus. However, if the group could not reach consensus, I encouraged students to explain their differences. Finally, I asked a member of each team to share their team response with the whole class.

To enable me to compare team responses with individual responses, I asked the students to record their personal response and team response on a Wikispaces page for homework. Some of the students did this, but they mainly recorded their individual thoughts. I found their responses in general to be simplistic and without much justification, which was to be expected to some extent as I had not introduced any genetics theory to the class in the early stages of the ethical dilemma story.

ETHICAL DILEMMA STORY TEACHING 2012

For the class of 2012, I implemented the Torn at the Genes ethical dilemma story at the beginning of the genetics unit at the start of Term 2. There were eight parts to the story and each part had one question for the students to consider. The questions for each part are displayed in Table 3-2.

Table 3-2 Summary of questions asked in the story

Story Part	Question
1	If you were Sonia, how would you feel about the tomato? Would you eat it?
2	Does 'genetically modified' in your view equal better quality? Answer as Sonia and yourself.
3	Do you feel that all teenagers always want what's new and trendy?
4	Who in the family do you most identify with? Why?
5	Was Sonia over-reacting by not using the tomato?
6	Do you agree with Jim who is saying that GMO foods are safe?
7	Do you think that Karen is just being over cautious, or does she have a point?
8	What would you decide? Would you allow the use of genetically modified crops in our food?

An outline for the teaching sequence for the whole term can be found in Appendix 3B. Parts 1-4 were conducted with pauses for the Think, Pair, Share activities, as described below. Typically, a lesson included the following six stages.

1. I told a section of the story to the whole class.
2. I posed to the class the question related to that particular section of the story.
3. Students engaged in individual thinking which involved quiet reflection and note taking regarding the question posed.
4. Students engaged in discussion with a partner about their thoughts regarding the question.
5. Students moved to their pre-arranged groups (up to four students per group) and debated the question posed and recorded a group response. I asked the students to write a response that all members of the group could agree to. It was not a requirement that they all agreed, but that they must understand other group members' decisions. It appeared that generally, the groups tried to reach consensus.
6. A member of each group shared with the class the group's response, including any disagreements.

At the conclusion of Part 5 of the ethical dilemma story (see Figure 3-1), I engaged the class

in learning basic genetics concepts for three weeks. My intention was for students to know the basic principles of genetics in order to be able to engage effectively with the ethical dilemma. Three topics were covered during this time: DNA – the DNA model and replication; inheritance in general; and human inheritance, in particular. The teaching of these genetics concepts occurred in a variety of ways. The most common strategy employed was for students to explore digital interactive lessons (called Learning Objects) about genetics. Another strategy that was used, especially when I determined that several students were experiencing difficulty understanding a concept, was direct teaching, often using a PowerPoint presentation to help develop the concept. Students also participated in several practical activities, such as extracting DNA from strawberries and kiwi fruit, building a marshmallow person based on random genotypes, and building a model of DNA.

Pros, Cons, Questions (PCQ)

The Think Pair Share tasks became more complex, as this encouraged students to use higher-order thinking. The Think Pair Share strategy was made more complex by adding a Pros, Cons, Questions activity (PCQ). I asked the students to fill in the PCQ template as they answered the question from the story. I directed them to fill in the PCQ individually, without talking, and then to work with their partner to add material to the PCQ before continuing to work in their team.

The PCQ template I used was a page with three columns labeled ‘Pros’, ‘Cons’ and ‘Questions’ as shown in Figure 3-3.

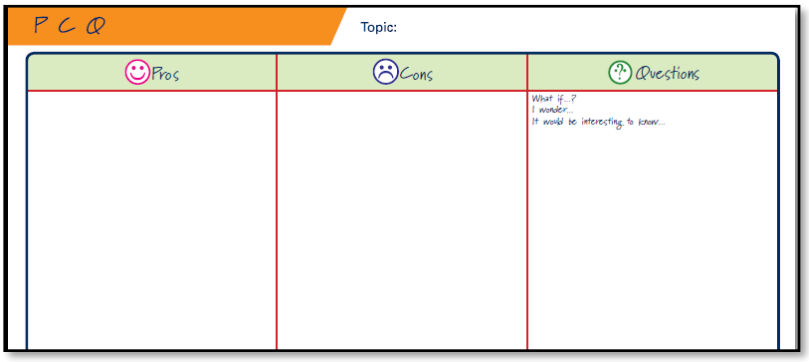


Figure 3-4 Example of a PCQ template

Student responses to the dilemma question posed to them in Part 6 of the dilemma story (see Table 3-2) led us to investigate the process of genetic engineering and modification (see 3-2 for summary of parts). That phase lasted around two weeks. A similar process occurred with

responses to the questions raised about Part 7 and Part 8 of the dilemma story. The question posed in Part 8 became the assignment question. During the implementation phase of the story, I employed a number of strategies and tools to enhance student participation and help me to gather information about their experiences of the ethical dilemma story. One of these tools was Wikispaces. The next section provides an explanation of Wikispaces and how I managed this tool in my first ethical dilemma story class.

Wikispaces

Wikispaces is an online tool that was used as online support for students, providing resources and opportunities for collaboration. I also used it as a data gathering tool for my research. Wikispaces is an open classroom management platform that facilitates efficient collaboration between students and teachers. It has developed and is supported by Tangient LLC, better known as TES Global. Wikispaces has a simple technical set up with useful features. I created a site that allowed me to set up a wiki that was private, meaning that only the students and I had access to it. Each student had a personal login and password that ensured privacy. I set up a personal journal page for each student using the 'Project' feature of Wikispaces. These online pages enabled students to record personal reflections and questions at any time, at school or at home, as long they had access to a computer/tablet and the internet. The wiki had the advantage that the material students produced was saved despite students being able to edit and review their material at any stage. This enabled me to have easy access to their writing, and if I was online when they were journalling I could comment and add my thoughts and advice immediately.

I created a 'Resources' section in their Wikispaces, where I provided links to useful websites offering support for the material covered in class or for assignments, as well as links to handouts and the PowerPoints that were used in class. One of the helpful features of Wikispaces, in my opinion, is the provision to track students' access to the site. The site records when, how often and what students accessed. It enabled me to view their edits and re-edits, thereby seeing the rationale behind some of their thinking. I was getting an insight into when students worked at home and how often. I noticed that the Resources page was visited more frequently closer to the due date of the assignment. These Wikispaces features enabled me to set homework tasks for students to complete on their personal journal pages. That section was readable and editable only by the student and me. The homework pages enabled me to see student responses and to comment if needed, providing me with knowledge of who had completed their homework, and enabling me to monitor each student's developing understanding of the curriculum material.

The most powerful part of Wikispaces (and wikis in general) is that it literally provides a tool for students to collaborate with each other on a given task. Online student collaboration is the subject of a much larger research area, as confirmed by several researchers (Donne, 2012; Kelsey, 2011; Pifarré & Kleine Staarman, 2011). I presented several collaboration tasks to the students throughout the unit, giving them opportunities to work on the tasks in groups either in class time or out of class, such as at home or in the school library. They were able to do this work using the Team Pages that I had created for the class. Each group had a Team Page on which they submitted their responses to a task. This enabled them to view and edit each team member's contribution and to put together a final response for the team.

A component of Wikispaces that I had not expected to use was the 'Internal Message' feature. I found that students made themselves aware of it, and I was surprised at first to receive messages from students, ranging from troubleshooting difficulties in the Wikispace to homework and assignment questions. It was satisfying to be able to answer students and address their concerns easily. I believe that this enhanced the student-teacher relationship, as they were able to communicate with me as an issue developed, and often I was able to respond to their questions soon after they asked the question. This demonstrated to students in a tangible manner that I was interested in their learning and success.

Alpha Ladder

The Alpha Ladder tool was a thinking tool that I had hoped the students would find useful in 2012. It enabled students to generate a table of the key words/concepts in the genetics unit. I hoped the students would refer to this resource when needed throughout the unit, and especially while working on their assignment. Table 3-3 displays an example of an Alpha Ladder using key terms from the topic of genetics.

Table 3-3 An example of an Alpha Ladder

	Key Word	Meaning
A	Adenine	One of the four nucleotide bases that makes up the genetic code or DNA.
C	Chromosome	A threadlike structure found in the nucleus of all body cells (except red blood cells) which consists of DNA and protein.
G	Genotype	The genetic make up of an individual
P	Pedigree	A diagrammatic representation of a family health history tree

My plan was to utilise the collaborative nature of Wikispaces to generate an Alpha Ladder. Students' teams were asked to include key words and concepts in their team Alpha Ladder as they progressed through the unit. I had intended to place a print-out of each team's Alpha Ladder on the classroom wall for sharing and refinement each fortnight. Unfortunately, I did not follow this up as more pressing tasks presented themselves, and the Alpha Ladder did not get the time or attention it warranted. I believed that it would be able to serve as a reference for students to recall the meanings of key genetics terms. These types of activities can be quite time consuming for the class and they have the potential to distract students from other learning activities. Perhaps the students' lack of interest showed that they preferred other ways of learning and this made it difficult to encourage students to complete the task consistently. The Alpha Ladder is shown in Table 3-3 was typical of most of the teams' contributions, but it seemed to me that the idea of the Alpha Ladder was lost on the students.

As I reflect on the classroom activities at that time, I believe that I was more concerned with covering the basic genetics concepts that I felt the students needed in order to engage meaningfully with the ethical dilemma story. Consequently, I did not reinforce the procedures associated with the creation of the Alpha Ladder and students forgot about it. At first glance, it can be difficult to understand the difference between an Alpha Ladder and a glossary. The main difference is that the Alpha Ladder acts as an easy retrieval chart for key information, using the alphabet to itemise parts of a topic. Additional criteria can be easily added to an Alpha Ladder; for example, rather than providing a meaning for a key word, cause and effect relationships can be added for key ideas.

Possibly the idea of an Alpha Ladder for the purpose I had in mind was not the most appropriate. I recall feeling frustrated that the students were not using the Alpha Ladder Tool. I believe that the most likely cause was the busyness of the class. I introduced the Alpha Ladder during the first two weeks of the term while the students were learning the basics of genetics. This was a hectic time as I was trying to cover the genetics topics that students would need for the ethical dilemma story that was to come later. The genetics concepts we developed in that two-week block could have easily taken four to six weeks. In addition to the intensive knowledge acquisition we were learning how to use Wikispaces. As might be expected with the introduction of new technology, there were various obstacles to overcome. As a result, I forgot to remind students to contribute to the Alpha Ladder, and when I checked how they were progressing, I found that it was near the end of the two-week block and many students had not contributed as I had hoped. I decided not to confuse the matter further and to stop encouraging students to contribute to the Alpha Ladder, as I felt that additional time and effort was better used addressing the aspects of Wikispaces that I believed were important to the

ethical dilemma story, as well as to the data gathering for my research. I made a note to reconsider this thinking tool when the next dilemma story was presented to a future class.

ETHICAL DILEMMA STORY TEACHING 2013

The Torn at the Genes dilemma story was implemented again a year later, during second term. The cohort was the Year 10 science students whom I had been teaching in the previous term. The focus of the unit, as in the previous year, was genetics, including the foundational concepts of genes, chromosomes and DNA.

My Revised Plans for the Unit

The advantage of having previously taught this unit was that I could revise strategies after the first experience. Dewey (1933 as cited in Danielson 2009, par. 3) suggested that reflection starts with a dilemma, a problem that requires a solution. This dilemma is related to my practice as a teacher, in particular the delivery of the first ethical dilemma story. As the first story progressed, I was continually reflecting on my practice. Ghaye (2010) says that reflecting on our practices helps us to improve our effectiveness. This is true in my case, as I was reflecting on the dilemmas with the presentation of the dilemma story. Should I give the students the background genetics before the delivery of the story? Have I organised the groups effectively? When should I teach the students how genetic modification actually occurs? Have I set too much homework? Ghaye (2010) discusses four common views of reflection:

- Reflection-IN-action
- Reflection-ON-practice
- Reflection-FOR-action
- Reflection-WITH-action

I could relate to these views on reflection, since at various times throughout the first dilemma story I could identify times and stages when I experienced each type of reflection. There were several changes that I had planned to make the second story more beneficial for the students. These changes included using a booklet for the student worksheets and changing from using Wikispaces as a learning portal to MYCOCT.

One of the major adaptations from the unit that I had taught in 2012 was my plan to teach basic genetics for two weeks before introducing the story and the introduction of the student booklet. From my observations of the previous year, I believed that students would benefit

from a general knowledge of genetics before they heard the dilemma story. The story was based on a generally higher level of genetics – genetic modification or genetic engineering. For students to have a deeper understanding of the story, I considered that they would need to have some conceptual knowledge of DNA, genes and inheritance and their relationship to genetic engineering.

The Student Booklet

I decided to reduce the number of student handouts, mainly because some students found it difficult to keep handouts organised. Some students were quite skilled at this, using a display folder to maintain the handouts in an organised manner. But I observed that most students fold the handouts, which are sheets of paper, and placed them haphazardly in their workbooks, making it difficult to refer to them again and easy to lose them.

I created the handouts during the holidays preceding the school term. They consisted of worksheets with spaces to fill in answers and templates for the Thinking Tools that I was planning to use. I put these together in a booklet with a variety of templates at the back to help encourage higher-order thinking. The booklet could be used as a source of research data, enabling me to compare students' individual responses with the group responses.

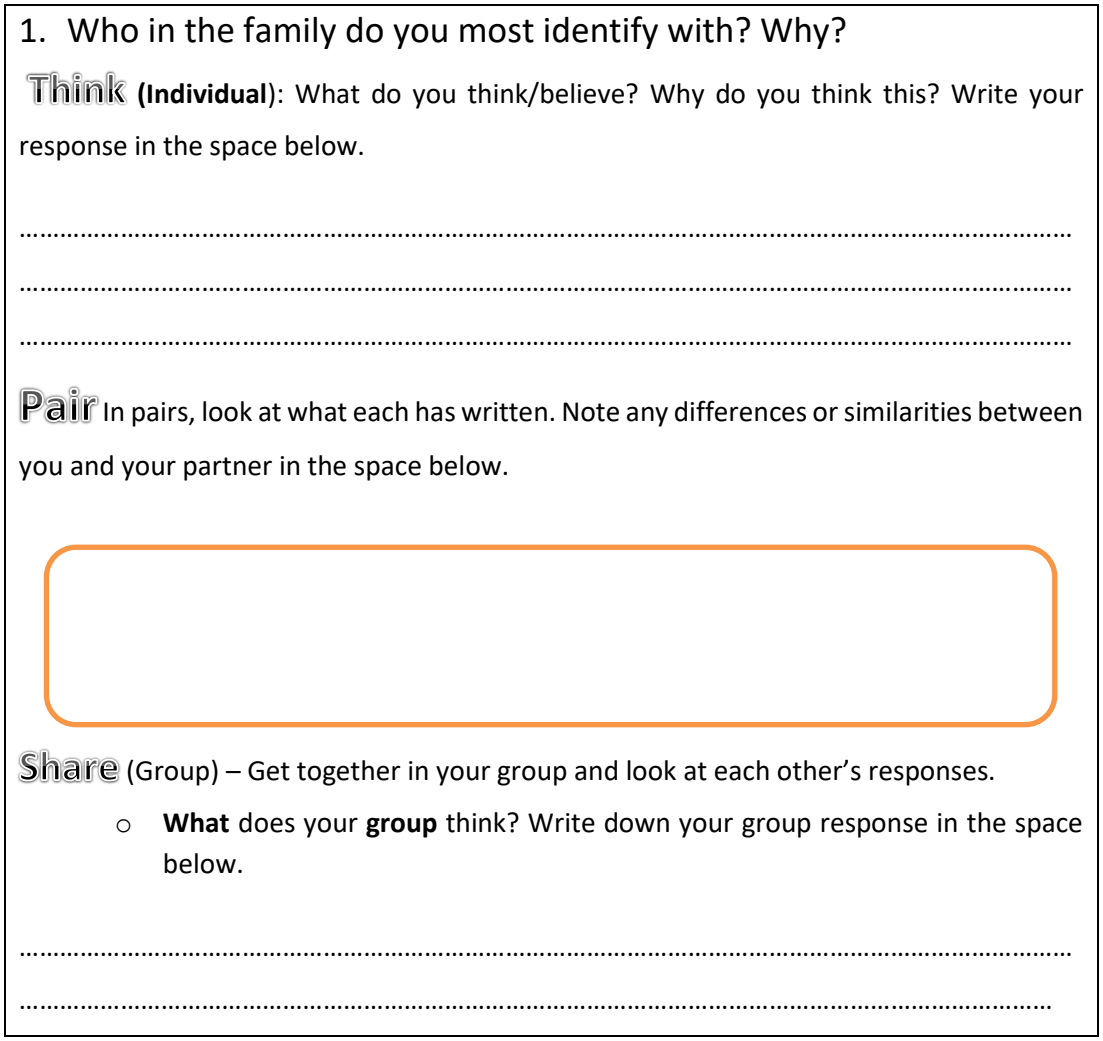
The Think Pair Share strategy was an integral part of the dilemma story approach. I provided sections in the booklet at each stage of the dilemma story for students to record information, that is, their individual thoughts, additional ideas generated from discussion with their partner, and the group decisions and comments. I intended to use this information to compare students' individual responses with their group answers to check for conflict between the group and the individual, primarily looking for a student reporting a perspective that was then not represented in the group discussion.

The booklet was divided into sections based on the various stages of the story (see Figure 3-4). The whole booklet is displayed in Appendix 3C. Each phase had a template for PCQ for students to fill out at each break in the story. Underneath the PCQ template, there was space for notes with guiding questions. The questions were designed to encourage students to write a sentence or two from the notes that they could then write in the PCQ.

In 2012, I had observed that most students seemed to have difficulty transferring information they had generated in their Thinking Tools templates to their assignment. I had hoped that by providing an opportunity for students to practice generating sentences from their PCQ notes,

this would provide a scaffold for them to take the next step, which was to write paragraphs based on their PCQs.

The student booklet was a new strategy that I implemented in the second ethical dilemma story. I introduced two new pedagogical tools to my teacher toolbox and to the students — the learning portal MYCOCT and a web-based tool, called Padlet.



1. Who in the family do you most identify with? Why?

Think **(Individual)**: What do you think/believe? Why do you think this? Write your response in the space below.

……

……

……

Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

……

……

Figure 3-5 Sample page from the Student Booklet

MYCOCT (My – Christian Outreach College Toowoomba)

For this unit, I used the College's learning portal MYCOCT which was being trialled by the College. This platform was based on the Moodle software that is commonly used by universities and schools across the world. I had been using the Moodle software periodically for the last eight years and am familiar with its operations and functions, which made the decision to change platforms easier than it might otherwise have been.

I had used Wikispaces in 2012 and was prepared to use it again. However I was undecided for a while, as I needed to assess the enormous variety of digital tools available for their suitability. But as MYCOCT was being managed in-house, and because of the enormous potential of the Moodle platform, I decided to go with MYCOCT as the learning portal.

MYCOCT provided a suite of features that I could use to support the learning of my students. Features included a blog, groups, choice, and a friendly method of storing resources for students to use these. I decided to use the blog on MYCOCT as a tool to record the students' weekly reflections. The reflections became a key source of data for my research. The students were asked to record weekly reflections, and I usually gave them time in class during the Friday lesson; however, sometimes they were required to do the reflections at home.

The success of this method of data gathering depended on the cooperation of the students. Firstly, not all students recorded reflections weekly, for various reasons. Initially, it took a couple of weeks for every student to have access to the website, as students would forget to log in for the first time and then forget or choose not to do to the task. I did not force the students, as this was an added extra to their usual routine of homework. In hindsight, it may have been better to ensure every student wrote their reflections. The participation rate increased when I asked the students to complete their reflections in class.

Wikispaces was a very useful tool in the previous project. MYCOCT has most of the features that Wikispaces provides, such as a repository for resources and collaboration, but in a format that is easier to manage. The main feature of Wikispaces that is useful is the wiki, which enables online, asynchronous collaboration. This enables efficient collaboration between students and allowed me to view the students' ongoing work. I had planned to use the wiki module on MYCOCT to facilitate group research among students. The intention was to provide a research question for students to investigate as part of a group. Each group member would then put their notes and sources on their group wiki to share with other members of the group. Thus, group members would have access to each other's notes and sources, and together they would be able to create a solution. However, I discovered that the wiki module in MYCOCT did not allow real-time collaboration. I was hoping that students could add material they had found while researching various topics to the wiki at the same time. This feature was possible on Wikispaces. It may have been possible, but in MYCOCT it was unwieldy. Students needed to save their work by clicking on the save button before other students in their group could see it. Unfortunately, I found this out during the lesson, and there was a time of chaos while I tried to work out why the wiki would not work as I had hoped. I

ended up telling the students not to worry about viewing other students' work at the same time, but rather to review it later. This was confusing for the students, and so my idea of online collaboration did not eventuate. In hindsight, there were two other strategies I could have used. Firstly, I should have tested the MYCOCT wiki first, but, in the busy life of a teacher sometimes thorough testing of technology does not occur, and one assumes the technology will function well for the task for which it was designed. My experience and success with MYCOCT modules meant that this was surprising. Secondly, I could have used Google Documents but the College had only just introduced the Google Education package and thus not all students had accounts, therefore it was not an option at the time.

Unfortunately, the group research was not as effective as I had hoped, but some students persisted with the wiki and were able to share notes and ideas. This generated another problem that I had not foreseen. It was not as easy to view their work as it was with Wikispaces. The MYCOCT wiki is clumsy and, to date, I am still unsure about how to view the student material, trying various options until their work appears. Overall, the MYCOCT wiki experience was not very positive.

Another module that MYCOCT offers is 'Choice'. This is a simple module where a question is asked and students can choose one of several possible responses. I found the opportunity to monitor students' decisions very attractive. I was able to receive immediate feedback that informed me which side of the dilemma story students were positioning themselves. Another useful feature was that students could see the statistics of the class, which were presented as percentages and as a graphical display. However, the take-up rate for the students was not as high as I had hoped, since completing the Choice module was set for homework and thus the advantage of using it was lost. Some students answered the Choice, and it did provide some insight into which side of the debate they were positioning themselves in. Twelve (out of 16) responded to a simple choice question regarding the location of the DNA in a cell. Four students responded to the question concerning whether they would eat the GM tomato. The response was two who were in favour of eating the tomato and two against; this did not provide useful data for the study.

Padlet

I was introduced to a web-based tool called 'Padlet' during the unit. Padlet is a website (padlet.com) that allows the user to put images, videos, documents and text on the user's 'wall'. The wall works like a sheet of paper and is a blank page in the internet browser. The user clicks somewhere on the page and adds content (Padlet, 2014). The Padlet page that I

used together with student responses to the question – "Would you eat the genetically modified tomato – why or why not?", is displayed in Appendix 3D.

One of the impressive features of the Padlet wall is that students were able to write on the wall at a time that was suitable to them, such as at home or in class. They did not need to have an account but could use a link that I provided to them.

SUMMARY

This chapter has described the classroom context and my plans for the ethical dilemma story unit. The chapter begins with an explanation of the development of the ethical dilemma story, 'Torn at the Genes', and examines my attempt to encourage the development of higher-order thinking in the classes. I have described the thinking tools that I planned for students to use during the ethical dilemma story unit of work. The chapter continues with a description of the implementation of the story in my 2012 Year 10 science class, followed by my 2013 class. I have discussed how Wikispaces and MYCOCT acted as a resource for each cohort of students and the development of a student booklet for the 2013 cohort that was specific for the ethical dilemma story in which students could keep notes. I have described how I found it difficult to encourage the effective use of the Alpha Ladder by the students. This was due to the unfamiliarity of the Thinking Tool to the students and the busy nature of teaching contributing to the lack of appropriate monitoring of student's entries by me. I also explained that I discovered the wiki that MYCOCT offered did not offer real-time collaboration which I believed to be essential for the group research activities that I had directed students to undertake.

CHAPTER 4
ENGAGEMENT OF STUDENTS IN ETHICAL DILEMMA LEARNING - 2012

INTRODUCTION

In this chapter, I share the story of the journey of my first ethical dilemma story, Torn at the Genes, with my 2012 Year 10 Science class. I address two research questions: (1) how well did students engage in ethical dilemma thinking? and (2) how well did I enable students to consider ethical and sustainability issues? The chapter describes students' experiences of ethical dilemma learning, based on major themes arising from the analysis of interview and journal data, with a special focus on student experiences of group work and higher-order thinking. The second part of the chapter presents case studies of two students, Jye and Kylie.

I used 'purposive sampling' to select ten students to interview. Purposive sampling is a:

> form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher, based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research. (Jupp, 2006, p. 360)

The students were selected based on their VLES survey results (see Appendix 5A) and my knowledge of them as their teacher, and represented a range of gender and academic abilities, including students who appeared to be for or against GMO food. Some embraced ethical dilemma pedagogy while others were ambivalent about this approach.

SHOULD GMO CROPS BE USED IN OUR FOOD? – THE STUDENTS' VERDICT

There was a range of student responses regarding whether or not we should allow GM crops to be used in food. Six out of the ten students interviewed said that it would be alright to use GM crops in food, though they had not always thought that way, with some changing their minds during the story. In this section, I analyse students' experiences of the ethical dilemma story, starting with students who indicated that they were in favour of GMO foods, followed by students who believed that we should not consume GMO foods.

Pro-GMO Food or, at Best, Positively Unsure Students

Andrew, Austin, Neal and Lyle agreed with the idea of using GMO crops in our food. It appears that these boys had decided this at the start of the story and had not changed their minds. In their interviews, though, Andrew and Austin did not seem overly confident about their decision, as they hesitated when responding to the question posed in the interview – should GMO crops be used in our food?

Andrew

Earlier in the unit, Andrew said in a journal entry recorded on Wikispaces that if the food is sold in the supermarkets, it would be safe to eat. Later, in his assignment, he wrote about his decision to support GMO foods. In the interview, however, he appeared undecided:

> I think we should and we shouldn't, we should because it obviously helps them to last longer and stuff like that and taste better and stuff but we shouldn't because… if they are not tested enough, I reckon they should be like tested a lot before we think about using them, consuming them. (An-In-Ln37)

Austin

Austin, another student who had agreed to the use of GMO foods, seemed to be trying to convince himself in the interview. He qualified his 'yes' by saying that certain conditions had to be met. He used a 'campfire' metaphor to describe the use of GMO crops and food. He said that if the campfire was controlled, the fire would be great, but if it got out of control, it would not be good, or a bushfire could result. I asked myself, did Austin struggle with his decision? Did he have a foot in each camp? He began by saying that he was in agreement with the use of GMO foods, but then stated that he was not sure. "I was a bit like, I don't know … I was like, oh what?" (Au-In-Ln101). He stated later that he did not really agree, only if it was controlled. It seemed he was trying to convince himself. He pointed out that one needs to consider the good and bad points, finishing with "but yeah…" He said it was a "bit hard" to make a decision, which demonstrated dilemma thinking.

Neal

Neal, a student who usually struggles with academic work, did not have much self-confidence. From my own observations I believed that he would probably agree with whoever he felt was

the “smart person,” but interestingly he made the following comment in the interview: "there is no point doing it,", that is, using GMO crops in food. He went on to say that if it fails, it is a waste of time. In the interview, he commented that he had not changed his mind, but his statement indicated that he may have considered doing so. He said that it was easier to make a decision once he had some information. This indicated to me that he believed that having information about GMO food and related issues helped him to make a decision. I wondered if he was struggling with making a decision? Maybe he did not feel empowered to make a decision on his own? Maybe he needed more of the Thinking Tools and skills to be made more accessible for him?

Lyle

On the other hand, Lyle appeared confident in his decision and did not change his mind. Lyle indicated that he thought that it was safe to use GM crops based on the Australian and New Zealand standards where, as he put it, the testing is "phenomenal." Lyle presented as a confident student in his interview, commenting that people (other students) often look to him for guidance and answers in science. However, in an earlier journal entry, he had written,

> I felt I agreed with Karen most, I’m against genetically modifying crops because it affects the wildlife as well as the crops. (Ly-Jn)

In the story, the story character, Karen, had said that she was against GMO foods. However, in the interview, Lyle stated that it was safe. I ask myself if this indicated a conflict in him or rather a change of mind? I consider his statement also in light of his later assignment, where he commented that he would allow GMO crops in our everyday food. Interestingly, Lyle indicated that he had made his decision without a struggle. But his reflections do not confirm this. Perhaps he simply forgot about his earlier thoughts, which is possible since the statement he made about Karen was made early in the term. Perhaps he had put on the mask of the cool and savvy guy who is good at science? I kept wondering about that.

It was a different story with Diane and Kylie; in their interviews and assignments they both said that they would agree with allowing GMO crops to be used in our foods. However, later they both changed their minds during the process of the ethical dilemma.

Diane

There were some indications that Diane had been 'struggling' with the two opposing sides of the argument. In her journal, Diane wrote that she had not yet decided and that she wanted more information about GMO foods before making a decision. This indecision suggested that she was struggling with the two sides of the dilemma, engaging in dilemma thinking. She had written that GMO foods would be beneficial, but she also asked whether GMO would affect the quality and taste of the foods, and whether these changes would be good or bad? Later in the unit, Diane recorded in a journal entry,

> Yes, I do believe that GM foods are safe. So far, my knowledge is that there was one major problem with GM foods, yet it was fixed. (Di-Jn)

In her interview, Diane seemed convinced that enough people are ensuring that GMO crops/food are safe, but then she stated that she personally would not choose GMO because "God didn't make it that way" (Di-In-Ln24). I think that Diane might have experienced a conflict between her perceived logic from her science learning and her personal beliefs and values. When Diane was asked if she had struggled to make a decision, her response was unclear at first:

> Um… well it wasn't completely quick but it didn't take a long time, cause, I wasn't… too focused on either area yet, because… I didn't have much of an overview of what we were really talking about completely… so... by the end of it, it did change to focussing more, but at the beginning not really. (Di-In-Ln83)

I believed that this response reflected the internal struggle she was having between the 'logic' of using GMO crops and her values. Perhaps she had not thought much at first about the issue, but through the dilemma story she had started to consider the issues more deeply. In her assignment she wrote that she would allow GMO crops to be used in our foods, as she thought that the advantages outweighed the disadvantages.

> The enormous potential of genetically modifying crops, partnered with the tight laws and standards provided by the Australian government persuades me to believe that genetically modified foods are safe for human consumption. (Di-As-p4)

Her assignment was one of the few that attempted to address and explain the issues. She discussed issues such as consumer health, the process of Australian approval, economics,

environment and ethical issues. Other students tended to provide a description or explanation of genetics and then briefly state what their decision was without a substantial attempt to justify their decision.

Kylie

Kylie appeared to be sitting in both camps. As she said in her journal

> I think Karen is right in saying that GMO has a negative effect on the environment but she also says that non-GMO does too. So I would like to know what has more of an effect. I also think she was being over cautious because she doesn't have a strong view for one side of statistics. (Ky –ClOb-2205)

Her journal entry also said that she did not want to take sides. However, it appeared that Kylie ended up making a decision when she wrote in her assignment that she would allow GMO food. She seemed to rely on the idea that 'they' (government) would keep it safe. She commented that if the safety precautions were not in place, she would not allow GMO crops to be used for food. Her assignment was weak in terms of the provision of evidence and explanations for her points of view, yet her interview provided deeper insights into her thinking. Even though she had stated during the interview that she had made a decision in her assignment, I wondered if she had actually made up her mind. For example, she said, "it doesn't seem safe," when she was talking about animals that had died due to eating genetically modified foods. Later in the interview, Kylie claimed that she had found it easy to make a decision, but commented that she did not completely believe in it herself. She tended to think that because of government regulations and testing as well as government concerns about the risks, genetically modified food must be safe. Towards the end of the interview, Kylie admitted to having mixed opinions regarding the use of GMO food. However, she explained why she thought it was acceptable, again referring to the amount of testing that occurs:

> I did because… maybe we should just leave it how it is, 'cause we have gone this long without using it, so maybe we should just put up with it and I don't really know much of an effect it will have. Like, unless we do it we won't know what things might come out of it…. [Perhaps] we should just embrace it because it's something that is proved…to help out with getting better produce and stuff. (Ky-In-Ln123)

This was in response to the question of whether she had struggled with making a decision, and seems to indicate a clear example of dilemma thinking. When she was asked about whether it was easy to make a decision in the assignment, she said she found it easy to make her decision even though she might not completely believe in it. Overall she thought that there was more information to support the claim that GMO was safe considering all of the government regulations and testing, and that they must have thought about the risks.

This section has examined the experiences of students who were seemingly in favour of GMO foods. In the following section, I explore the experiences of students who were seemingly against consuming GMO foods.

Students Against GMO Food

Mark, Mary, Jye and Heidi said in their assignments and interviews that they did not think that using genetically modified crops in our foods was safe. Jye, Mary and Heidi stated that they had made this decision at the start of the story, whereas Mark said he had been in two minds for most of the unit.

Mark

Mark had began the unit by thinking that GMO foods were safe; however, later he appeared to be undecided, stating that he could not say that they are 100% safe, but he would not say that they were totally unsafe either. Mark commented,

> like I said before, I originally was for it, but by the end I was more neutral, I was sort of for it, but definitely against in a way. (Mk-In-Ln99)

This statement showed he had a struggle with the two opposing sides of this issue. He wanted to make sure it was safe, but he also commented that many aspects could be of concern. In his assignment, he concluded that GMO was unsafe; he had to do more research before he was confident with his decision.

Mary, Jye and Heidi

Mary, Jye, and Heidi were definite about their decision from the beginning of the story, saying that GMO food was not safe, and they did not change their viewpoint. Mary commented that she thought it might be safe in the short term, but that in the long term she thought there could

be problems and so maintained her initial stance. Jye also said that he did not think GM food would be safe in the long term, although he was not as certain as Mary, commenting that the long term effects "probably" could be negative. Heidi, on the other hand, in her interview, said 'no' without giving a reason. She indicated that she did not struggle with the decision, saying 'no' from the beginning and she then 'stayed with it'. Later in the interview she appeared to have thought through the issue a little more, possibly remembering her comments made earlier in the unit. She reported that she had been thinking about the issue outside the classroom, wondering with her mum on the weekend whether or not organic wheat was genetically modified. In an earlier journal reflection, Heidi had commented that she was finding the topic difficult and that she did not know much about genetically modified foods. Although she had made a decision not to eat genetically modified foods, she seemed a little unsure, and was aware that not many other students in the class felt the same way.

Having summarised aspects of the classroom experiences of students participating in the ethical dilemma story, I now consider the involvement of students in group work.

Are We Working in Groups? – Oh No!

During their interviews and reflections, students indicated that generally there was cooperation and negotiation when working in groups, as they listened to each other's points of view when discussing appropriate responses. However, a couple of students said that they were not entirely comfortable with how well their groups were working together.

Kylie

Kylie said that she was happy with her group but felt that one member of the group did not contribute enough. I wondered when she said that she was happy with the group overall whether she was simply being polite or was really comfortable with the other two members of the group, both of whom were boys. The boy she was referring to battled to keep up with the work and was not highly self-motivated in science in general.

Heidi

On the other hand, Heidi stated that she was not happy with her group; she had felt left out and her views were not considered. She felt that the boys in her group "mucked around" and only finished the task at the last minute. In contrast, Andrew from the same group felt that the group worked well. He may not have realised that they had procrastinated and had annoyed

Heidi.

Mary

Mary had made up her mind at the start of the story, but said that although she had made her decision she did not mind listening to ideas as it helped her to reinforce her own. Mary and Diane, who were in the same group, both said that they felt their ideas were considered, and they did not feel any pressure from the group members to change them. Neal, who was also in this group, seemed to rely on what the girls said, especially Diane (who was one of the top students in the class) and may not have had the confidence to trust his own ideas.

Other groups, except for Andrew's and Heidi's group, were fairly consistent in reporting that they listened to each other's opinions. Austin and Mark, however, expressed some frustration with people who would straight away say no (to the use of GM crops in our foods) without considering the issue in more depth, feeling that these people were too negative. Mark and Austin showed some lack of empathy towards the opinions of other group members, whereas other groups appeared to show empathy by listening to each other.

My Reflection: Majority Rules

Each group had the task of negotiating a group response to the set task. How did the groups develop their response? The notion of 'majority rules' was a common thread among the groups. Even though different members of the groups had different opinions, it seems that democracy (allowing differences) was in action. I do not have records of how group negotiation took place, and this is something I needed to keep in mind for the next ethical dilemma story with another cohort of students. It was common for the students, however, to listen to each other, but the "majority vote" was the decision making process that most groups chose, not necessarily the validity of the arguments. This led to another question for me to consider – what arguments did students make when presenting their ideas? Did they present an argument or did they say – "yes, I agree" or "no, I don't," and provide a justification that only scratched the surface?

Some students seemed to be happy to accept majority rule, as for them it seemed an easy way out; they did not have to think too much for themselves, or they respected (or were intimidated by) members of the group who were known to be 'good' at science. This is evidenced by Neal's comment that he usually decided whatever Diane decided, and he was happy to go with what the group said. The idea of majority rule was the method used when the group could not

agree, and resolution was not reached through discussion. Some of the groups had three members, and some had four members. So for the three-membered groups, majority rule meant that one person's opinion was not necessarily valued. This is how Heidi felt with her group. This indicated to me that I needed to be more aware of how groups were progressing and that if a member felt disempowered, then I should guide them with strategies to help generate discussion that considered all viewpoints.

In the following section, I explore the experiences of two students in more detail: Jye and Kylie, whom I considered to be typical students from the cohort.

CASE STUDIES OF JYE AND KYLIE

Why did I Choose Jye and Kylie?

I chose Jye because he had indicated that he was interested in science. He had an independent character and was not easily swayed by peers when making his decision, and he had found the ethical dilemma story engaging. I observed that Jye engaged in dilemma thinking, as he considered both sides of the dilemma. Kylie was the second student I investigated in more depth. She explained that whilst science was interesting, she did not have any intention of pursuing science as a career. Kylie had clearly engaged with the story and its implications; however, she was one of those students who appeared to struggle to make a final decision. Both students had a desire to achieve, but their motivational levels differed. I believed that they could both achieve highly academically, possibly not at the top of the class but certainly in the top third of the cohort. On investigating the VLES survey results, I noticed something interesting with these two students. Whilst Jye's perceptions of the learning environment seemed to generally match those of the whole class, Kylie's differed markedly from the rest of the class for the domain of 'Learning About Science'. Graphs of their perceptions compared with the class can be found in Appendix 4A.

Jye

Jye was a bright young man who was a keen musician and usually worked hard in class. I had the impression that he would like to enjoy science but that he was 'bored' with worksheets. I had often observed Jye with his head down on the desk while watching videos on the laptop. In the more mundane learning activities in class, Jye could become disengaged but be quite involved and active in practical activities such as experiments. This may have indicated that he was an auditory and kinaesthetic learner rather than visual. Unfortunately, our science

lessons for the year were mainly in the afternoon after lunch when the students were more likely to be tired, and it often appeared that Jye was tired and not engaged.

In the interview, Jye indicated that he was interested in science and commented that he was looking at a career in geology or physics but was keeping his options open. This was a little surprising to me as it did not match the observations that I had made from his class work and behaviour. He seemed more interested in music, and he would often 'spark up' if I mentioned music and his guitar playing.

Jye's Views on the Ethical Dilemma Story

I asked Jye during our interview how he felt about the genetics ethical dilemma that we had just completed. Jye responded "it was good, because… we are going to be leaders of the future, so, we have to know what we are going to be dealing with because that has been a big debate that's been going on" (Jy-In-Ln18). It appeared that Jye had some understanding of concepts related to sustainability and future consequences. He indicated that he could see the value of studying the unit as he realised that one day his generation would be making the decisions for our society and that the debate on the use of genetically modified foods is ongoing. He was able to identify that there were positive and negative points associated with the dilemma. I wondered if he was starting to realise that while the development may be significant, there is often a downside to the technology. When asked about his personal values, he did not mention them but said that it was tough considering the two sides.

Students were required to listen to a section of the story and then undertake a Think Pair Share activity, and they were required to write their responses on a handout. The 'share' part of the activity required the students in groups to generate a 'group' decision. It appeared that Jye engaged in this group discussion armed with his individual thoughts and ideas and that peer pressure did not necessarily sway his personal decision, but he was also open to group negotiation, as demonstrated in the interview excerpt:

> I: OK. Did you, in your groups, were there any different opinions to yours or... to each other, or did other people in the group have different opinions?
> Jye: I think two of us were for it and two of us were against it, so… when you gave us the questions, we would come up with the positive and negative as well.
> I: …and then how did you resolve those differences, to come up with a group response?

> Jye: I guess also, um, on strong points, say if someone had a good, or a very good point then we would probably stick to that instead of someone just saying yes or no. (Jy-In-Ln55)

There is evidence that Jye and his group discussed the points and decided if they had strong arguments. I wondered what he meant by the term 'strong'. Did he mean arguments that could be backed up with evidence as they were encouraged to do? Or did a 'strong' point refer to a group member or members who express their point in a dominant manner? It seemed that Jye and his group were considering ideas that had some substantial evidence or some sound reasoning behind them. Perhaps a 'strong' point referred to a response to a given question that a group member had suggested, supported with evidence. In any case, I observed that students who were discussing the issue, rather than simply saying yes or no were demonstrating engagement in the learning activity.

Jye's Engagement in the Ethical Dilemma Story

Engagement in the ethical dilemma story by Jye can be seen in the fact that he was not swayed by his group but was solid in his decision. This does not mean that students who did change their mind were not engaged. Jye mentioned in his response to one of the Think Pair Share worksheets that some of the points referred to by Karen (a character in the story) were good points as he considered them plausible. These points were related to the possibility of 'superweeds' and the threat of weeds in national parks. While he thought that it was an issue to be concerned about, he also thought it would take a long time to be an actual problem, but 'taking the chance' that the issue would not be a concern in the long run was worth it. This point is illustrated in his responses to the Think Pair Share worksheet questions: *What do think? Do you think Karen is just being over cautious, or does she have a point? Are the benefits of GM crops greater than the risks?*

> The two points are very good points; this would take a long time, but it could happen. I don't think that there is any point taking these chances just to make food just a bit better. (Jy-Pt7TPS)

Without realising it, Jye had made a value statement here. He did not think that the benefits of genetically modified food outweighed the risks. He confirmed this with his response to the next set of questions: *So what? Does it make any difference to you if we use GM crops or not? Why or why not?*

> I disagree with using GM crops just to make fruit and vegetables a bit better when it is already good enough. (Jy-Pt7TPS)

Jye apparently thought that our fruit and vegetables were suitable as they are now. This could be interpreted as a narrow view and that he had not looked at the topic in depth, as genetically modified meant more than just better quality fruit and vegetables. Had he considered other aspects such as eliminating allergies, or the medicinal value? Perhaps not at this stage, as he responded to questions about the story which focused on the quality of fruit and vegetables. I did not pursue this line of thought further in the interview.

I wonder if there was an underlying simplicity in Jye's thoughts? Responding to the questions on the Think Pair Share worksheet: *Now what? So what can you do? What's in store for the future? Will your grandkids thank you?* Jye wrote,

> I don't think that God wants us tampering with his creation of food. This could end badly, so I disagree. (Jy-Pt7TPS)

My Reflection: Clashing Worldviews

The College uses a curriculum based on a Christian worldview. Thus material covered in class was within this context. However, it is not the goal of the College to have students blindly follow a Christian Worldview, but rather to have students develop their worldviews in an informed way, hoping that they develop their personal faith rather than tagging along with the faith of their parents or that espoused by the College. It is a concern for me as a science teacher to see a student such as Jye using simplistic thought, such as we should not tamper with God's creation, without examining it further. He did not seem to consider how much science had already tampered with food, crops and livestock over many generations of selective breeding. However, Jye was not the only student to suggest this; at least two other students, Mary and Diane, had similar ideas.

Jye as a Group Member

As he continued to work through the Think Pair Share worksheet, the class was asked to pair up with another student and compare thoughts. They were directed to make notes in a different colour on their sheet if there were differences from or similarities with the responses of other group members. Jye did not make any notes on his sheet, so there is an assumption that there was general agreement between Jye and his partner. It could also be interpreted that Jye did

not follow the direction of the task, but my observations made in class indicate that the pair were discussing the topic. The students were then directed to move into their groups and generate a group response. Jye recorded the following for the group response,

> we think she [Karen]was only slightly reacting. What she said might happen over time. Neither Karen nor Jim can prove their theories currently. Because we have only seen the short term effects so far. We think it is better than other options. We should just leave the food the way God made it. (Jy-Pt7TPS)

It appeared that the members of the group decided to agree to disagree. Firstly, they wrote on their response sheet that genetically modified foods was an option that was worth considering, but then they further commented that we should leave the food the way God made it (whatever that was/is). This highlighted a level of disagreement in the group, since a definite decision could not be made by the group, so to keep the peace the two different choices were presented.

Jye and Ethical Dilemmas

I wondered if Jye had a dilemma with his decision? I asked this question in his interview, to which he responded that it was beneficial to have the dilemma presented as a story, as it highlighted the opinions of different people and enabled him to see that there were more issues to the topic than he first realised, as the following interview excerpt demonstrates:

> Jye: Um...at first I was sort of, it took me a little bit to work it out but then when we heard..., one of the points was about long-term effects, I sort of thought, well yeah, that could be possible.
> I: Ok so you sort of ended up changing your mind?
> Jye: …ah well I really didn't mind it first but then yeah… [I] went towards saying no. (Jy-In-Ln86)

His comments reflect that he struggled with the two sides of the dilemma. The story was set up so that supporting the use of genetically modified crops in our food was a good idea, and at first he thought using genetically modified food was appropriate. His phrase, “it took me a little bit to work it out,” suggests that he had to work through the issue. The deciding factor could have been the concern for the long-term effects of using genetically modified crops in our food. In his interview, Jye indicated that his change of mind was based on information that was presented in the story and in class:

> I: Do you think you used your science knowledge to help you make your decision in the unit?
> Jye: Yes, I think, yes because, from what we did in class, there was good and bad points and we were able to decipher between them, but also um, Peter, Dr Peter Stone came, yeah, he had some good points… as well. (Jy-In-Ln69)

Dr Peter Stone (CSIRO) was a guest speaker who spoke to the class about genetically modified crops and organisms. He did not openly comment that he supported genetic modification, however, he made it quite clear that there was a substantial amount of misunderstanding in the community. Students, including Jye, placed a substantial amount of weight on his words as an authoritative voice other than that of the teacher. This highlighted the value of using experts to present information to the students, who seem to respect the knowledge and expertise of people who are working in a particular field of study. Jye combined information from the dilemma story, the material presented and researched in class, and from a scientist (Dr Stone) to make his decision. I wondered how Jye used this information to make his decision. Did Jye use higher-order thinking skills to help him generate his decision?

Jye and Higher-Order Thinking

One of the goals of this project was to encourage and enable students to use higher-order thinking skills. I provided a series of thinking skills tools. Some of these are generic and can be seen in various forms across various education sectors, and others are unique ITC Publications that use the Thinking Skills Framework, which is discussed in Chapter 3.

I asked Jye in the interview if he had used any of the Thinking Skills tools. Jye's response was "um..." indicating that he didn't know, and when prompted further he responded with

> Well, I think everyone sort have had questions in their own mind but… a lot of mine were questions that were answered through what you were saying or what the professor guy said. (Jy-In-Ln104)

I asked Jye if he would use the Thinking Tools if he had an opportunity to do the unit again. His response indicated that he would not and that he was satisfied with the method he had used.

I was intrigued that Jye could not name any Thinking Tools that he had used, as several were introduced, explained and used in class at various times throughout the unit. Jye had

previously used some thinking tools such as the PCQ, Extended PCQ, Double Bubble Map and the Decision Making Matrix, all which had been introduced and explained in a previous science unit. I was concerned that Jye (and other students) had not seen the value of using these tools. Perhaps the information they had generated had been ignored, or perhaps used subconsciously when they worked on their assignment. Each of the tools and the tasks they presented were designed to help students develop their ideas for the assignment on recommending whether or not genetically modified crops should be used in foods.

I asked Jye if he thought that he had gone into enough depth in his assignment. He responded,

> I reckon with my draft… for the assignment, I was a bit vague but, when you said to… back it up with facts, I just found facts from different sites and from Dr Peter Stone who came and put it into there as well. (Jy-In-Ln114)

My Reflection: More Depth?

Did going into more depth for Jye include getting facts to back up what he was saying? It prompted me to wonder what does 'going into more depth' really mean for me and the students? Often I would write on assignment drafts — "go into more depth," but what did that really mean to me or the students? Did going into more depth mean considering all aspects of the topic, for example, to look at the benefits and barriers or to investigate the cause and effect relationships?

In his assignment Jye presented some advantages and disadvantages of using genetically modified crops that were displayed as dot points with statements for and against. His conclusion stated: "Even though there are some great advantages in GM crops, most of these positives can be ruled out by the negatives" (Jy-As). Jye did not provide additional information explaining how and why he thought that way, but indicated that he was relying on his belief that we should not 'play' with God's creation and the concern that too many things could go wrong. He justified the use of pesticides and their safety because there had been much testing. He provided enough background information but did not demonstrate an ability to present a reasoned argument.

It appears that the dilemma story encouraged Jye to engage in science learning and in dialectical thinking, as he considered both sides of the dilemma and formulated his decision. However, the depth and breadth of his thinking seemed questionable to me. I noted to myself that in my next dilemma story project, I needed to examine the pedagogy of Thinking Tools

as students considered the dilemma.

In reflecting on the progress of Jye in class, it could be said that while Jye had a compliant attitude and a willingness to do the right thing, he had a tendency to complete class tasks as quickly as he could. He did not take sufficient time to consider the task more carefully and hence engage effectively in ethical dilemma learning.

Kylie

Kylie was a positive and friendly young lady who appeared to have a desire to achieve highly. She found science interesting but did not have the goal of a career in science. Kylie enjoyed the practical part of science and completing activities at the laboratory benches rather than bookwork and using the laptops. She indicated in a PCQ that was conducted at the start of the term that she got frustrated when using the laptops as they sometimes can take 'a long time' to start up. This suggested that she would rather get in and start working rather than 'wasting time' waiting for the laptops. In the same PCQ, Kylie said that she considered that book work is "basically just getting you to look in the book and copy an answer — so you don't really learn much" (Ky-Jn). I felt that this was an interesting comment, and showed that she is keen to learn and also to think about what she is learning rather than work through routine tasks.

Kylie and the Ethical Dilemma Story

The first part of the ethical dilemma story was based on the beginnings of a debate in the family about genetically modified tomatoes. Mum (Sonia) is upset that Amy has bought the tomatoes, but Amy cannot see the problem since in her view they are of a better quality and a new and trendy idea. Questions were then asked for the class to answer as a Think, Pair, Share about their thoughts on 'better quality' food, teenagers following new trends, and which character they identified with the most. The students were not asked to make a decision at this point. The responses generated by Kylie seemed to be uncommitted to either viewpoint and demonstrated some misunderstanding as to what was meant by the term genetically modified. Kylie commented,

> I don't think that it would necessarily be better quality - they are just basically making the buyers pay for them to put chemicals in their food. (Ky-Jn)

It appeared that to Kylie, genetically modified equated to putting chemicals in food, which was not surprising at this stage, as certainly material is 'placed' into the food or crops.

Kylie was not convinced that the genetically modified foods would be better quality. I wondered if she was biding her time to see what happened with the rest of the story? More evidence that she did not want to commit was that she wrote in her journal that she identified more with the Dad (Ross) who wants to support his brother Jim who researches GMO crops and does not want to take sides, preferring to keep the family peace.

> I think I am most like the Dad because I am not totally opposed to the idea of genetically engineered food but I wouldn't promote it and I'm not fully for it. I don't want to pick sides. (Ky-Jn)

As the story progressed more information was presented to the students and the focus moved to Jim (the Uncle) who is convinced that GMO foods are safe. The students were asked in their Think Pair Share activity whether or not they agreed with Jim. To help them generate a response, the students were asked to complete a PCQ (Pros, Cons, Questions) worksheet. Kylie's responses demonstrated some development in her thinking and understanding. Kylie had suggested previously that genetically modified foods were due to chemicals. However, later in the unit she said that genes were 'crossed' to make a product that looks and tastes better. Kylie also developed some concerns related to sustainability. She felt that environmental issues had not been considered, and she asked the question, "What effect does it have on the farmers and the environment?" She also raised the point that possibly less chemical spray may be needed with GM foods, as the plants (crops) could be more resistant to diseases. I assumed here she was referring to pesticides and herbicides.

However, her written response indicated confusion about concepts. She had disagreed with Jim, who claims that GMO foods are safe, but her reasons indicated misunderstandings and confusion. She mentioned chemicals, apparently confusing them with genes:

> No, we weren't made to consume all these chemicals. The chemicals mess around with your system too much and I think it's just best to keep food as close to normal as possible. (Ky-CLPCQ)

At first, I thought she was referring to chemicals from pesticides and herbicides, but since she referred to keeping food as close to normal as possible she was probably referring to GMO foods. I believe that this could come from a common theme that I had observed among some students, which is that the food is 'God's creation', and we should not necessarily change it. Keeping in mind the context of the College and its teachings based on a Christian worldview,

this is not an unexpected outcome. However, the students needed to be encouraged to think and process the issues rather than generating a blanket statement. In discussion with some students, I pointed out that our crops and food have already been changed and modified through selective breeding over the past generations. I raised the question, "What is the difference with genetically modified crops?" In hindsight, this is an issue that I could have explored more with the students, encouraging them to have sound background to their opinions.

In Part 7 of the story, I asked the students to answer the question of whether they thought that Karen was just being over cautious, or if she indeed had a point? At this stage of the story, Jim explains that GMO crops are safe, but Brian (brother) brings up the issues of mutations, natural selection and insects developing resistance, to which Jim responds that they were not a concern given available evidence. Karen disagrees, and raises concerns about superweeds, labelling of foods, insect resistance and the possible consequences in forests. Jim counters that the heavy use of pesticides and the problems associated with them justify GMO methods, which give a better outcome compared to broad spectrum use of pesticides. Karen argues that she does not like the use of pesticides either because of her concerns for the environment.

Kylie and Higher-Order Thinking

I added more scaffolding to the Think Pair Share activity that followed this section of the story by creating a worksheet that asked students individually a series of questions designed to help them think more deeply and personalise the issues and consequences related to the question. The questions are:

- What do you think? Do you think that Karen is just being over cautious, or does she have a point? Explain your answer. (Use your points from your PCQ to help you answer)
- So what? Does it make any difference to you if we use GM crops or not? Why or why not?
- Now what? So what can you do? What's in store for the future? Will your grandkids thank you?

Kylie responded to the 'what do you think?' question that she agreed with Karen, in that GMO crops could have a negative effect on the environment. She also pointed out that crops that had not been genetically modified could also be detrimental to the environment. She did not identify how, but it could be inferred that Kylie was referring to the heavy use of herbicides

and pesticides. However, this was not clear from her response. Kylie took her argument a step further and questioned which had more of an effect on the environment — genetically modified crops or normal crops?

The fact that Kylie took the question a step further demonstrated a level of higher-order thinking. Rather than simply answering the question she raised questions and investigated the issue further. I believe that what may have helped Kylie develop this idea was the use of the PCQ (Pros, Cons, Questions).

The assignment was the culminating task for the unit. It required the students to explain the background theory relating to genetically modified crops. I expected that this theory would include an explanation of basic genetics, genetic modification and how genetic modification is undertaken. The students were required to provide an argument to support their decision to the overarching question — Should we use genetically modified crops in our food? The assignment task sheet can be found in Appendix 4B. The assignment was an opportunity for students to demonstrate their knowledge of genetics and their ability to evaluate and make judgments based on evidence and sound science. I recall looking forward to Kylie's assignment, as she had seemed so engaged with the unit, and she usually achieved highly in assessments. However her assignment was disappointing. It covered the basics of genetics superficially, and she made statements about the genetic modification of foods without explanation or evaluation. Her submission about making a decision was one paragraph in length, which was far less than what was expected. This was a general trend in the class, though on average most students wrote more than Kylie. I discuss further my students' reluctance to evaluate and provide quality arguments to support their decisions in Chapter 6.

It was evident to me from Kylie's assignment that she had eventually cleared up her initial misunderstanding about 'chemicals' and genes used in genetic modification. She explained that genetic modification was based on the alteration of DNA in some manner. She very briefly (one sentence) mentioned the various methods of genetic modification including infection, biolistics and microinjection. Kylie also explained that genetic modification has been occurring in the past through selective breeding. It appeared, therefore, that her knowledge of genetics had developed throughout the unit.

Perhaps I was a little too harsh when commenting on Kylie's evaluation: she had provided some statements justifying her decision, but these statements were not fully explained. Below is an excerpt from Kylie's assignment where she justified her decision.

> Since the beginning of history people around the world have never stopped inventing and creating new ideas. The world wouldn't be where it is today with technology, medication, transport etc. if it weren't for the people who experimented and weren't afraid to try new things. I feel that Genetically Modified foods do have some risks, including the risk of super weeds, allergies, and environmental effects however the positives, such as food that tastes better, looks better, lasts better and is easier to produce with restricted use of herbicides and pesticides, far outweigh the negatives. I am in favour of using Genetic modification in our food and with many precautions that are in place such as buffer strips around experimental GM crops, bird and animal proofing and thorough cleansing of harvesting equipment, this method is the wave of the future and I would positively embrace it. (Ky-As-p2)

She has justified the use of genetic modification techniques in principle, pointing out that our society over time has sought to improve our way of life – 'inventing and creating new ideas.' That was not going to change. She had decided that genetic modification of crops intended as foods was appropriate but with conditions. This demonstrates that she has explored the topic. The mention of buffer strips, bird and animal proofing and cleaning of harvesting equipment indicates that she has researched the issue and found methods that can be used to combat problems such as superweeds, environmental effects and the spread of seed and pollen.

Her final decision indicates that she would 'positively embrace' the use of the genetically modified crops in our food. Her decision seemed to be based on the notion that it was going to happen anyway as technology developed. She suggested that the positives outweighed the negatives, but she did not explain how and why they do.

In the interview, Kylie was asked if she struggled with the two sides of the dilemma. Her response was:

> I did because, it's kind of true that maybe we should just leave it how it is because we have gone this long without using it, so maybe we should just put up with it and I don't really know [how] much of an effect it will have... unless we do it, we won't know what things might come out of it, but then again, I kind of feel like we should just embrace it because it's something that is proved to kind of help out with getting better produce and stuff. (Ky-In-Ln123)

These statements reinforced my view that she was trying to keep things as they were whilst moving with technology. She indicated that there could be possible effects (not saying whether they would be positive or negative), but seemed to be willing to give it a go and see how it worked out. Kylie said that that she found it easy to make a final decision, though she later added that she did not completely believe in it, but felt that with research, safety regulations and testing in place, GMO foods would be safe.

Kylie as a Group Member

In terms of group work, cooperation and collaboration, I had the impression that Kylie enjoyed the group work but was frustrated with one member of the group who did not seem to pull their weight. She felt that she was doing most of the work, so possibly the group responses were mainly her own. Did she and her group members need some group coaching — how to include others in the group, and collaboration skills? Kylie recognised that there were different opinions in the group — various points of view that she (or the group) had not considered before, and she said that they were able to have a good discussion about it which resulted in changes of opinion.

When asked about disagreement in the group, Kylie said, "one week, we all had a good opinion, we were pretty firm in our belief...." Did this mean that the group consensus was reached? She then said that once they were given more information from the story, people started to change their minds, but others did not, so the group began to have disagreements, but she commented that this was a “healthy disagreement,” but they were still not decided on the final answer.

Kylie, The Story and Engagement in Science

Kylie said that she liked the story — "it was easier to relate to," and she preferred its stimulation rather than getting "pounded with information" through PowerPoints. She seemed to like the opportunities to carry out more of her kind of research (where she was looking for material that they thought was relevant); she commented, "if we didn't understand something we could do our own research.” Kylie commented that she thought that the story helped her realise that there were more sides to the issue, and that the tomato story helped her understand that. The story also provided prompts for further research such as environmental issues and health issues.

Throughout this unit, there was evidence that Kylie struggled with the dialectics of the

dilemma, using some higher-order thinking to synthesise a decision. However, there was scope for her to think more broadly and deeply about the issue, and she could have used more Thinking Tools and their by-products to help her synthesise a stronger argument. Overall, it appeared to me that Kylie was engaged in the unit, as she researched her own areas and considered the different aspects. This was confirmed by her VLES survey results for the domain of 'The Dilemma Story,' where she rated the story highly, saying that she felt curious about the story, could understand it and wanted to solve the problems presented in the story (see Appendix 4C). However, this prompted a question in my mind: how does one understand engagement in the science classroom, especially when the students are involved in group work activities? I have found that group work often generates a significant amount of noise, which I encourage as 'busy' noise, hoping that students are indeed on task. But how do I know for sure? Students can appear to be on-task, and the converse may be true. I discuss this concern in Chapter 6.

My Reflection: What did I Learn from the Experience?

My feeling was that the students, in general, did not see the need to use higher-order thinking or they saw the need but struggled with the idea of carrying out the work required to do it, taking the time and effort needed. Maybe this was not a concern if there was evidence of higher-order thinking occurring without the use of the Thinking Tools. Thinking Tools are not entirely necessary for higher-order thinking to occur, though they can help with the processes and provide scaffolding for the students. However, considering the two students I have examined more carefully, there was not much evidence of the use of higher-order thinking in their assignments as they synthesised their decisions. Indeed, this was the case for nearly all of the students' assignments for the class.

Kylie was asked if she thought that she had considered the topic in enough depth. She replied that she thought so, but also suggested some areas that she could have looked into more. This prompted me to ask myself and my colleagues: what does 'enough depth' actually mean? Do the students know? Do we as teachers know? I had often commented on draft assignments, 'more depth needed'. What am I after? I posted this question on a PLN network on Facebook that has as its members teachers from our school. Only one response occurred, saying that this was a good question. Does the lack of responses mean that other colleagues are not sure either? I was under the strong impression that our students don't know what it means, which indicated to me the need to model to the students the type of work we would like them to produce.

SUMMARY

In this chapter, I have discussed my initial investigation of how my first cohort of students engaged in ethical dilemma story learning. I have outlined how the implementation of the story unfolded. I have discussed the experiences of selected students, describing how they participated in higher-order thinking and group work. The analysis continues with a focus on two students – Jye and Kali - who were typical of the cohort. Their individual experiences illuminated my understanding of the implementation of the ethical dilemma story.

Generally, students engaged in ethical dilemma thinking. Several students were indecisive regarding the issue of GMO food. Although some thought that they were confident in deciding one way or the other, they indicated in their interviews that they experienced a level of uncertainty. This prompted, for some students, a desire to find out more about the issue so that they could make a more informed decision. Both Jye and Kylie shared that they struggled to make up their minds. Kylie was able to articulate that she benefited from higher-order thinking to help her make a decision, however, Jye appeared to rely on his own beliefs rather than identifiable higher-order thinking. Both shared that they found the topic and story engaging. Some students shared that they could see the value of GMO for society, placing their confidence in government bodies to maintain control and safety. However, they also said that personally they did not like GMO foods. This indicated a personal conflict and demonstrated consideration for sustainability issues.

Collaborative learning was a tool that assisted many of the students. A significant number suggested that they believed that there was cooperation and negotiation when they were working in groups. They shared that they listened to each other's points of view. Two students, however, when interviewed, acknowledged that they felt that their group did not value their opinions and knowledge, and they expressed frustration. I believe that some of this frustration could have been alleviated if the students had a skillset that enabled them to work collaboratively.

CHAPTER 5
ENGAGEMENT OF STUDENTS IN ETHICAL DILEMMA LEARNING - 2013

INTRODUCTION

In this chapter, I focus on the second implementation of ethical dilemma story, Torn at the Genes, with my Year 10 Science class in 2013. The main research question addressed in this chapter is: how did the students experience ethical dilemma story pedagogy in the context of education for sustainability? To address this question I present case studies of four students, followed by a cross-case analysis.

Setting the Scene

A year later I conducted the ethical dilemma story with a new cohort of Year 10 science students. As discussed in Chapter 3, there were key differences in the implementation of the story compared to 2012. One key difference was that the students experienced approximately two weeks of teaching that focussed on basic concepts of genetics, rather than starting the story at the beginning of the unit without any background knowledge of genetics, as was the case in the first study. Another major difference was the development of a booklet in which students could record individual and group responses. A third contrast to the class of 2012 was the use of MYCOCT rather than Wikispaces.

FOUR STUDENTS' EXPERIENCES

This section explores the experiences of four students – Amanda, Wade, Harry and Hayley. In a similar manner described in Chapter 4, I used 'purposive sampling' to choose the four students for this case study. The results of the VLES survey (see Appendix 5A and Chapter 2 for discussion regarding the survey) and my knowledge of these students formed the basis for choosing the four students for this analysis. I compared the four students' perceptions of the classroom learning environment, as indicated by their VLES results, to those of the whole class. I also chose students to represent a range of academic abilities and levels of engagement in the ethical dilemma story.

Amanda's perceptions generally matched those of the whole class, but I noticed in her interview and blog that she did not seem in favour of the dilemma story. She performed at a high level academically and appeared to engage with the topic of GMO, and I found her

thoughts about the dilemma story and the use of group work interesting, as I discuss later in this chapter.

Wade's perceptions did not change significantly between the pre and post VLES surveys, in contrast to the rest of the class. Wade's only significant change, which was negative, was related to his response to the supportive role of the teacher. I found this worth investigating, because Wade did not normally achieve well academically.

Harry's perceptions matched those of the whole class for teacher support, but he responded less positively to the VLES domains of 'learning to collaborate', 'learning to learn', and 'learning to think', which suggested that overall he did not find the dilemma story as engaging as other students.

Hayley's perceptions generally matched those of the whole class. As a mid-range student academically she provided a balance between extremes.

Other students could have been chosen, but these four students appeared to be broadly representative of the class.

Amanda

Amanda was a highly motivated Year 10 student in most areas of school life. She consistently achieved academic awards and gained As in nearly all of her subjects. Amanda performed at a high standard in the sporting arena as well, being age champion for swimming, athletics and cross country. Swimming was her main sport, and she trained morning and evening. Amanda also played the saxophone and piano, and was a member of the choir and a performance band at the College.

Amanda worked diligently on her academic work. For example, with assignments, her drafts were carefully crafted and she expected quality feedback to help her improve. Without direct evidence, I assume that Amanda spent a considerable amount of time on her studies, as her homework was always fully completed. The fact that she excelled in her assessments pointed to an effective study pattern. I wondered how she managed to fit her swimming, studies and music into her days.

In my science class, Amanda appeared to have a positive attitude to science and learning. Talking about science in general, she said in her interview that she liked learning about science

and about how “everything” works and “what we are made up of.” In her blog, written after the two-week block of basic genetics, she wrote:

> I am understanding most of the content being taught, and I find it very fascinating. I am not quite understanding gene crossing, which we were introduced to through a clickview video on Friday. I think next week I will understand it when we look at it in more detail. (Bg-Am-Wk 2)

Amanda was in a positive frame of mind with regard to learning science and genetics before we started the ethical dilemma story. Since one of the aims of the dilemma story was to encourage student engagement and thereby promote positive attitudes towards the science discipline, it was intriguing to note how her attitude developed over the course of the dilemma story. I hoped that the dilemma story would continue to engage her and not cause her to lose interest.

Story: Part 1 – Warming Up

The dilemma story was started in week three of the term and parts one and two were covered on the first day. The first question the students had to answer was, “[I]f you were Sonia, how would you feel about the tomato? Would you eat it?” To answer this question, the students were asked to fill out a PCQ table in their booklet. This thinking tool template enabled Amanda to generate some interesting points about the question early in the story, without any prompting from the story or from me. She noted that the GMO tomato is better value for money and lasts longer, but she noted other issues such as that genetic alterations cause health problems. She raised the question about her morals and beliefs, commenting, “This is not how God intended food to be.” What she wrote in the PCQ confirms that the PCQ template allowed Amanda to think more deeply about the question and reflect on the bigger picture involved with the issue. Amanda’s responses to the PCQ follow:

> **Pro Sentence**:
> The tomato will last longer than normal, therefore they can be bought in bulk and will be better value for money.
> **Con Sentence**:
> The tomato has been created through new technology and there may still be problems. It also may affect health and even cause health issues.
> **Question Sentence**:
> What genes have been used/added to the tomato? Is there any chance of health

problems? What would the health problems be? (Bk-Am-p2)

This ability to think about the bigger picture in science is a component of the Australian Curriculum, specifically the cross-curriculum priority of sustainability, general capabilities of ethical understanding, and critical and social capability, and is a part of the Science as a Human Endeavour strand — Use and Influence of Science. Amanda appeared to have considered most of these components before they were encountered in the dilemma story.

Further evidence of this was demonstrated in the second part of the story, which directed the students to answer the question — "Does genetically modified in your view equal better quality? Answer as Sonia and as yourself".

Story: Part 2 – Genetically Modified Equals Better Quality?

Amanda used the PCQ template provided in her booklet and raised questions about possible effects on the human body. She also realised at this stage that she did not know what the genetic modification processes were or how they worked. I was pleased to note this as I was reviewing their booklets, because one of my goals was to move the students to a point where they realised that they needed more knowledge to make appropriate decisions. Amanda wrote this in her booklet:

> **Pro sentence**:
> The produce will last longer and will probably be in best condition.
> **Con sentence**:
> The tomato has unknown effects on the body, and it is unknown what is used to make it.
> **Question sentence**:
> Has the tomato lost nutritional value? What effect will it have in the future?
>
> (Bk-Am-p3-4)

Amanda's blog entry for the end of the week commented on the assignment task and the fact that she needed to make a decision about whether she was for or against genetically modified food. She did not say in her blog which way she was leaning, but her booklet entries and her group summaries indicated that she was deciding against the use of genetically modified foods.

An interesting side point is her opinion of one of my teaching strategies, collaboration through working in groups. I had required students in their groups to research a particular topic, sharing their findings on a wiki where they could easily view each other's work and share ideas. Amanda said in her blog "we are still at the research stage, and we are meant to research in groups, and upload what we find to a wiki. This is a good strategy in theory, but won't and doesn't work, when all the group members don't put in equal effort. I prefer working by myself so I know exactly what I have done and what I need to do" (Bg-Am-Wk 3)

I wish that I had noticed this entry before I had conducted the interview with her, as it could have been an excellent opportunity to explore this point. At this stage, I could only comment on my general experience of observing students in groups, and my thoughts and reflections on this can be found in Chapter 6. In any case, Amanda appeared to be frustrated or annoyed that students in her group had not put in an equal effort. During a casual conversation approximately a year later, she confirmed that she was frustrated. She continued by saying that group work works in theory, but does not account for different personality types, and there will always be someone who does more work than others in the group. This could be especially frustrating if, as a higher achiever, one was relying on other students to be fully engaged to develop material that is needed for success. Amanda made mention of this frustration in her interview a couple of times. She said that although her group agreed on responses to questions raised by the story most of the time, there were times when they were not working. She also said that she felt it was obvious that other members of her group had not developed sufficient knowledge on which to base their opinions. Possibly she felt that they agreed with her because she was the 'smart' one. I can only speculate on this now, but I have observed this type of behaviour to be common in social interactions amongst students. Amanda said, as part of a later member check, that it was not so much because she was the "smart" one in the group, but more that she had researched more and, therefore, had more knowledge and understanding of the topic, and hence other group members were more willing to agree with her. She also said that often in group work other members wanted to have an opinion on a topic but lacked the background knowledge on which to base it.

The story continued the next week with students exploring the processes of genetic modification. They were asked to complete a KWHL (a Thinking Tool template — what I **k**now, what I **w**ant to know, **h**ow will I find out and **w**hat have I Learned). Amanda continued to reflect on the moral and health issues that were in her mind, recording in the Know section that there was a "conflict over the issue — both morally and health related." She recorded several points in the second section (What I want to know), including:

- health risks?
- what processes are involved?
- what genes do they take from what organisms?
- can they improve?
- how they change the food? (Bk-Am-p5)

This list indicated that Amanda had developed a good knowledge of the dilemma for this stage of the story. She understood that genetic modification involved genes rather than chemicals. In contrast, quite a few students mentioned chemicals or parts of organisms when trying to explain genetic modification. She had also thought about possible health risks, again without direct prompting from the story, as well as noting that she needed to understand the actual genetic modification processes. This indicated that the dilemma story had enabled Amanda to maintain her interest and engagement in the genetics unit. This is confirmed in her blog entry for the week where she wrote, "I have found the research very interesting."

Her blog entry also indicated for the first time the struggle she was having with the dilemma. She said, "...but I am still not sure what my views are. Both sides of the debate have valid points." Amanda appeared to be struggling with her decision. Although she said that she could see and understand the benefits of genetically modified food, this seemed to be in conflict with her own values. Amanda commented in her interview that she did not find it easy to make decisions, and this was supported in her final decision, which she wrote about in her assignment. I discuss this later in this chapter, but it appeared that the dilemma story had made her reflect. In the interview, Amanda said that she was "against" the idea of using GMO foods from the start as it, "just didn't sit right," but this thought appeared in conflict with her blog entry. Amanda was displaying a degree of cognitive dissonance (Robbins, Judge, Millett, & Waters-Marsh, 2011). She felt the incompatibility between her moral attitude and the need for change in future behaviour that this information required. Robbins et al. (2011, p. 63) note that "research has generally concluded that people seek consistency among their attitudes and their behaviour." The discomfort of this dissonance might cause students to defer the decision until life circumstances mean that they are compelled to make a decision.

Story: Part 4 – Who in the Family do You Identify With?

Amanda's struggle to make a decision continued in Part 4 of the story, where the students were asked to answer the question, "Who in the family do you most identify with? Why?" She

responded in the 'Think' section of the booklet with the following – "I identify with Ross and Sonia the most. I probably lean more towards the disagree side, but I'm not sure. Once I have done more research, this opinion will most likely change" (Bk-Am-p7).

I found, "This opinion will most likely change," to be a fascinating comment. Was Amanda convinced that with more information her moral and personal value-driven doubts might dissipate, or be overridden with the 'facts' of science? It is difficult to say, but at the very least, points to the dialectical struggle that she was experiencing.

Story: Part 6 – Do You Agree with Jim?

Further parts of the story directed Amanda to consider other aspects of the dilemma. The story introduced possible problems with genetically modified food, as well as the arguments or defence against those problems. Amanda's dilemma appeared to move to another level. In the short-term, eating the tomato would not be a problem; in fact, she highlighted that not eating it would be a waste. On the other hand, she emphasized the unknown nature of the long-term effects of genetically modified foods. When asked if she agreed with Jim (who argued that genetically modified foods are safe), she commented that lots of testing had been completed, but the long-term effects had not been studied. She also raised the question, "Who does declare that GM foods are safe?" further indicating her consequential thoughts regarding actions in science. Her group wrote at this point in the story (this was written in her booklet, so I assumed that this was her viewpoint as well)

Scientists have thoroughly tested and experimented with GM foods and would not declare them safe if they weren't sure. However, long term and unseen effects have not had an opportunity to be tested and different people will react differently. Until GM foods have been around longer and studied further, they are not completely safe. (Bk-Am-p11)

Story: Part 7 – Is Karen Being Overly Cautious?

Part 7 of the story addressed the possible disadvantages of genetically modified foods. It raised problems about immunity to pesticides, superweeds, problems with antibiotics and possible effects on the food chain and hence ecosystems. The question was asked whether students thought that Karen was being over cautious, or whether she had a valid point. The PCQ template appeared to enable Amanda (and other students) to attempt to have a balanced view of the issue. At this point of the ethical dilemma story, it was hard to say whether or not Amanda was still looking for science to provide the winning blow. She wrote the following

for her Pros, Cons and Questions sentences:

> **Pro sentence**:
> Karen is being rather emotional about GM produce and has a right to be. However, she also isn't being very open minded about the topic and is ignoring testing and research that has been done.
> **Con sentence**:
> There are very realistic effects that GM foods could have on nature. Ecosystems and food chains disrupted, unknown long-term effects, control over food supply. These are all viable effects and Karen has a right to be concerned.
> **Question sentence**:
> Are the effects of the chemicals currently being used on crops greater than GM? (Bk-Am-p13)

Amanda had also considered control over the food supply. Food supply was mentioned at this stage in the story, but in relation to safety of supply rather than control. In her assignment, Amanda discussed ideas of companies having monopolies on genetically modified seeds. As this was not mentioned in the story, Amanda had probably researched the issue herself, indicating that her interest and engagement had not reduced, but rather increased as she sought to find a solution to this dilemma and understand the breadth of the discussion. Another possibility was that she was keen to get the assignment finished as she managed her demanding and high achieving lifestyle. A later member check confirms this may have been the case; Amanda said that she was often keen to get the assignments finished but tried to balance that with finding real solutions to problems. She said that she was brought up to consider both sides to an issue and thus wanted to research everything about the topic before actually writing the assignment and making a decision.

Amanda was also trying to maintain a balanced view of the dilemma. Evidence of this was her response about Karen. Firstly, she agreed that Karen was being emotional but actually said that she should be, indicating that Amanda thought that it is appropriate to be emotional in the face of a challenging situation. Possibly this pointed to the notion that Amanda was striving to find a solution to the dilemma rather than simply trying to get the assignment finished. Her balanced view was demonstrated by the counter statement that Karen was not being open minded about the topic.

Story: Part 8 – What Would You Decide?

The last part of the story asked the students to say what their final decision regarding the dilemma was. Amanda's thoughts at this point, once the whole story had been told, were:

> **Pro sentence**:
> There are benefits to GM. Idealistic crops that are more nutritional and are supposedly all round positives. They have been thoroughly tested, with strict regulations and theoretically should work.
> **Con sentence**:
> There are unknown health risks, both short and long term. There are also various environmental concerns and ethical issues in regard to "crossing" plants and animals.
> **Question sentence**:
> What does the Bible have to say? Which is worse for the environment? (Bk-Am-p17)

Amanda's group responses were as follows:

> There are various positives and negatives surrounding the genetic modification debate. However, it comes down to four major questions.
> 1. Which is worse for the environment?
> 2. Possible health effects?
> 3. How could it be reversed once introduced and turns bad?
> 4. What does the Bible have to say in relation to such issues?
> 5. GM produce is not ready to be introduced. (Bk-Am-p18)

The group response was consistent with Amanda's personal views, suggesting that the group was in agreement and probably was following Amanda's lead. The question of whether or not the genetic modification could be reversed was a new idea, not mentioned by Amanda, but potentially brought up by another group member. This suggests that Amanda was willing to listen to her group members and value their thoughts and ideas.

The group conclusion that "GM produce is not ready to be introduced" indicated that the group had decided that, on balance, they should not use genetically modified crops in their food. However, there was some evidence that, even at this late stage, Amanda remained undecided.

She said in her blog entry, which was made after we had finished the story, that she still had not made up her mind and was not entirely certain of which side to take for the assignment. She said that she could see the strong points of both sides, but thought she would rather take the side of the negative. She explained this decision by saying that GMO produce did not "quite align" with some of her ethics, especially crossing animals and plants. She then stated in her blog the main issues for her, and that she will undertake further research on the topic. Even though she said she would make a negative decision, she stated that once she had examined the issues "substantially," she would make her final decision. In Year 11, approximately a year after the genetics class in Year 10, Amanda commented that she struggled with the idea of crossing plants and animals as it did not sit right with her personal values, but she was indeed looking to science to control and manage the risks and uncertainty of GMO foods.

During the time given in class for students to finalise their assignment, I asked the students to answer the following question on Padlet, "Would you eat the genetically modified tomato? Why or why not? Amanda wrote on the Padlet wall, "no, I wouldn't eat the GM tomato because scientists don't understand the full effects of GM yet. There are unknown long-term effects; on the body, environment, and even the economy. I also believe that crossing animal genes and plant genes is not ethical and is against God's word" (Pd-Am).

At this point in time, I was convinced that Amanda had finally made up her mind and looked forward to reading her assignment. However, another twist developed. Amanda wrote a brilliant assignment in which she considered and explained many issues, both the advantages and disadvantages. Her recommendation (or decision) was a surprise. When I first read it, my initial thoughts were, "Wow, she has found a way not to make a decision!" Maybe I was too quick to generate that conclusion, but that was my initial response or 'gut feeling'. I checked with Amanda approximately a year later and she was quite quick to respond with, "Yes! I seemed a little embarrassed." It appeared that the cognitive dissonance experienced by Amanda would not finalise her decision, but instead the conflicting views of the advantages and disadvantages and her personal values were reconciled into a recommendation that she was comfortable with. Her recommendation was as follows:

> The debate surrounding the benefits, risks and ethical concerns has always been highly polarized. This report's recommendation is motivated by a philosophical concept sometimes known as a '*precautionary principle*'. Many European governments and agencies have argued that the precautionary

> principle should be invoked in the case of GM foods…….
> Australia should adopt the precautionary principle to justify a stringent and restrictive regulatory action. For genetically modified products already in use, policy should respect freedom of choice (for both farmer and consumer) and maintain very strict labeling and traceability standards. (As-Am-p13)

I had not heard of the concept of the Precautionary Principle prior to reading Amanda's assignment. After some research, I found that it is a principle that is used by governments in areas of development where the risks are uncertain, such as GMO, climate change and nanotechnology (COMEST, 2005). The World Commission gives a working definition of the Precautionary Principle, which states in part, "when human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm" (COMEST, 2005, p. 14).

Dilemma Thinking

There was evidence that the ethical dilemma story Torn at the Genes, allowed Amanda to experience the highs and lows of dilemma thinking. She indicated several times that she was uncertain of her decision, pointing out that while her personal values seemed to push her to disagree with the use of GMO foods, she seemed to be waiting for the science to demonstrate otherwise, that GMO foods are safe. This uncertainty led her to reflect critically on her values, questioning them. She seemed to struggle with science and her Christian values, as can be seen in the following excerpts from her reflective journal: "I believe that crossing animal genes and plant genes is not ethical and is against God's word" (Bg-Am-Wk 6); and earlier in the journal, "what does the Bible say in regards to issues like this?" (Bg-Am-Wk 5).

Amanda often said that GMO foods are in opposition to her Christian values, but she did not actually state with certainty what those Christian values were and why they were opposed to GMO foods. She said in her personal reflective blog that "crossing animal and plant genes is not ethical and is against God's word." She did question herself, wondering what the Bible does say in regard to GMO foods but recognised that the Bible would not specifically mention genetic modification. Amanda commented in her interview that she did not know why she had a problem with GMO but just knew that she did, "that it just does not sound right, it is not how God created it to be" (In-Am). She went on to say that it was based on "evolution" and that her moral compass was based on Christianity. Her language, however, indicated a great deal of uncertainty; she finishes with "I don't know...".

Amanda's critical reflective thinking regarding her values appeared to be ongoing and without resolution. She did not mention her personal values in her assignment; rather, she discussed various ethical issues that were found in mainstream society. Her conclusion, likewise, did not seem to use her personal values, which were replaced by the precautionary principle. Perhaps she felt comfortable with this as it aligned with her values but also provided an avenue for her to support the science side of the issue. I wonder why she did not discuss her Christian values in her assignment. Maybe she thought that the religious position was not appropriate to include in a science report.

Another aspect of the nature of dilemma thinking that is closely linked with reflective thinking and values clarification is dialectical thinking. Simply stated, dialectical thinking involves thinking with more than one perspective, considering and testing the strengths and weaknesses of opposing points of view (The Critical Thinking Community, 2014). Amanda had certainly considered and explored both points of view regarding GMO foods. The PCQ provided a tool to help her achieve this in the booklet, where she had expressed the positives and negatives about various positions. She wrote in her assignment about the advantages and disadvantages of GMO foods, and explained major points for each position. I wondered, however, if she was thinking truly dialectically, and whether she had positioned herself to reflect upon the issue from both sides. It appeared that most of her reflections occurred in her personal position. She did not provide arguments for the ethical concerns she raised in her assignment. Maybe this was too much to expect a Year 10 student to write about in a word limited assignment? She tested the strengths and weaknesses of opposing opinions, generating a conclusion that the risks of GMO outweighed the benefits in the long term. As she was debating the merits of each viewpoint, the interchange between her reflective thinking regarding her values and the dialectical struggle between her concerns based on her personal belief and the desire to support the science led to more uncertainty. This occurred throughout the dilemma story unit as more information and dilemmas were provided.

I now discuss another student, Wade, who in contrast to Amanda did not normally achieve well academically.

Wade

Wade was an energetic young man who left the College after the dilemma story was completed. He loved sport and sought to do his best in any sporting endeavour. I did not class him as an academic student at the time, but as a 'battler' in science and mathematics. He usually won places in athletics and cross country events. Without having direct evidence, I assumed that Wade did not have an active study pattern at home. He appeared to be content with completing the bare minimum to keep his teacher/s happy. He was not disrespectful, was very personable and appeared to have a positive attitude.

In his interview, he indicated that he liked science, especially experimenting with chemicals in chemistry. Wade did not have a plan for a career in science but rather intended to pursue options in the Defence Force. He commented that he enjoyed the genetics unit and the dilemma story overall. He also stated that parts of the story were confusing to him, but he enjoyed it, and felt that he had learned a lot. Wade said that he felt that the story made science more interesting.

Story: Part 1 – Warming Up

Early in the dilemma story, using the PCQ, Wade was able to identify issues of concern relating to genetic modification. After Part 1 of the story, when the genetically modified tomato was introduced, Wade identified obvious benefits in the PCQ such as less juice in the tomato that made sandwiches soggy, and that it tasted better. However, Wade also generated ideas that were not made in the story at this stage such as, "It has been tested." I do not know where he had this idea from; it may have come from previous exposure to the topic. Wade also presented some 'big picture' ideas, raising issues such as possible allergies to tomatoes and questions related to health, such as "Is the tomato bad for your heart?" and "Could one get sick from the tomato?" These thoughts were generated by Wade on his own during the 'Think' part of the activity.

Wade wrote the following for his group response,

> we think that genetically modified food is not necessary and may have unseen dangers that stem from its use. While technology has improved and there are some benefits, overall it is still risky and violates beliefs and morals. (Bk-Wd-p3)

It was interesting that another group member (Amanda) had written an extra line in her

booklet: “We would not eat the tomato.” Perhaps the reason Wade did not write this was that he was not sure about the issue at this stage or maybe he just missed that point when writing down the group response. In his interview, Wade said that he “first thought it was OK” but when he saw that there was some uncertainty, he started ‘leaning’ towards not using it. Discussion with his group may have initiated this uncertainty or even confirmed some of his fears.

Story: Part 2 – Genetically Modified Equals Better Quality?

Part 2 of the story asked students to consider whether they felt that genetically modified foods have improved quality. The students were required to fill out another PCQ template. The sentences that Wade wrote are as follows:

> **Pro sentence**:
> In a way it can be good, but also confusing, but we can change things to make them better.
> **Con sentence**:
> If we happen to get something wrong, they could be very dangerous. (Bk-Wd-p3)

Wade also recorded in the PCQ table for the Con section that the GM food could be poisonous and might possibly make other plants die. This indicated that Wade was thinking of possible harmful consequences of a science action. While the Pro sentence was somewhat general, his KWHL for this section suggested that Wade had acquired some knowledge about the topic. He listed ideas such as that tomatoes had genes taken from other organisms to “improve” the product. He noted that there was a lot of conflict and argument surrounding the matter. This suggested that Wade understood the concepts but had found it difficult to communicate these ideas in writing.

Story: Part 4 – Who in the Family do You Identify With?

Wade appeared to be struggling with making a decision. In part 4 of the story, students were asked “Who in the family do you most identify with? Why?” Wade recorded that he would “sit mostly with Brian, because I don’t really want to take a side but I would want to put my opinion out” (Bk-Wd-p7). There are two key points from that sentence: (1) he does not want to take a side and (2) he wants his opinion heard. Developing the second point in his interview, Wade commented:

> Wade: I did find it pretty good to work in a group cos you give your opinion and discuss it but also I found it, like sometimes when you're writing, someone else like puts all their points down and only some of your points and like some of the points don't go along with the ones we discussed.
>
> I: So some of your opinions that you voiced were not being recorded?
>
> Wade: ...some were but they would take it into consideration, but then they would just leave it there and they would come up with something else.
>
> *Interviewer*: How did that make you feel?
>
> *Wade*: I guess I was OK with it because the points they did, they were pretty good but like the ones I gave could have actually helped us a bit more. (In-Wd-Ln124)

It appeared that Wade was frustrated that some of his points of view were not fully appreciated by his group members. He acknowledged that the opinions or points of view from his group members were good, but he felt that his points would also have contributed to the group. This may have been because he had knowledge of the topic but seemed to have difficulty communicating it; and he had pre-conceived perceptions of each group member. Possibly, the other group members, knowing that Wade did not achieve at a high level academically in science (usually he received only passes), did not value his thoughts. Along with this, one of the group members, Amanda, was a high achiever and often topped the class. The group may have naturally deferred to her wisdom when discussing and generating solutions. More careful observation by me would have been needed to verify this interpretation.

Another possibility was that Wade did not have the knowledge to provide valid or meaningful opinions. There are issues that point to such a conclusion: Amanda commented in her interview that she felt that the other group members were not pulling their weight when researching and contributing to group discussion. It is possible that Wade did not research as much as he should have during the times provided in class. Furthermore, Wade had very little recorded in his wiki. Another indicator was his responses in the interview.

> I: Ok...Just thinking about the unit of work we just did on genetics, the

> dilemma story, what did you think about it? Wade, what would be your general thoughts about the whole science unit on genetics we just did?
>
> Wade: I enjoyed it overall, some bits were a little bit confusing and I didn't get how exactly genes combined, but I thought it was fun and I did learn a lot.
>
> I: You said that you learned a lot, can you give me some examples?
>
> Wade: As much as I don't know about how they cross they actually did interchange like something with the plant interchanged with the weeds, to create a superweed and that, in the end genetically modified stuff isn't actually ...it's ..nothing really different about it from the other one except that they have another plant in it and they have a different growth way. (In-Wd-Ln49)

While Wade was required to answer this on the spot, which is something most people would find difficult to do, it demonstrated that his knowledge base was fractured. He had mentioned various keywords or terms and tried to link them together to generate a suitable response.

Wade's comments led me to reflect on what I could have done differently to support and help him to achieve his best results while also feeling valued. There were several key issues that I needed to explore. Firstly, Wade's conceptual knowledge. Most of the time I set tasks that required students to acquire their knowledge through guided research. I tried to structure their research providing suitable sources — websites and interactive learning objects — rather than asking students to start from a 'blank slate' and start Googling. This method may not have suited Wade's learning style, or perhaps I should have monitored him more closely, providing support, asking questions and providing more feedback. As Wade appeared to be a kinaesthetic learner, he may have developed some knowledge from the online learning objects and practicals conducted in class; however, I do not have observations to support this.

Reflections on Managing Group Work

The second key issue that this discussion had generated for me was how to manage group work. There was a common problem — perceived by students, teachers, and parents, perhaps real — that some students in group work do not put in a full effort and rely on the smart and/or conscientious students in the group to complete the task. The challenge for teachers, in my view, is to ensure through suitable practices that students are contributing equally in group work. This does not mean that they need to provide the same level of work, but work that

students like Wade believe that they can achieve without being embarrassed. On the one hand, the students who have a good understanding can help the students who are battling with the material. However, some of these students may not have the skills and/or patience to explain or would prefer, as in the case of Amanda, to get on with their own work in order to get the task completed at the high level they want.

This raised questions for me about what constitutes the role of the teacher. Also I questioned what I saw as my role as a facilitator of learning. I suppose since higher achieving students usually manage their learning to a better extent than other students, more of the teacher's time could be spent supporting the battlers. The tension here is between supporting students who might struggle while maintaining the challenge and engagement of the task for all students. I discuss group work and collaborative learning further in Chapter 6.

This is where the dilemma story had strength as a pedagogical tool. This particular dilemma story was open enough for the higher achievers to really achieve, but still created enough interest and 'do-ability' for the battlers to maintain their engagement and interest. There is evidence of this in some of Wade's comments in the interview. As mentioned earlier in this section, Wade said that he enjoyed the unit and thought it was fun, and he felt that he learned a lot. Wade also said that he thought that the story made the unit more interesting and he could relate to it. He commented that the family discussion in the story was similar to discussions that he has with his family. These comments by Wade lend support to the value of ethical dilemma story pedagogy.

I now discuss the contribution of another student, Harry, who did not appear to find the dilemma story as engaging as I would have hoped.

Harry

Harry was a confident and bright student who had a genuine desire to succeed. He was a student who also participated at a high level on the sporting field, but in a different sport to Wade, competing locally and state-wide with sports people of his own age and also competing against adults. He had a clear goal and that was to compete in the Commonwealth Games, which are to be held on the Gold Coast in 2018. I believe that his desire to achieve was not limited to sporting endeavours, but also infused his academic and personal life. Harry embraced technology, especially in the IT field, and could be approached for technical advice on devices such as smartphones, strategies for games and creative software solutions.

Harry had an interest in science and enjoyed learning about the universe and how it was created. He had career aspirations to work in the area of physics. In class, Harry was an attentive student overall, but could occasionally appear to be distracted by conversations with friends who sat with him. However, I realised that a significant percentage of those conversations were about the topic that the class was discussing, and that the boys were discussing questions they had, or they were considering the issue in more depth, which suggested that he was not distracted but on task with the topic.

In the interview Harry said that he thought the genetics unit of work — the dilemma story — was a good unit.

> I thought it was good unit. I learned a little bit about how they use the punnet square to work, predict what genes and that were going to be in…a baby or a plant or something. (In-Ha-Ln61)

He appeared to see the value of the topic, listing concepts he had learned, such using the Punnett square, and being able to predict the genotype of various organisms. Interestingly, he did not mention, at this stage, the dilemma story itself or GM food and crops. However, when prompted as to whether he thought his personal values were challenged in the unit, he responded that they had been. He thought it was "confronting" to discuss genetic modification and its implications, and he felt that some people could be upset about the idea. He explained further that some people preferred not to modify the genes, whilst others could see the benefits, saying that GMO crops were the "way of the future."

> …people think that it's just better to have it unaltered so it might be more, I suppose, pure, where some people see genes as the way of the future. (In-Ha-Ln80)

Story: Part 1 – Warming Up

The GMO tomato was introduced into the story without any indication of its possible problems, yet Harry identified two key points when he considered the potential negative aspects of the GMO tomato. These were: "it is not natural," and the tomato "could contain chemicals." He also questioned where the tomato came from and what genes were altered. The PCQ Thinking Tools template encouraged Harry to think 'outside the box' right from the beginning of the story. This indicated that Harry initially started to consider the positives and negatives and had questions regarding the tomato. If the PCQ template had not been used, it is more likely that the answer to the question posed would have been more simplistic, perhaps

just a ‘yes’ or ‘no’ with a simple explanation. The PCQ encouraged Harry to expand his thinking somewhat.

The ethical dilemma story pedagogy involves the telling of the story with questions, with appropriate breaks. Students carried out a Think Pair Share based on the questions. The story then moved on, providing more information about the issue. I created a booklet in which students could work on their Think Pair Share. The Thinking part of the process was a time in the class when no-one was speaking, providing students with individual time to reflect and record their thoughts. They were given the PCQ as a prompt to assist their thinking and were allocated only a minute or two for this stage. The short time for reflection gave the students a sense of urgency so that they would start the task promptly. It also gave the students the positive impression that they did not have to do the thinking for a long time. I have found that students can be more productive if they have a time limit. The Pair stage required the students to discuss their PCQ results with a partner, which was the person that they happened to be sitting with. The students noted in their booklets any new or different ideas from their partner. The Share stage was when the students formed their allocated groups and discussed their PCQs. As part of my adaptation of ethical dilemma story pedagogy, the students were asked to synthesise a group response and to record it in their booklets. Ideally, the group response should have been the same in each group member’s booklet, as this was the agreed response. This occurred on most occasions, though sometimes students would write an extra note of their own. The final part of this stage was for one member of each group to read out the group’s response. This meant that everyone in the class heard the other groups’ thoughts and ideas.

Harry and the other two members of his group recorded a similar response for the question in Part 1 of the story. This was expected, and if students did not record the same as other group members this would have provided strong evidence of group dissent. As all three members recorded the same response it appeared that at this stage, each member of the group was comfortable with the group's position. In summary, the group felt that there were positives and negatives to genetically modifying food. It was interesting to note that each student also recorded an extra sentence which said that the group members did not fully agree. The question that they were answering was, “Would you eat the tomato?” The group was not in agreement regarding whether or not they would eat the tomato, but were able to come to an understanding and generate a statement that was non-committal.

There was evidence of empathy and negotiation within the group. One of the group members (Makayla) recorded in her booklet that she would not personally eat the tomato, but the other two members of the group (one of which was Harry) disagreed with her, saying that they

would eat the tomato. I recall that this group was animated in their discussion, and I recorded in my observations of that lesson that Harry was "quite loud and opinionated." I do not recall whether I spoke with Harry about his behaviour, but I reminded the group, and all other groups, that they would need to aim to reach consensus within the group. As a group, even though there was disagreement, and with one student, Harry, being assertive with his ideas, they were able to write a statement that satisfied each member even though they did not answer the question.

At this point of the dilemma story, it appeared that Harry had taken a supportive position regarding GMO foods, although when I questioned him approximately a year later during a casual chat while I was on playground duty, he said that he thought he was a "bit undecided" regarding whether or not he would eat the tomato from the beginning. With this in mind, Harry was able to generate positive and negative points relating to the use of the tomato. It did not appear that he had been so strong in his position that it affected his thinking process. The PCQ perhaps encouraged a balanced reflection and evaluation of the topic. Harry was able to generate the same number of points for both the Pro and the Con section of the PCQ, although some of his points were points that Sonia (a character in the story) made. Harry recorded the following in the Question Section of the PCQ which indicated that he may have had some doubts.

> Where was the tomato made? What chemicals were used and what genes were altered? (Bk-Ha-p2)

He was wondering whether the tomato was safe and also wanted to know how the tomato had been modified. This led into the next activity I had planned: researching the techniques of genetic modification.

Story: Part 3 – Do Teenagers Want What is New and Trendy?

The next question the group worked on, "Do you feel that all teenagers always want what's new and trendy?", provoked some more differences in opinion between group members. Harry responded by saying, "Yes, because they feel like they have to keep up with the new trends because they don't want to be left out by the rest. They will also feel popular and included" (Bk-Ha-p6). Makayla and Gabby both stated that whilst not all teenagers would want to have what is new and trendy, they thought the majority would. Harry's response suggests that he thought that it would be all teenagers (he did not qualify with words like "majority", "most" or even "some"). There was evidence to suggest that group negotiation occurred. Harry

recorded for his group a similar response to the two girls; even though his response was worded slightly differently, the intent appeared to be the same.

Story: Part 4 – Who in The Family do You Identify With?

At this stage of the story, evidence suggested that Harry supported the use of the genetically modified tomato. However, the first 'chinks in his armour' of confidence appeared in Part 4 of the story, when the students were asked the following question, "Who in the family do you most identify with? Why?" Harry responded, "I am Brian, because I support both sides of the argument and I know lots of info about the subject" (Bk-Ha-p7).

In the story, Brian, a university student, was Sonia's son and Amy and Karen's brother. In the story Brian did not have an opinion either way, but enjoyed arguing both sides, questioning everything to show his superior intellect. Maybe this description suited Harry more than he realised. The self-confidence evident in his statement indicated that he believed he knew a lot about the topic. Harry was feeling comfortable with the topic and working within his ability and comfort zone. I was wondering if it was a misplaced confidence. Possibly so, since we had not yet discussed methods of genetic modification or the environmental concerns.

Unfortunately, Harry did not provide more information to clarify his statement that he supported both sides. A year later he stated that he had been "sitting on the fence" until he made up his mind. The dialectical struggle was evident. He recorded in his blog a week or two after we investigated the Part 4 question, when we were close to finishing the story, "I am undecided on GM foods and still wondering about my assignment." During his interview, though, when asked about whether or not he had changed his mind, Harry said:

> I started thinking that it wouldn't be the best idea because it hasn't been tested, but then I saw some of the good qualities in it and researched a bit and leaned towards the yes, we should use and then you would research a bit more, it makes superweeds and mutant animals and that, so I sort of sat in the middle of the fence and I sort of had to pick a side and weigh up the benefits and the negatives so I would pick the benefits just because we are still developing it, so it can become better and stop the superweeds and that later. (In-Ha-Ln241)

I doubted then that Harry had indeed been as supportive of the GMO tomato as he appeared to be earlier in this analysis. It is hard to know whether his comments referred to the whole of the dilemma story, part way through, or from the point where he started to write his

assignment. I assumed that his comments referred to the whole of the story. Even if they did not, these comments added weight to his blog and the booklet, pointing to the fact that Harry had struggled to make a decision. Harry may not have thought that he had 'struggled', but a dialectical tension appeared when he said that he was supportive at first but then changed his mind because of the possible adverse effects, causing him to sit 'in the middle'. However, when he realised that he indeed had to make a decision, he developed criteria of his own to help him decide. He decided to support the side with benefits because he felt that in time research will be able to overcome the negatives.

Story: Part 6 – Do You Agree With Jim?

At this stage of the unit, Harry laboured under a common misconception that cells are injected into food. This was evidenced by comments on his KWHL chart. This mistake was soon resolved through his personal research. He discovered that genetic modification involved changing the genes rather than adding new cells.

My Reflection: Higher-Order Thinking

I was disappointed that the students did not appear to use the range of Thinking Tools that I provided (excluding the PCQ which they used extensively), and I was concerned that they may not have been using higher-order thinking. However, Harry's comments indicated to me that he did use higher-order thinking, particularly critical reflective thinking. The criteria he developed to help him make a decision were not suggested in any way by myself as his teacher, meaning that he developed or created the criteria himself. He had to apply his knowledge, analyse and evaluate the problem, looking at positives and negatives, before he created the criteria. While this process was not explicit, the dilemma story provided an opportunity for Harry to do so. This raised a question: how often do students actually use higher-order thinking? I believe that since it is not in a form that we as educators recognise, the students are not recognised for the skills that they have. I continue to outline my developing understanding of students and high-order thinking in Chapter 6

I now discuss the fourth and final student, Hayley, and some of her experiences of the ethical dilemma story unit.

Hayley

Hayley was a conscientious student who had studied the topic of genetics the year before in a previous school. She generally worked well in class and, while she did not achieve high marks in science, she was motivated to learn and undertook most class tasks with enthusiasm. Hayley indicated in her interview that she liked science, especially biology, and one of her career options was to be a nurse, so she found this unit of work on genetics interesting, particularly as she had studied genetics before. Interestingly, at a parent-teacher interview, her mother commented that Hayley had an interest in being a mechanic. Hayley stated in her interview that having studied genetics before enabled her to understand it more the second time around and helped her "go into more depth."

The assignment required students to discuss and explain genetic modification techniques and explore the advantages and disadvantages of the technology. They were then required to make a recommendation regarding whether it was appropriate to use genetic modification technologies. Hayley suggested that it was appropriate to use genetically modified crops. Her recommendation seemed to be based on the technique of 'micro-injection' and the "many positive aspects" that could help with the health of people in the world. This recommendation appeared to be in contradiction to her thoughts about the issue throughout the unit of work.

Hayley commented in her interview that initially she did not have a problem with GMO foods, that is, the GMO tomato from the story, but when she found out about the disadvantages she changed her mind. She said that she was "really set on agreeing," that is, agreeing that GMO foods were appropriate, but as she found more problems it was hard to keep this opinion.

Story: Part 1 – Warming Up

It is difficult to pinpoint precisely when Hayley changed from not having a problem with GM foods to developing an opinion against GM foods, based on perceived disadvantages. Hayley's response in her booklet for the first activity, "Would you eat the tomato?", indicated that she had identified some issues with GMO foods. Her PCQ had more entries in the Cons section than in the Pros. She wrote in the Cons section, "you don't know what effect it can have on your body. It is an unfamiliar food. The food can't be trusted because it was cross genetics" (Bk-Hy-p2).

The group response recorded in her booklet reads:

> It is good that technology is expanding its knowledge and creating new things, but it isn't allowing people to see what it is doing. Mixing genetics with a tomato can have negative side effects to the body and it [the story] hasn't mentioned what the tomato's genes have been mixed with, therefore making it untrustworthy. (Bk-Hy-p3)

I assumed because her response was similar to those of her group members, that Hayley agreed with the statement that the GMO tomato was "untrustworthy." One of her partners did not have anything recorded for this, so it could be concluded that Hayley fully supported the position taken by her group since she did not write anything that was different to her group. Furthermore, her other partner (whose booklet I do not as she did not submit it) was a quiet, almost meek, student who appeared comfortable agreeing with other students and not arguing her point. Hayley had quickly indicated a distrust of the GMO tomato. Maybe, when Hayley initially heard Part 1 of the story, she might have felt then that there was nothing wrong with the tomato, but after discussion with her partner and then her group, distrust seems to have grown. Her PCQ, which had been completed independently as part of the Think time, had entries indicating concerns with GMO tomato. She recorded:

> **Pro sentence:**
> The positive aspects of the tomato is that because of the cross genetics, the tomato does spoil or soften
> **Con sentence:**
> The negative aspect is you are not familiar with the food, you can't be sure that is could have an effect on your body
> **Question sentence:**
> I wonder what the tomato got genetically crossed with which would cause it not to spoil or soften
> (Bk-Hy-p2)

Story: Part 2 – Genetically Modified Equals Better Quality?

Part 2 of the story asked the students whether they thought that genetically modified equals better quality. In a similar manner to Part 1, Hayley raised some compelling potential aspects of GMO foods via the PCQ, pointing out that the taste could be better or the tomato would not spoil so quickly. However, she raised some concerns: "You won't get anything natural. It doesn't always have to be better quality, the mixed genetics could make it look better but be bad for your health. It's expensive" (Bk-Hy-p3).

These statements identified criteria or values that she felt were crucial. It appeared that the issue of a "natural" product was a concern for her. She raised this concern three more times throughout her booklet. For example, she recorded:

> It will stop foods being natural. (Bk-Hy-p3)
> We wouldn't eat the tomato because it is unnatural and is full of chemicals which could be harmful to certain people. (Bk-Hy-p4)

This idea of not changing the "order of things" was common; it was brought up several times by other students, such as Amanda, as discussed previously. Hayley was asked about her values in the interview:

> I: Did you find throughout the whole unit, your values, your own values and morals challenged? In what way?
>
> Hayley: I never really had anything. I have heard of genetically modified food and I have never really had anything against it, but then I learnt what they do and what could happen and so that's kind of changed what I thought of genetically modified food.
>
> I: What would be the values that caused that change, your own personal values that caused that change in thinking?
>
> Hayley: It is a hard question...trying to think...I don't know. (In-Hy-Ln70)

This interview excerpt highlights two points. Firstly, even though there was evidence that Hayley had a set of values that helped her make decisions, she could not readily identify them as values. One plausible reason for this was that Hayley could not say what she valued because she did not consciously know. This may because she had relied on her parents' or the college's values, and did not have an opportunity to have her own values clarified. Ethical dilemma stories provide a starting point for values clarification. In hindsight, I believe I could have spent more time discussing with the class the idea of personal values (values clarification), ethics and morals. Unfortunately, time was not available (or not made available), and I relied on students themselves looking at handouts and websites that I had provided.

The second point is that Hayley was using personal values in her decision making. She mentioned the idea that GMO foods could have possible problems, and she was concerned

about “what they do and what could happen.” Her booklet and blog indicated Hayley valued “natural” products and not tampering with nature and human health. This demonstrated that some students, especially Hayley, even though they may not be able to articulate it, have personal values they use to make decisions. If the unit had been a ‘typical’ science unit, the chance of students using or even identifying their personal values would have been minimal. The dilemma story provided an opportunity for students to develop a critical perspective based on their personal values.

Hayley made clear her decision to accept or reject the GMO tomatoes and therefore GMO foods in her group response to the Part 2 question. She stated that the group would not eat the tomato. Hayley appeared to weigh the benefits and barriers of the product, stating in her response that while the quality may be better, concerns about the expense and possible health issues create more barriers to accepting the technology.

Story: Part 4 – Who in the Family do You Identify With?

Part 4 of the story asked the students which family member in the story they identified with. Hayley had responded that she identified with Ross, who was the father in the story. Ross was not sure where he stood on the issue. He wanted to support his brother, but at the same time did not want to create more disagreements within the family. Hayley wrote in her response:

> I identify with Ross because I am unsure about the matter. Crossing DNA with other things could be a bad thing but it could be good. But I also don’t really care about modifying genes, as long as it doesn’t kill anything or anyone. (Bk-Hy-p7)

Hayley stated in her interview that while she wanted to support GMO foods, the barriers were preventing her. So even at the interview stage, which was a couple of weeks after the assignment was submitted, Hayley appeared to still be in conflict. This provides further evidence that the dilemma story may have provided a platform for dilemma thinking and challenging students. The question, then, was how did Hayley resolve this issue for herself? Hayley responded in her interview that she did not use any of the thinking tools. I wondered if she employed any higher-order thinking skills to help her or did she just make a decision to get the assignment finished? I found out in the interview that she had created a list of genetics technologies and undertook a process of elimination to reach a decision, demonstrating higher-order thinking.

Story: Part 8 – What Would You Decide?

In Part 8, when the students were asked the question, "Would you allow the use of genetically modified crops in our food?", Hayley responded:

> We believe that GM foods should not be used in our crops because it can cause a negative effect on our environment, disrupting the natural progress of the environment. It also affects the body in a negative way because research shows that people who eat GM foods die of cancer more than people who eat organic. Even though the substance has been tested multiple times, it still does not prove it is 100% safe to eat. (Bk-Hy-p18)

While there were some 'holes' in her point of view from a scientific perspective, it was evident that the barriers outweighed the benefits in Hayley's mind. This appeared consistent generally with her approach throughout the dilemma story unit. However, in her assignment she 'performed a backflip', indicating in her conclusion that she had changed her opinion:

> After thoroughly researching for information about the chosen technology, I have become aware of the positive and negative aspects of Microinjection, the well-known Genetic Technique, which is used to cross genetic animals' and plants/crops' DNA. I think that Microinjection is a very useful and well invented injection procedure. There are so many positive aspects of this scientific method, which could change the world's health. I have changed my opinion on the use of genetically modified crops. (As-Hy-p6-7)

A change of mind seems to have taken place. Hayley appeared to have found a benefit that outweighed the barriers, that of improving world health. This seemed to contradict the rest of her assignment which discussed mainly the disadvantages (or barriers). Her introduction only mentioned disadvantages and was written with a negative bias against GMO crops. For example, she wrote, "They are becoming reliant and in a way obsessed with the use of technology... They are messing with natural food substances… scientists do not know …. could cause an allergic reaction" (As-Hy-p3).

Hayley described a GMO modification technique, microinjection, in her assignment. I had asked students to explain the process of only one or two techniques so that they had ample opportunity to evaluate the decision. After the description of the technique she reported that

microinjections were used all around the world, they were reliable and a straightforward procedure. She then listed the advantages and disadvantages in a table followed by a paragraph outlining the disadvantages of microinjection in which she raised ethical issues, values, and concern for the environment. Furthermore, she discussed the issues of going against nature and religious issues. Her last sentence said that "they create" an increase in minerals, vitamins and so on, which is beneficial for the body. I assumed "they" referred to the GMO techniques.

COMPARISON OF AMANDA, WADE, HARRY AND HAYLEY

So far I have written about individual students and their unique stories as part of the ethical dilemma story unit. While each student had their own experiences of the unit, I also asked the question, "Were there any commonalities or variations between the students' journey through the unit?" I endeavoured to cater for individual needs, yet reality often dictated that the concerns of the class as a whole influenced the planning and implementation of the units. I was hoping that undertaking a cross-case analysis could help generate further knowledge and understanding of the individual cases (Schreiber & Valle, 2013) through a comparison of similarities and differences between the students' experiences. In this analysis, I consider the emergent themes of group work, values and impact on society, and the story pedagogy.

Collaborative Learning

A key part of this research was to encourage and develop collaborative learning, focusing on empathy, negotiation and collaborative decision making. There was evidence that collaborative learning had occurred consistently. All four students – Amanda, Wade, Harry and Hayley — commented in their interviews that they had enjoyed the opportunity to discuss issues and opinions shared by other members of their group. Generally, students felt that this was a positive aspect of the group work. Hayley stated, "[I] liked the group work because you could work with people and share what you thought" (In-Hy-Ln115). As students debated and discussed the issues in this social context, they appeared to gain insights and develop ideas that added to their understanding of the genetics topic and related issues. To me, these interactions were examples of social constructivism in action, where the students, through their interaction with each other, exchanged ideas, thus adding to their knowledge and understandings of the concepts (Schreiber & Valle, 2013) and dilemmas inherent within the problem, that is, whether to trust the scientific community and engage with the genetically modified food movement.

The four students indicated that there was little disagreement within their groups. Hayley even

commented that due to the lack of difference, she thought it would have been a good idea to change groups so that they could work with different people. While there was little disagreement within groups, there was evidence that negotiation must have been an integral part of the group's discussion and decision making, since it appeared that while individual students may have had different ideas, as group members they discussed each other's ideas and respected the voice of other group members. The idea of 'majority rules', where students compromised their opinions, seemed to have been a key part of discussions and decision making within the groups. All students mentioned that each point was discussed; however, when the time came to record a group response, variations of the original discussion were recorded in their booklets.

Harry reported that their group openly discussed the points and then identified which 'side' the group members were on. As a group they then decided which side was the best. Sometimes there were group members representing the opposite side of that decision, with one group member sitting in the 'middle', not sure which side they should support. Harry mentioned that group members would then attempt to understand the ideas of the other group members (a form of negotiation), and then perhaps change their views on the point in question. Hayley, in a similar manner, commented that group members would speak about their opinions, but if there was a disagreement more discussion would occur and the group members would try to "empathise with what they were thinking" (In-Hy-Ln142). Her group then attempted to generate a response that satisfied all of the group members, compromising individuals' points of view for the greater good of the group.

Wade, on the other hand, had a slightly different experience. Whilst discussion and negotiation occurred in his group, there seemed to have been a lack of empathy for Wade's ideas from other group members. In his interview, Wade mentioned several times that he thought that the other group members did not take him seriously. He stated that while he felt that his ideas were taken on board by the group, when the time came to record the group response his ideas were often ignored. He recognised that ideas made by the other group members were good, although he thought that his points could have "actually helped us [the group] a bit more" (In-Wd-ln135). Amanda (a member of Wade's group) noted that her group members were not pulling their weight and did not have the background knowledge to make valid decisions. Perhaps this confirmed the perceived lack of respect for Wade's ideas?

This tension between students' abilities to achieve in science (for example, Amanda being a high achiever and Wade a student who battled to pass) was an intriguing part of the group dynamic that would have been interesting to investigate further. There were a number of

factors to consider, and the question of how to maximise the learning potential for both students was a difficult one to address. I felt that I could have encouraged Amanda to mentor and support Wade while helping her to still maintain the goals and standards that she had set for herself. Perhaps I could have supported Wade more in his learning by managing his desire for knowledge whilst acknowledging his difficulty in acquiring it, and his apparent fear of appearing 'dumb' to his peers. Is there truly a benefit in the more able students peer mentoring other students, or does this provide a barrier of some sort to their own learning and potential? Is it fair to always expect the high achievers to scale down and support the battlers? This is an ethical dilemma in itself and a tension that I continue to struggle with, especially in my mathematics classes where there is a wide range of abilities.

Perhaps the tension between Amanda (the more gifted student) and Wade was due to Amanda's preference for working alone. French, Walker, and Shore (2011) state that studies have shown that there can be a preference for gifted students to work alone, which can increase with age, or can be affected by the context in which the learning occurs. This can include the composition of the group and the student's own academic confidence. Vygotsky's social constructivist theory suggests that students who do not feel comfortable with their social situation may prefer to work alone (French et al., 2011). Amanda seemed not to feel comfortable with her group, and felt that they would not "pull their weight" with assigned tasks. Feeling academically confident, she may not have felt that she needed the other group members to succeed.

It appears that at various stages during the unit, Wade was within a zone of proximal development; that is, Amanda was a more capable peer and Wade was a learner, and they were working together on activities that Wade might not have completed successfully were it not for Amanda's help (Wass, Harland, & Mercer, 2011). Moreover, Amanda's preference for individual work and her frustration with her group may have hindered Wade's ability to progress with the task and move to a stage where he could complete it independently.

My Reflection: "I Could Have…."

I found that in my teaching career there have been numerous times when I thought "I wish I would have…" or "I should have…" This is another one of those occasions. Wing-yi Cheng, Lam, and Chung-yan Chan (2008), Gillies and Boyle (2010), and numerous other studies, have found that collaboration in group work is more successful if groups are prepared. This is a technique that I did not focus on when I organised the groups. I assumed that, as fifteen-year-olds, the students would be able to manage themselves in a group. I discussed with them

how each member's contribution should be counted as valuable, but I did not teach or demonstrate group work skills. I could have discussed with the class the possible formal roles in a group; for example, a timekeeper, encourager, recorder, leader, and spokesperson. Perhaps with more careful planning and instruction in collaboration/group work skills, Wade and Amanda may have had a more productive learning experience.

Values and Impact on Society

One aspect of science that has not received significant attention in science education, in my experience, is the values that individuals hold and how they can affect decision making. Students and teachers often think that science is only about knowledge and facts, explaining how the universe works, and rarely recognise that science is very much values-based. Introducing a moral dilemma as part of a story encouraged students to consider their values, whether they recognised that or not. My four students certainly appeared to have had their values system affected by their decisions, and vice-versa. However, self-understanding varied between the students.

Right from the start, Amanda expressed her values system, which was based on her Christian heritage and beliefs. She commented in her interview, "I just know that… it wasn't right, but then I was thinking and it's all based on evolution, and [my] moral compass is based on Christianity and that is kind of… it was just fundamental… yeah, I don't know" (In-Am-Ln44).

Amanda thought that the idea of genetic technology was in conflict with her Christian values, and while she seemed to have a good understanding of her values, she had difficulty explaining why there was an issue for her. I wondered if she was thinking of other genetic technologies, such as cloning, genetic gender selection or genetic techniques to choose specific traits, rather than genetic modification in food. This misunderstanding appears to be common in society, as most genetic technologies are bundled together under one umbrella. This lack of understanding drives popular opinion and hence public decision making. The challenge for teachers such as myself is to enable students to be critical thinkers and consider technologies individually on their own merits or the lack thereof.

Amanda seemed to understand that the lack of knowledge about the genetic modification process could be affecting her viewpoint. She stated in her interview that she did not know what specific genes and processes were used for, and was concerned about crossbreeding between plants, animals and bacteria. To her, it did not sound right, since she thought it was

not how God created life to be. As discussed earlier, Amanda seemed to want technologies to be appropriate, but her personal values meant that she struggled to make decisions. Similarly, she expressed a strong sense of social justice in her assignment, referring to the dangers of possible monopolisation of products by companies.

Wade did not have much to say about his values, but he also referred to the idea that we should not change God's creation, especially when choosing the gender of babies. He was also concerned about life, worried about possible mistakes that scientists could make as they explore genetic technologies which may destroy life in general. Wade placed genetic technologies generally under the same broad umbrella.

Hayley, on the other hand, could not state what her personal values were, only that they were present. She appeared to be more concerned with the impact of adverse side effects on society. Once she had identified some of the disadvantages, she seemed to change her viewpoint regarding genetically modified food. She apparently had a sense of social justice and disliked the idea of "using people" to test genetic modification technology.

Harry had a personal value system based on Christian heritage and beliefs, similar to Amanda. At first, he commented that he enjoyed studying science, because he could "find out about the universe and what God created it to be" (In-Ha-Ln10). Harry confirmed that his morals and values had been challenged by the dilemma story. He answered with an emphatic "yes" when asked that question. He felt confronted by having to talk about genetic technologies, and he realised that these issues could upset people. Perhaps he gained this insight from his group work, or perhaps because he understood this from life experience. He knew about the viewpoint shared by Amanda and Wade (and many other people) that it was better to leave things unaltered, rather than using genetic technology – a conservative but common point of view. However, he also realised that progress was occurring and that many people view genetic technologies as the way of the future.

In his assignment, Harry stated that genetic modification was a more refined and exact process of selective breeding; this was a point that other students with similar Christian heritage did not seem to understand. He then made a judgment call, pointing out that while there were ethical problems with genetic modification technologies, the benefits and the possibilities of preventing diseases might outweigh the ethical issues. He concluded that the advantages of higher yields and drought resistance in crops might outweigh the negatives of GMO foods.

My Reflection: Christian Fundamentalism and Social Responsibility

I wondered if this viewpoint aligned with Harry's Christian heritage in that, overall, people might be better off. The viewpoint that Christians have a social responsibility to look after God's creation has led the Catholic Church to suggest that GMO crops can help by "improving the lives of the poor" (Allen Jr, 2009) and "become a decisive weapon in the struggle against hunger and environmental pollution" (AgBioWorld, 2011). Other Christian circles follow the concept of not mixing different kinds of animals or plants, stated in the Creation story in the Old Testament: "Do not mate two different kinds of animals. Do not plant your field with two different kinds of seed" (Leviticus 19:19); so interspecies breeding is discouraged (Armstrong, 2000). Some fundamental Christian groups interpret this as a prohibition of GMO, which can involve inserting a gene from one species into another species. However, another common viewpoint is that Christians have a social responsibility to look after the poor and creation, and so a balance needs to be maintained between the benefits and risks of GMO foods. It is beyond the scope of this study to explore the variety of Christian beliefs regarding GMO, or indeed of other religious opinions on this subject.

Story Pedagogy

There seemed to be a consensus among the four students that the story was helpful and made the genetics unit more attractive. Wade and Harry both commented that it gave them something to relate to. Harry stated that "it brings it back to like a family sort of level" (In-Ha-Ln103), while Wade reported that "it relates to my family a lot because we discuss things that way…." (In-Wd-Ln109). I found this encouraging, as I had hoped that the story would capture students' interest and engagement.

A common theme for the four students was that it was good to have some background knowledge before the ethical dilemma story commenced. As a class, we covered the basics of genetics for two weeks, covering concepts such as genes, chromosomes, DNA, punnet squares, dominance and recessiveness. Hayley had studied genetics previously at a different school, but said she had forgotten most of it, so the two-week block on genetics had helped her. Harry stated that having background knowledge helped him to better understand the science ideas in the story and gave him insight into the dilemmas in the story. Hayley agreed with Harry, and said that the background knowledge had helped her understand what the characters were saying. Wade concurred, commenting that if they had started the story without background knowledge, it would have been difficult to understand some of the ideas in the story.

As I planned the unit, I had debated with myself whether to start the story at the beginning of the term or instead to cover the basics of genetics before the story. In the project the year before, I had started the story at the start of the unit. Evidence from student interviews led me to try a different approach this time, which appeared to be more appealing to the students and more effective pedagogically. However, while Amanda appreciated having some background knowledge of genetics before the story, she wanted more. Her comments suggest that she would have liked to know more about the actual genetics technologies before we started the story. I think Amanda, as a high achieving student, was more concerned about finding out about the theory behind the technologies than worrying about the story itself, which she may have perceived to be less about the core elements important for the assessment of the subject. When asked if she thought the story would be a good idea for other units, she was hesitant and said that it would be, not as the primary focus but as an additional activity. Amanda appeared to be more concerned about the assessment. She was likely to view activities such as the story as a distraction rather than a valid learning experience, as it did not directly contribute to the assessable knowledge base that she perceived she needed for success in her assessment pieces.

SUMMARY

This chapter presents an exposition of the ethical dilemma learning experiences of four students - Amanda, Wade, Harry and Hayley. Generally, the students engaged well with the ethical dilemma story and were challenged to consider their personal values as they struggled with the 'horns' of the ethical dilemma concerning production and consumption of GMO food in terms of the impact on human health and the environment. Three themes emerged from the analysis: group work, values and the impact on society, and the pedagogy of the ethical dilemma story. The discussion reveals that the students thought that collaborative group work was productive, but some found group work uncomfortable or not necessarily helpful. Some students were able to articulate the basis of their value system, while others recognised that they valued certain ideals but did not know the origin of these values. The ethical dilemma story itself was received positively; students commented that it was good to have something to relate to while learning the abstract concepts of genetics. However, one high achieving student expressed that she would not want it to be the sole focus of a unit of work.

CHAPTER 6
TOWARDS ETHICAL DILEMMA THINKING

INTRODUCTION

In this chapter I reflect critically on the analyses of Chapters 4 and 5 to generate new understandings about students' engagement with the ethical dilemma story experience. I focus on key aspects of my initial research question, namely, students' experiences of ethical dilemma story pedagogy in the context of education for sustainabilty. My experiences, as the science teacher, of putting ethical dilemma story pedagogy into practice are also considered. I discuss the development of dilemma thinking, examining the barriers to achieving the outcome of engagement in ethical dilemma thinking by considering critical reflective thinking and collaborative learning. I also elaborate on my new understandings and consider the implications for me as a teacher.

My aim for the students was to provide a personally and educationally challenging process through which they needed to make a decision between competing ideas. I provided a process to help them engage with ethical dilemma thinking, which involved individual reflection and collaborative learning, both in the classroom and online. The desired outcome was that students would make evidence-based decisions with a deeper understanding of their personal values that helped focus their ethical decision making.

CRITICAL REFLECTIVE THINKING

A barrier to the students' effective engagement in ethical dilemma thinking was their varying ability to engage in critical reflective thinking. As described in Chapter 3, I provided thinking tools to help students to engage in critical reflective thinking, individually and collaboratively. These tools included the PCQ (Pros, Cons, Questions) and the KWL (Know, Want, Learnt). I have discussed in Chapters 4 and 5 the engagement of students with the PCQ in developing creative and reflective thinking. Generally, students' use of the PCQ was very good as it was given as a class task that they were required to complete. I monitored students' progress and provided prompts to help those who experienced difficulty with the task. However, when the students were given the freedom to choose to use other thinking tools, I found that they did not appear to value the tools as aids for developing a compelling argument.

Reluctance to Use Thinking Tools

Generally, across both Year 10 cohorts (2012, 2013), students did not use all the thinking tools available to them, and this lack of take-up was exacerbated by a difference in my introduction of the thinking tools to each cohort.

The first cohort (2012) experienced a detailed demonstration of the use of the thinking tools during a single class session. I taught them how to use the PCQ, which was used to answer one of the questions in the ethical dilemma story, and other tools that were designed to help students compare and evaluate ideas. I commented in my reflective journal that they gave meaningful responses and that their interest appeared higher than usual. During that class, I pointed out to the students that they would be able to use these responses in their assignment, which may have improved their engagement with the assignment task.

The second cohort (2013) experienced the PCQ on a regular basis as it was part of their student booklet (see Chapters 3 and 5) where they recorded responses to the questions posed by the ethical dilemma story. Unfortunately, this cohort did not get a satisfactory opportunity to use other thinking tools due to the end of term and assignment deadlines. I spent only a little time demonstrating the thinking tool templates to the class and suggested ways in which they could be used to help generate a reliable evidence based argument to support their decision. This brevity could explain why they chose not to use the templates.

Throughout this research, while working with each cohort and during analysis, I consistently wondered—why? First, why don't the students choose to use the thinking tools? Second, are they choosing not to use higher-order thinking or are they already thinking in this manner and do not need the templates as a tool to help them? Addressing the first question, it could be argued that the second cohort did not have enough exposure or training to feel confident in using the thinking tools, and in the case of the first cohort they had only experienced the particular thinking tools once or twice. In order to empower students to feel confident to use the tools as a matter of habit perhaps they need more consistent exposure to them and not just a brief experience.

This study has led me to believe that students would be more likely to use thinking tools if they are an ongoing part of their classroom learning activities. For example, the second cohort of students were instructed to use the PCQ in their booklet as an ongoing activity. They used this tool reasonably successfully and, as discussed in Chapter 5, developed ideas further than they normally would have. At least one student used some of the points that she and her group

produced by using a PCQ from her booklet in her assignment. This could indicate that with growing familiarity there would be more opportunities taken by students to use these templates to enhance their responses.

My second question asked: do students want to use higher-order thinking? This is a difficult question to answer, and I have only limited data. However, I have noticed over the years that most teenage students choose an easier path rather than travel the more difficult path requiring more concentrated effort. Discussion with colleagues has confirmed this. For example, I was chatting with an English teacher about students not using the thinking tools and he mentioned that he had a similar problem. The English department had taught their students how to use a thinking tool to analyse a particular type of poem. My colleague said that if students follow the template the analysis of the poem could be completed almost automatically. His frustration that students chose not to use the template was very evident.

Perhaps, though, students are using higher-order thinking anyway. In Chapter 5, I discussed Harry, who had set up his own criteria to help make his decision. Almost certainly, students who achieved higher standards in their assignment have used higher-order thinking at some stage to meet the criteria for the assignment. This has led me to realise that I could have been more concerned that students were not using the thinking tools. I could have made more careful observations regarding whether students analysed and evaluated the information they had as they were answering the questions posed by the ethical dilemma story.

Learning to Reflect

As discussed in Chapter 3, students in both cohorts had the opportunity to record personal reflections. The 2012 cohort wrote their reflections in Wikispaces and the 2013 cohort recorded reflections in the MYCOCT blog. Writing these personal reflections outside of class, for example for homework, was another situation where students had freedom of choice pertaining to completion of the task. The students were aware that I was monitoring and reading their reflections but some astute students understood that I was not going to enforce personal reflective writing, especially as an assessment task. However, a significant number of students attempted to write reflections in their personal time and appeared to need more guidance regarding what to write. Some, especially male students, tended only to list the activities carried out during the previous week rather than reflecting on their thoughts and difficulties encountered with the dilemma questions.

As a result of this study, I have gained an understanding that not all students know what to write for a reflection and can be confused about how to keep a journal/log book. This is an issue in my teaching that I can look towards developing, that is, providing more scaffolding initially for students to record their reflections.

I made a note in my reflections regarding the first cohort of students: it "seems to be a chore to get them to do their weekly reflection." This was also the case for the second cohort. Once they actually wrote their reflections, some students recorded brilliant work, but I found it a struggle to persuade students to consistently record their reflections. Perhaps I was a little hard on the students, expecting them to reflect automatically. It may not be so much that students don't want to reflect, as they generally prefer not to do an activity that requires effort, such as thinking and writing. This could be said of many classroom learning activities. For example, I have observed that most students prefer to watch an instructional video passively, rather than take notes or fill out a worksheet during the video.

It is up to me as the teacher to create an environment that is conducive for reflection—just like any class task that I may require students to undertake in order to develop their learning. In the case of the two classes that were part of this research, I did not, prior to the ethical dilemma story unit, ask students to reflect on their learning, so when they were asked to reflect on their ethical decisions perhaps they were not sure how to start or what to write. Although I provided scaffolding, they were possibly uncertain about what to do, asking themselves: What am I supposed to do? What should I write? Why do I have to do this? (Costa & Kallick, 2008). Perhaps this uncertainty underpins some of the students' simplistic responses to resolving the ethical dilemma, such as "I found the decision easy".

Costa and Kallick (2008) put forward the idea of setting the tone for reflection. They suggest that most classroom activities have their own tone, such as when listening to a presentation or undertaking a group discussion task. Reflection time has its own tone, whereby students stop what they are doing and teachers help students look "back rather than move forward" (Costa & Kallick, 2008, p. 223). Time is required for this to occur, which is always a dilemma for me, as I am often concerned about covering the 'required content'.

However, this study has helped me to realise that learning is not all about covering the content but, more so, that it is important to enable students to learn the processes of learning, one of which is the art of critical reflection, which is one of the general capabilities described in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2010d).

Student reflection does not have to occur after every lesson or learning activity, but it does require some time for solitude, quiet time that allows the students to consider their experiences (Palmer, 2012). There are numerous possibilities for encouraging and enabling student reflection. One that I attempted during the project was a weekly reflection via Wikispaces or MYCOCT (discussed in Chapter 3). The advantage of these online tools is that they enable me to easily review and comment online on the students' reflections.

This study has prompted me to consider that I need to further develop these tools, especially for completion of homework that requires reflective thinking. In any case, the students need modeling and scaffolding to help them develop the art of reflection.

Beyond the Classroom

I was encouraged by one of the students in the first cohort whose comments indicated that she had been reflecting about the GMO issue in her personal time. I recorded this reflection in my journal.

> [Heidi] has not directly said she agrees with Karen, but has pointed out concerns such as killing off bees (which we have not talked about). Interesting.... [Heidi] told me about a personal experience from the weekend when she was down at the coast....she and her mum are gluten free. But they had eaten something that had wheat in it, and they were OK. They found out it was organic wheat and [Heidi] said she wondered if they were OK because the organic wheat was not GMO....so she has been thinking about this outside the classroom...

Heidi was obviously engaged deeply with the ethical dilemma story, thinking about it while not in class and reflecting critically on issues that directly related to her. I suspect that there were more students who were not able to express themselves in the written form who were wondering about the GMO decision as they went about their daily activities. This example suggests that in my future teaching I should not rely solely on the set learning activities to deem whether or not students are engaged in ethical dilemma thinking.

COLLABORATIVE LEARNING

One of the primary focuses of this project was to foster collaboration in order to facilitate students' empathy, negotiation and collaborative decision-making. During class time, group work was used to facilitate collaborative decision making. Group work extended outside the classroom to online activities, using tools such as Wikispaces and MYCOCT to facilitate collaborative research on genetics and genetics technologies.

I posed the following questions: Did group work, when used as part of ethical dilemma story pedagogy, encourage engagement and learning by the students? Did it enhance the teaching and learning of science in my classes? The use of group work as a strategy was not new to me as a teacher. I had used it often over the years in various formats. These included practical work in the science laboratory, research tasks, problem-solving tasks activities in both science and mathematics, and preparation for assessment tasks. There are recognised benefits of group work for students, such as the collaborative development of knowledge (Frey, Fisher, & Everlove, 2009), which was a focus of this study.

Enhanced Engagement

As discussed in Chapters 4 and 5, the students generally enjoyed the group work part of the ethical dilemma learning. Comments such as "I think working in a group was actually good," "…it was good," "I really like being in a group" suggest that the group work was a positive experience for students. It could be inferred that these comments were made largely because students appreciated the social aspect of group work. However, most comments indicated that students liked group work because it helped them complete the set task and helped them learn.

Several indicators help teachers determine if individuals and groups are indeed engaged and interested in a topic or task. Marzano (2012) states that students are engaged if they are paying attention and are interested. He lists the following behaviours as evidence that students are interested:

- Lots of participation
- Enthusiasm in voices on tasks
- Sense of purpose on tasks
- Energy
- Lots of questions being asked
- Challenging classmates
- Ideas that go beyond what was asked. (Marzano, 2012, par. 7)

As the classroom teacher, I closely observed students' behaviours for the duration of the ethical dilemma story unit, and concluded that ethical dilemma story pedagogy seemed to enhance the engagement of students in my science classes. I recorded in my journal that the groups appeared to be working well, with students participating in discussion, some of which was of high energy as they defended their points of view as the groups discussed and debated the ethical dilemmas. I recall lessons in other units where students appeared not to be interested in productive group work, engaging instead in unrelated chatter. However, during the student interviews I learned that I need to observe more carefully interactions within groups.

Lacking Empathy

Two students, Heidi and Wade (see Chapters 4 and 5), one from each cohort, stated that they felt disempowered by their group. Their reasons were similar, in that both students (who 'battled' academically) either did not feel that their group listened to them or were not confident enough to share their ideas, and hence they relied on the 'perceived smart' student/s to generate their group's answers. Heidi, who had a strong desire to achieve academically, was frustrated with her group; she claimed that the other group members were not cooperative and did not value her point of view.

On the other end of the scale, Amanda (see Chapter 5), said that she was frustrated with her group and their work ethic, as she wanted to learn as much as she could about the topic to achieve a high mark. Even though Amanda and Heidi were both irritated, it could be argued that this was in part due to their desire to learn more about the topic and engage in the dilemma that was being presented.

These examples suggest lack of empathy between some group members, whereby some students did not value other group members' needs. What I have learned from this issue is that while students may appear to be working well in groups, individual students might not be having a positive learning experience. In future class activities that employ collaborative learning strategies I could spend more time observing and monitoring individual students rather than relying solely on the whole-class atmosphere to assess students' engagement in learning.

This study has led me to understand that with a pedagogy such as ethical dilemma stories there can be an increase in students' engagement and interest, which can translate into enhanced learning in science. The final year project in my undergraduate degree involved creating a

series of investigations about magnetism for middle year students. I had not, at the time, studied any education units and so did not have knowledge or experience about engaging students in learning, but I remember a quote from the project: “When students are interested, they will learn.” I have never forgotten that. I have noted that this is very much the case with my 13-year-old son. When Minecraft was the flavour of the ‘year or two’ he learned so much about the game. He gained this knowledge by voluntarily watching YouTube clips. He did this because he was interested, he wanted to know how to succeed. I believe this level of engagement can be the case in the classroom. If students are interested they will learn. This research has demonstrated that ethical dilemma stories can provide a mechanism for students to be interested in a topic that relates to their daily lives, and the collaboration that is generated by group work can increase engagement in learning as students debate ethical dilemma questions.

DIALECTICAL THINKING

As Paul (1993) articulates, when one has to decide between two equally viable but competing options, one is reasoning dialectically. The context of sustainable development provides many examples of the use of dialectical thinking. For example, deciding whether to clear the habitat of endangered species so that housing development can occur or to preserve that habitat so that an endangered species is protected. Another example is that of a local council deciding whether to cull 'messy' White Ibis in a bushland park so that public eating areas are clean and healthy or to preserve the local population of White Ibis. And, closely related to this study is the example of a cotton grower deciding whether to plant seeds that have been genetically modified to resist a certain pest and thus reduce his use of pesticides or to continue planting non-GMO seeds and which requires higher levels of expensive pesticides that could be harmful to the environment.

The ethical dilemma story used in this study, Torn at Genes, requires students to decide whether to support genetically modified crops as a food source in order to improve food quality or to choose non-GMO food and accept the variable quality of non-GMO foods. Veraksa, Belolutskaya and Vorobyeva (2013) state that dialectical thinking involves observing a phenomenon or situation where opposites are present. It involves creative and productive thinking in order to resolve the dilemma. It does not mean that a resolution cannot be found, but dialectical thinking seeks "clarity out of opposing contradictory views" (Hanna, 1996, p. 15). Hanna comments that to find understanding and resolution, consideration and deeper understanding of the opposites occurs. For Costa (2004), students need to learn how to determine the strengths and weaknesses of competing arguments.

Struggling to Resolve the Ethical Dilemma

In this study, there is evidence that students engaged in dialectical thinking as they struggled to resolve conflicting ideas. In Chapters 4 and 5, students' blog entries and journals revealed that they were thinking dialectically about the consequences of using GMO foods. As discussed in Chapter 4, Jye indicated that he had difficulty deciding whether or not to support GMO food. Initially he said that he thought that GMO food was appropriate but he changed his mind when presented with more information later in the story. Kylie stated that she struggled with the two sides of the dilemma. She was worried about the possible long-term effects of GMO food but was also keen to embrace the new technology. Amanda (see Chapter 5) was able to consider the opposites of the dilemma, pointing out the benefits of GMO food but also noting that were also negative aspects. She indicated in her reflective blog that was unsure of which way to decide. Amanda's dialectical thinking was resolved when she discovered the Precautionary Principle.

Other students not discussed in Chapters 4 or 5 also seemed to have struggled with the ethical dilemma of GMO food. Gabby (2013 cohort) recorded the following in her blog:

> After looking at the research we have today, I'm swaying towards agreeing with Genetically Modified Foods. There are many positives such as: added nutrition, frost and pest resistant plants, reduced need for pesticide and the potential to help solve world hunger. Although, I'm still not sure. There are still worries with allergies and pesticide resistant weeds. I usually would rather natural foods although I now realise that GM foods can help add more nutrition for our bodies. It's a bit weird how scientists are messing around with the genes of plants and things, it makes me think that they're going to create some sort of monster like in the movies. I think, I still need to keep researching to come to a definite conclusion over what I think. [Bg-Ga, 2013]

At this stage of the ethical dilemma story, Gabby was undecided. Dialectical thinking occurred as she weighed up the advantages and disadvantages of GMO. Her deep engagement in the ethical dilemma story was shown by the length of her reflection.

Macy (2013 cohort) struggled with reconciling conflicting points of view. She recorded the following in her blog during week 4:

> At the start of this unit I was definite that I did not agree with GM foods as I

> like the idea of healthy, natural, organic foods. However with doing further research today, I have found that there are in fact many benefits that come from GM foods. I still don't like the fact that it is created in labs and altered, however the benefits such as the food being more nutrient dense which could help the malnourishment crisis has affected my opinion. I feel very strong about helping those who suffer and perhaps this is where my opinion of GM foods has changed. I still need to research more about how the process affects the human body and if the nutritional value increases in all areas or increases in some areas but decreases in others, to have a definite opinion. [Bg-Mc, 2013]

Then in week 5, Macy recorded:

> I am still unsure if I agree with GM foods. There are both positives and negatives that are involved in GM foods. I am still very for eating healthy, natural foods that have many beneficial factors for our body. This is where GM foods worry me; being processed in a lab, altered, controlled and changed from their natural state could have some bad effects on the nutritional value and the quality. The effects it may have on the environment is also an issue that I have. The problem of super weeds could have a dramatic effect on future food production from uncontrollable weeds; however the fact that GM foods could help the food crisis in third world countries, I believe could be very beneficial. The fact that the food will also last longer is a factor to consider. As you can see I am still very unsure about the topic. I am probably more against GM foods at the moment. However, my opinion could change. [Bg-Mc, 2013]

These two blog entries demonstrate the dialectical thinking that Macy was struggling with. Her indecision continued in her week 5 entry; her critical reflection showed that she was aware of the positives and the negatives and could see both sides of the issue, which was causing her to struggle with the decision.

Personal (Faith Based) Decision Making

Regarding collaborative decision-making about resolving the ethical dilemma of GMO food, all groups generated a decision and presented a 'consensual' response. However, Chapters 4 and 5 reveal that ‘majority rules’ was sometimes the basis of these decisions. As a group students appeared to come to a shared conclusion but then changed their decision when writing individually about their decision to accept or reject GMO food. In a significant number of cases, it appears that students' personal (faith based) values over rode their group's decision.

In both Year 10 cohorts students commented on the overriding importance of 'not tampering, changing or interfering with God's creation’. These students did not seem to consider that humans have been changing 'God's creation' since humans came to be on this Earth. It was pointed out to students that we have been changing numerous aspects of God's creation, such as crops and livestock, through selective breeding methods; and the wheat plant that we source flour from is vastly different to the wheat plant of Biblical times. However, these students maintained their point of view. It seems as though some of the students’ determination not to be seen to be in conflict with their Christian heritage may have been a barrier to considering with an open mind the opposing ethical ideas raised by Torn at the Genes.

As I discussed in Chapter 5, students may have been basing their beliefs on Bible verses found in Leviticus. Chapter 19 instructs the Israelites not to mate two different kinds of animals or mix two kinds of plant in the fields (Lev 19:19). Perhaps there was some confusion or misinterpretation of the scripture as well as a misunderstanding of GMO processes. It may have been the case that the students were not knowledgeable about scripture and how it relates to issues such as GMO crops. A significant part of their beliefs or values typically would stem from their parents or other figures of authority in the church, such as pastors or youth leaders, or in the case of our College, their teachers. It would be interesting to study how the scriptural knowledge of teachers, especially science teachers at the College, relates to the many ethical issues that exist in our society.

On reflection, I realise that I had assumed that students had a sound basis for their points of view, but this assumption now seems to be in error. As required by ethical dilemma story pedagogy, they were not given any direct instruction regarding their personal values or beliefs about the use of GMO crops in our food. Instead, the Torn At the Genes story and the Think Pair Share activities were intended to engage students in thinking reflectively and critically about ethical benefits and consequences. The majority of students raised the contentious point about not changing God's creation when I questioned them in the interview about whether they

found it hard to make a decision. Kylie mentioned not changing God's creation in her response to an interview question regarding a connection between the story and her values. But there was no evidence of her (or other students) being able to explain how their values were based on their beliefs.

The study revealed another assumption that I had been harbouring: that the students had a sufficient science knowledge base to distinguish between various genetic technologies. It appeared, as exemplified by Amanda (see Chapter 5), that GMO may have been confused with other genetic technologies, such as cloning or the possibility of choosing the character traits or gender of babies. These are much more controversial issues as they directly affect human life. It is understandable that if students were conflating various genetic technologies with GMO technology they would be inclined to have a negative opinion about the latter, based on their religious beliefs.

Where does the development of students' personal beliefs and values occur? It seems, that in this Christian school, this would occur in the family home. Children tend to identify with and take on parental values, especially if they look up to and want to emulate their parents (Knafo & Schwartz, 2012). Their beliefs determine the values they hold (Havel, 2005) and are likely to be molded and remolded by various influences, such as grandparents, church, school, peers and the media. There could be other sources, but it is beyond the scope of this research to investigate them. Suffice to say that, within the two cohorts of students that I studied, some might have held a narrow or simplistic view of the stewardship of God's creation. The response by some students to not changing God's creation would be a much easier option than reflecting critically on deeply held values and beliefs, or allowing them to be challenged. I am not critical of the students who held those beliefs; a willingness to stand up for what they believe is an admirable quality, but as a science teacher in a Christian school, I would like students to have stronger (scriptural and scientific) understandings to support their views.

I did not have in-depth discussions with colleagues regarding this issue during this study. This is something that I intend to do; to ask questions about aspects of my teaching practice of which I may not be aware and that affect students' learning outcomes. There have been discussions in staff meetings about teaching with a Christian Worldview. Facilitators of those discussions have highlighted that everyone has their own worldview whether they recognise it or not (Anderson, 2014). Teachers in our college are encouraged to teach with a Christian Worldview. But this does not mean that we require students to maintain a particular belief system; rather, for them to know why we as a College believe this way, and that we challenge the students to be able to say for themselves why they believe what they believe. The College

realises that often students' beliefs are based implicitly on their parents' beliefs, but the students may not have a sound understanding of why those beliefs exist. Hence our goal is to empower students to 'know' why they believe.

SUMMARY

Chapter 6 presents a meta-analysis of Chapters 4 and 5. In this chapter, I have discussed my reflections and new understandings arising from the research conducted with two Year 10 Science classes regarding the potential of ethical dilemma story pedagogy to engage students in ethical dilemma thinking while learning science. The following is a summary of the main issues.

In this study, I found that students were reluctant to use the optional thinking tools that I had provided to help them develop sound evidence-based arguments. On the other hand, when a thinking tool was required to be used as a class activity it proved useful in enabling students to engage in critical reflective thinking. Similarly, students were reluctant to engage voluntarily in reflective writing as a homework task. In my future teaching of ethical dilemma stories, I will spend more time modelling to students how to write personal reflections, thus enabling them to appreciate that reflective writing can help clarify their position on an ethical dilemma.

Collaboration, in the form of group work, appeared to enhance students' engagement with the ethical dilemma story. Generally, students commented that they enjoyed the collaboration and believed that it helped them understand the Torn at the Genes story and the science associated with it. However, some students indicated frustration with group work due to a perceived lack of empathy by other group members. They were concerned that their suggestions were not listened to or that their group was not taking the task seriously. In my future teaching I will take more care to monitor the individual student in each group in order to improve the social dynamics of ethical decision-making.

The Torn at the Genes story provided numerous opportunities for engaging in dialectical thinking. This was evidenced by students sustaining a struggle to decide between the benefits of GMO food and disadvantages such as environmental problems and sustainability issues. Some students seemed to be bound by their Christian heritage when considering how to resolve this ethical dilemma; they readily defended the anti-GMO premise that science should not tamper with 'God's creation'. When I teach science using an ethical dilemma story in the future, I will spend more time exploring with students the origin of the values they use for

making ethical decisions. This could take place before the presentation of the ethical dilemma story or at appropriate times during the unit. If students are prematurely basing ethical decisions on their faith-based values, I will help them explore the reasons for their beliefs. In order to facilitate this, I will provide resources such as thinking tools with detailed instructions on using them, and I will endeavour to collaborate with teachers of other learning areas, such as Religious Studies.

CHAPTER 7

POST-SCRIPT: REFLECTING ON MY TEACHING AND LOOKING FORWARD

INTRODUCTION

This final chapter outlines the understandings about my teaching that I have gained throughout this ethical dilemma story research experience, reflecting on themes arising in Chapter 6. I discuss my shift from content-based delivery of lessons to an inquiry learning approach which was inspired by the implementation of ethical dilemma story pedagogy. I also share my thoughts on where I stand on genetically modified foods and student workload. I continue with a discussion about future aspirations and goals as I seek to develop and implement further ethical dilemma stories in my own Science and Mathematics classes and collaboratively with colleagues in other curriculum learning areas.

MY TEACHING OF SCIENCE WITH ETHICAL DILEMMA STORIES

One of the emergent goals of this research was to reflect on whether ethical dilemma story pedagogy encouraged me to move away from content-driven lessons and use a variety of teaching strategies to engage students in meaningful learning and developing higher-order thinking skills.

Counter-Balancing Direct Instruction

Before implementing ethical dilemma story pedagogy I had used a variety of teaching strategies; however, a strategy that I commonly used was 'direct instruction' based on PowerPoint notes followed by worksheets or questions from the textbook, with practical lessons serving either as an introduction to a concept or as consolidation. I had also used various brainstorming strategies, web-quests and small-group research, but not consistently, aiming simply to provide variety for my students. The curriculum content required to be covered and upcoming assessment had always been the driving force behind my teaching.

However, the ethical dilemma story teaching started a journey into innovative teaching with less focus on content delivery. This was evidenced by the reduction in my use of PowerPoint lectures, as noted by Kylie in her interview:

> I really liked the story because it was easier to relate instead of just getting pounded with information, kind of, of a PowerPoint and I think that there were more opportunities for us to go and do our own research kind of, if we didn't understand something. [In-Ky-Ln100]

I continued to make PowerPoint presentations, but mainly when I thought the class needed to be taught a particular concept that they were not picking up in their research or whenever they seemed to be having an obvious misunderstanding. This does not mean that I ignored the content altogether; it was always the underlying feature of the unit, which is what the students are in the class for—to learn science, and in this case genetics. The ethical dilemma story served as a platform that helped students engage in the learning of science. I was always conscious that they needed particular concepts to enable them to respond to the dilemma questions as well as to satisfy the requirements of the Australian Science Curriculum, especially the Science Understandings strand.

Inquiry learning was the fundamental teaching strategy for the first genetics unit, with the ethical dilemma story enhancing student engagement and providing focus questions for student research. Science inquiry skills are one of the strands of Science in the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2015c). Thus, using the ethical dilemma story provided an opportunity to satisfy the requirements of the Australian Curriculum. The science inquiry skills of identifying and posing questions, planning, analysing and interpreting evidence and communicating findings were integrated in the ethical dilemma story unit (ACARA, 2015c). On reflection, students would have benefited from more guidance and scaffolding during inquiry-based learning, such as helping them generate guiding questions and providing tips on reflective writing. Rather than providing all the information needed for students to respond to the questions posed by the ethical dilemma story, I used a range of strategies, including direct teaching with PowerPoint notes, YouTube videos with discussion, and interactive software from the internet, and I allowed time for student research. As discussed in Chapter 4, I found the platform of Wikispaces useful for stimulating student collaboration and reflection.

Science as Human Endeavour, the third strand of the Australian Curriculum–Science, can also be addressed by ethical dilemma story pedagogy. Aspects of this strand, such as evaluating scientific claims and recognising that advances in technology can affect people’s lives, are deeply embedded in ethical dilemma pedagogy (ACARA, 2015c). For example, in the Torn at the Genes story, students were required to evaluate varying claims that GMO food would or would not affect people’s lives.

Inquiry learning was also the fundamental strategy for the second cohort of students who were allocated only two weeks to learn the basic concepts of genetics. I resisted the temptation to directly provide the content they needed for resolving the ethical dilemma story; instead, I set them up in research teams in a similar manner to the first cohort. However, instead of using a team page for collaboration in Wikispaces, I had hoped to use the Wiki Module found in the Moodle platform. But this was not a success, as discussed in Chapter 3.

In Chapter 6, I discussed that collaboration in the form of group work appeared to enhance the engagement of students. The implementation of group work served to help me deliver less content-based diadatic lessons. There were two main aspects to group work: (i) research teams and (ii) discussion teams. The discussion teams spent time discussing the dilemma question posed by the story. They met several times, depending on the stage of the story (see Chapter 3). Research teams worked together collaboratively in class and online to seek to understand the genetics that was fundamental to the story. Rather than me standing in front of the class delivering content, students discovered the genetics theory and applied it to the situation in the story. Students were given guidance to help them discover the material that the curriculum required in the form of guided inquiry (Martin-Hansen, 2002). I could have conducted an open inquiry, however, I was concerned about the extra time it would take for students to locate appropriate resources.

I suggest that one of the reasons for students' enhanced engagment in the ethical dilemma story was their experience in group-work learning about genetics. Students were able to drive their own learning at their own pace. They did not have to be concerned about ‘keeping up’ with PowerPoint lectures and writing down all the notes before the teacher changed slides. If they were understanding the concepts students had the freedom to go ahead and not wait for the rest of the class. If they were uncertain about something they could easily and quietly ask another group member or the teacher without the embarassment of asking in front of the whole class.

As a result of using the ethical dilemma story in the two classes, I have come to an understanding that a variety of strategies should be used to teach science. Prior to this research, I had often thought that when I am instructing directly the whole class students are receiving the information they need to satisfy the Science Understanding descriptors of the Australian Curriculum for Science, and I was concerned that an inquiry learning process would not ensure that they were gaining the necessary information, even though this would satisfy some of the Science Inquiry Skills descriptors of the Australian Curriculum. However, this research has

enabled me to understand that with direct instruction students might not remember or understand the concepts. Perhaps some students do, but the majority are constructing meaning using only a small part of the knowledge presented. I believe that using one strategy most of the time disadvantages some students, as their learning styles may not be suited to that approach. It seems to me to be more beneficial for students to have a range of learning strategies that suit a variety of learning styles.

Amongst teachers, three commonly known learning styles are visual, auditory and kinaesthetic; and it is well established that students experience more effective learning when the lesson is taught using their preferred learning style (Alexander, 2011). This theory of learning styles is based on neuro-linguistic programming which is concerned with how students communicate and how this affects their learning (Pritchard, 2013). Other models of learning styles include the Myers-Briggs, Kolb and Felder-Silverman models (Pritchard, 2013). Teachers often teach using methods similar to their own preferred learning style (Alexander, 2011). Pritchard (2013) explains that research has shown that students learn in different ways and that their performance in subjects is related to how they learn. He argues that when students are taught with learning experiences that complement their learning style, their performance in the subject is significantly higher. This underlines the need for teachers to provide a range of learning strategies in order to cater for the variety of learning styles of their students.

I am still on the journey of resolving the problem of making sure that I 'cover the content' of the curriculum. However, the ethical dilemma story approach has enabled me to progress along this journey, understanding that teachers cannot teach students everything they need to know, but we can teach them the processes of learning. The Australian Curriculum requires students to be given opportunities to "develop personal and social capability as they learn to understand themselves…and learn[sic] more effectively" (Australian Curriculum Assessment and Reporting Authority, 2010a, par. 1). Two of the organising elements of this general capability include self-awareness and self-management. The Australian Curriculum Authority advocates that students should be able to: understand themselves as learners and develop reflective practice; develop self-discipline and set goals; work independently and show initiative; and become confident, resilient and adaptable (ACARA, 2010b).

In this study, working collaboratively in groups provided a safe atmosphere for students to develop reflective practice as they considered the ethical dilemma questions. Although it could be argued that students have opportunities to hear other students' points of view in a teacher-driven lesson, I believe that in a small-group setting there is more scope for students to express

their own opinions, which means that some initial thought and reflection would have occurred.

In Chapter 6, I discussed that ethical dilemma story pedagogy provided opportunities for students to engage in ethical dilemma thinking. At the outset some students had their minds made up with regards to the dilemma question, but after discussion in the group setting, listening to other group students' opinions, sometimes their definite opinion would waiver and they would start to struggle with the opposing side of the dilemma, thereby engaging in the experience of dialectical thinking. I am not confident that I would have observed a similar degree of dialectical thinking if I, the didactic whole-class instructor, had been the primary focus of the lesson. Perhaps, students may individually think about their ethical decision and some might express their ideas to the whole class, but many would not. In the safer environment of the small group there is more scope for students to discuss their ideas as they attempt to come to a consensus about the dilemma posed.

Don't Give the Game Away

During their ethical dilemma learning students occasionally asked me, "What do you think?" I usually responded in one of two ways to that type of question. One response was "I don't know." The students could see through this, though, and they would comment – "Yes you do know!" They would ask again and I would respond with the same answer. Often they would respond with—"You do know, but don't want to tell us," and I would respond with "Yep – that is right." Sometimes, the students would accept that and continue with the task. Other times, there would be more questions, some whining and groaning, but eventually they would get back to the class tasks that I had set.

Another response of mine would be, "I am not saying…." This was meant to indicate to the students that I had an answer but I wasn't going to give them the answer. Often students, in the daily routine of class, will look to the teacher for the answer, whether it is for a maths equation they cannot solve or for methods of setting up a science experiment. Teachers often just give the answer—it saves precious time, students are used to this, and so when the teacher refuses to provide the answer students can find this difficult to accept. One of the key aspects of ethical dilemma story is the requirement for the teacher to remain impartial and facilitate voice to both sides of the ethical dilemma (Settelmaier, 2009). On the whole, however, students in both classes appeared to accept that I wasn't going to give them "the answer." I hope they realised I would help them, such as pointing them to an appropriate resource or helping clarify questions related to the decision that they had to made at the time. For example, students asked me what I thought about 'superweeds' or possible benefits for third world

countries and GMO food. Rather than explaining my opinions or even the facts, I helped them find appropriate resources so that they could develop a response. I decided not to tell the students what my opinions were so that my views did not affect the opinions and decisions of the students. I have noted, over the years, that students can be swayed to generate a response according to what they think the teacher may believe, rather than their individual thoughts.

Did I struggle to keep my position invisible to the class? I would like to think that my students did not ever find out my position before they made their final decision and submitted their assignment so that I was not influencing their decision. I was happy to discuss my views after the assignment was submitted, but the opportunity did not come up. Even though my position was not solid, as far as I know I did not share it with the students. In one of the interviews, a student asked about my views but I did not share them. So, did I struggle to do that? Regarding the overall question, I don't think so. There were occasions when students may have tried to work out my views from my answers.

For example, some students would say that we should not mess with God's creation. In some cases, I would try to encourage them to think a little more openly or divergently, and to encourage the students to think more broadly, comment that we have been using natural breeding for centuries. I would explain that, for example, the wheat or corn plants that we have now are very different genetically to those in biblical times. Perhaps during these conversations, students thought that I was supporting GMO food, but they did not make a comment in this regard.

In class, I emphasised to the students that their decisions should be based on the scientific evidence and on their personal values. This is where students seemed to find the task either difficult or less attractive to complete. Weighing up and deliberating on the evidence to help make a decision was a difficult task for the students, requiring higher-order thinking. I tried to help them with this process throughout the ethical dilemma story unit; however, making decisions based on their personal values was a skill that I wished I had discussed in class with the students during the ethical dilemma story. Unfortunately, there was not enough time, which is often the case. I find the tension between time and content an issue as a teacher and I am sure other teachers grapple with this as well. How do we cover the content required while also covering important aspects of the curriculum such as personal values and ethical behaviour? Perhaps students' personal values or morals should be explored in other curriculum areas such as Christian Studies, but if this is to occur, science teachers pursuing values education need to liaise with the teacher of Christian Studies and investigate whether the issue aligns with the content covered in Christian Studies. This leads me to the

consideration of collaborating with teachers in other curriculum learning areas to implement ethical dilemma pedagogy.

Students' Workload

I expected my students to make evidence-based decisions using thinking tools and in their own time writing personal reflections. Was this expectation too high within the allocated time frame? As I reflect on the demands of my full-time teaching and researching, I wonder about the demands on a student's life and whether this influences their ability to engage in higher-order thinking such as making evidence-based decisions?

A Year 10 student at our College has seven classes per day, each of approximately 40 minutes. Some may be double lessons. In any case, at one time students may be working on Mathematics, and then the next class may be English, so they have to switch off Mathematics mode and switch on to English mode for their lesson. Morning tea then comes, and the social aspect of their friendships rises to the forefront of their minds. After morning tea there is a different subject, and on it goes. After lunch they have Science, and they need to switch their minds to science mode and the challenge of the ethical dilemma they are trying to resolve. The students go home and face the mountain of homework assignments for a number of subjects while attempting to juggle sporting training, music lessons and helping around the house. Some might forget all this and spend time gaming or socialising on Facebook. How do they get the headspace to achieve what they do, let alone use higher-order thinking in their subjects when required, as in the ethical dilemma unit?

Timing of Implementation

The ethical dilemma stories originally designed by Elisabeth Taylor (see Chapter 3) ran over two or three lessons and appeared to be embedded as part of a particular unit of study. I approached ethical dilemma stories in a slightly different way, using the story as the focus of the whole unit of study. Instead of using two or three lessons, the ethical dilemma story that I used ran for a whole school term, of eight to nine weeks. The only variation between the two cohorts of students was the timing of the introduction of the story. I started the unit of work with the first cohort of students by using the story as the focus of the unit, the hook to grab their interest. I introduced the ethical dilemma story to the second cohort after a couple of weeks of teaching the basics of genetics to the class, believing that they would be better prepared to understand and develop the issues that arise from the story. Both cohorts were required to write a final report for an assessment that requires students to make a decision and

explain why they had made that particular decision.

When I use ethical dilemma stories in my future science and mathematics classes, I intend to present the story in a variety of ways. For example, regarding the Genetics unit in Year 10, the class would learn the concepts of genetics and genetic technologies, such as GMO and cloning, over a number of weeks, and then for a week (four 40-minute lessons), engage in ethical dilemma story learning. The ethical dilemma story could be used for informal or formal assessment, with students creating a poster or an infographic, and either orally or in writing explaining their decision-making process.

GENETICALLY MODIFIED FOOD – WHERE DO I STAND?

This research has enabled me to consider my position on the ethics of Genetically Modified (GMO) food. Prior to this study, this topic was something that I had not thought much about or considered deeply, even as I taught the subject to my class. A question that this research has made me pose to myself is ‘why not?’ This question caused me to explore the ethical issues related to GMO. I also investigated my personal values and how they related to my teaching of the Torn at the Genes ethical dilemma story.

Prior to teaching the Torn at the Genes dilemma story, if I was asked what I thought about GMO and food I probably would have said that I think it is OK. My knowledge of this genetics was rather limited, although I did have a 'working knowledge'—I had studied a genetics unit at university 20 or so years ago, but that unit did not (as far as I can recall) consider the ethical use of genetic technology. I checked my old university textbook (Strickberger, 1985) to investigate whether genetic technologies were part of the unit and discovered that it did not include anything relating to genetic technologies. I think that I only touched on genetics a few times in my early teaching career. I do not have any clear recollection of it when teaching Biology at one school for a year and Year 10 Science at another. In both cases the genetics that I taught must not have made much of an impression on me. I can remember well other lessons but these are more related to my primary subject areas of Physics and Mathematics.

My first encounter with the ethics of GMO, or any genetic technology, was probably when I was planning units for a new subject in Queensland, 'Science21'. I was part of the pilot course and was starting from scratch to design the course to suit the context in our school. I recall viewing information about genetic technology on a website that I accessed for teaching ideas, 'NOVA Science in the News' (published by the Australian Academy of Science). I do not recall the exact technology but it could have been about GMO food. When I viewed the site

recently there was a series called 'More food, cleaner food' (Australian Academy of Science, 2012), which had a familiar ring to it. I remember putting it in the ‘too hard basket’. As this was more than ten years ago, I cannot discern why I would have had this reaction. Maybe I thought that the topic was too high level for the type of student that I was teaching. Typically these students were not high achievers in science subjects such as Physics and Chemistry, but may have been talented in the humanities or vocational education fields. I now realise that the topic could have been of interest to all students and the level of genetics could have been managed. I think that a more plausible reason was that I did not want to deal with possible ethical confrontations that could arise with the topic. I think that I did not know enough to be able to defend my position or even determine my position or know what it should be. Perhaps, because I was teaching in a Christian (Lutheran) College at that time I felt that I was expected to support a particular ethos, but perhaps this thought was more of an excuse.

Although Lutheran Education Queensland, and hence the College, does not appear to have a policy regarding GMO, a search that I conducted of Lutheran Church policy worldwide revealed that the ACT Alliance has a policy regarding Food Security, which has advice concerning the use of GMO in foods. The ACT Alliance is a group of 140 churches of which the Lutheran World Federation is a member (ACT Alliance, 2014). In general, the policy does not support the widespread use of GMO crops and advises either to use GMO crops with caution or not use them at all, especially in countries where the available technologies cannot offer reliable protection (ACT Alliance, 2006). In hindsight, I realise that GMO would have been a great topic for engaging students, and could have encouraged healthy discussion and debate. Perhaps, I felt that I did not have the skills to manage that type of debate. There are a lot of ‘perhaps’ mentioned here, but the greatest perhaps was that deep down I did not want to deal with the issue.

During this research, I have become aware that my personality has perfectionist characteristics which, at times, results in indecision based on not having the best information available. It invades many areas of my life. For example, if I have an opportunity to go fishing (which I really enjoy) I will explore fishing forums regarding the best fishing spots in the area that I will be going to. The type of bait or lure will be tossed around in my thinking, time of day, what part of the tide, and other things will be pondered. I look to a friend and ask his opinion, not wanting to make a decision myself. I wonder why I am this way, and I think it comes down to the reason that I do not want to fail. I do not want to make the effort of going fishing and not catching any fish, so I consider all the aspects that I can because of my inexperience.

Perhaps this personality trait of wanting to make the best decision, wanting enough

information so that I have confidence making a practical decision, explains why I find it difficult to make a decision about controversial topics. With regard to GMO, it has been a long time since my university days with easy access to experts in the field, so it is likely that I felt that new genetic technology should be thoroughly researched before I felt comfortable teaching it with confidence. Because of this I had not made a firm decision about the ethical acceptability of GMO food. I don't think I am alone with this experience. I am sure that most of the Science students that were part of this study would not have made a considered decision regarding GMO food if they had not been required to in this unit. This is one of the great aspects of ethical dilemma stories—they pose a situation where there is an ethical dilemma that students may not have considered before. They provide a platform for students to examine information related to the dilemma as well as their personal values in an environment where debate is encouraged and safe. Consequently, my students acquired a set of skills or, as I often say, more tools in our toolbox to deal with problems that arise, that can be used to make decisions in their lives, whether it be where to go fishing or whether they should vote for the political party supporting or not supporting an ethical issue. These sets of skills can be equated with some of the general capabilities that are described in the Australian Curriculum, including 'critical and creative thinking' and 'ethical understanding' (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010d).

This section asked the question – GMO foods, where do I stand? Prior to teaching the ethical dilemma story in 2012 and 2013, I would have said that GMO foods should be allowed to be used with some conditions. Firstly, consumers should know when they are purchasing GMO foods, and secondly, the GMO foods should have been tested for safe human consumption. After teaching the ethical dilemma story units I have modified my positioned. On the whole, I believe that GMO foods are safe to use. There are many misleading arguments against the use of GMO foods, often presented by those who do not understand the science behind the technology. However, in a similar manner to that of my students, I have my own ethical dilemma as I am now experiencing dialectical thinking which has given rise to two reservations with GMO food. First, I believe that I need to conduct more research to understand the environmental impact of GMO food production. My second concern is very personal: due to having two children who suffer allergies to most preservatives, additives, dairy and nuts, I need to be convinced that GMO food does not increase the risk of allergic reactions. I may be happy to consume GMO food myself, but I am not sufficiently confident to give GMO food to my children.

CROSS-CURRICULUM COLLABORATION

I have chosen to start this section with a story about my recent encounters with colleagues that reveals the exciting potential of expanding ethical dilemma story pedagogy across the curriculum.

> It was the last week of school. The students had finished school the previous week, leaving for holidays and anticipating their report cards. We, as teaching staff had a couple of meetings to attend and a checklist to complete before the end of the week, when we would go for a well-deserved break. Our teaching loads were emailed to us yesterday, and there was eager discussion and comparison of the subjects we would be teaching next year. I was happy to find that I had Year 9 and 10 Science classes instead of Mathematics, and a colleague was pleased to have a teaching partner for the Science subjects. We, in particular my colleague, Robyn, had been puzzled to hear the Year 9 students discussing food webs and ecosystems as part of their SOSE unit earlier in the last term. I wondered why they were doing that in SOSE? Robyn, who is super organised, was thinking ahead to the possible units in 9 and 10 Science for next year. She decided to talk to the Head of SOSE about the Year 9s covering biology in SOSE. He explained that it was part of the sustainability unit and then went on to suggest that the Science and SOSE teachers work together during that unit. Robyn thought this was an excellent idea and mentioned to me that the Year 9s would need to cover an Ecology unit that would fit nicely with the SOSE unit. Robyn and Karl, who is also the Director of Learning as well as the Head of SOSE, chatted for a while and then called me over to see if I had any ideas. "What about a dilemma story?", I suggested, and briefly explained what ethical dilemma stories. Well that was a good idea; 'what type of story?', 'where would we get one?', 'how can we use it?', were questions raised by Karl and Robyn. I said that I knew of a website with a variety of ethical dilemma stories available for use, and I emailed the link to Karl, who promptly read the material. A little while later, I walked past Karl's desk and observed him still reading the website: www.dilemmas.net

Beyond this thesis research I am continuing to implement ethical dilemma stories in my middle years science classes. In 2015 I used the Torn at the Genes ethical dilemma story with my Year 10 Science class in the Genetics unit. This was the third time that I had used the story and it was an opportunity to learn from the understandings I had gained from previous years.

My current use of ethical dilemma stories involves collaborative planning with another Year 9 Science teacher. We are planning to use an ethical dilemma story in an Ecology unit with our Year 9 Science classes. But teachers of learning areas other than Science are also awakening to the power of ethical dilemma pedagogy, and the prospect of cross-curriculum planning is starting to be realised.

One of the Drama teachers has expressed a desire to link Drama and Science by writing a senior Drama unit based on students dramatising a science concept. In relation to an ethical dilemma story, drama students would take on various roles based on the characters in the story and create a role play based on the story. As they develop the characters, the Drama students would reflect on the feelings, emotions and opinions of the characters and compare these to the core and frontier science behind the issue in the ethical dilemma story.

In the context of my own teaching, students in my Years 9 and 10 Science classes could develop a play from the ethical dilemma story as part of their Drama studies (in consultation with the Drama teacher). The timing of the creation of the play would need to be considered. It could be created before the Science unit involving the ethical dilemma story, such as the previous term. Or perhaps the students could develop the play during the unit. Furthermore, the play could be video recorded and included in Media Studies.

Implementing an ethical dilemma story in Mathematics also could occur. For example, the College has a Probability unit for Year 9 Mathematics that is based on demonstrating to students the dangers of gambling. They explore how casinos and other gambling facilities are always going to make money through strategies such as the 'house edge' and 'weighted odds'. As part of the unit, students investigate typical casino games, and the major assessment requires the students to create their own game that looks attractive to play but is designed to make money for the designer. A culminating activity at the end of the unit involves teachers organising a mock casino for all Year 9 students. The students are given a set amount of counters that they use as money to play the games. If the students run out of counters, they borrow more from the bank, and this is tracked on a spreadsheet. At the end of the game play, students tally the number of counters they have left and this is recorded on the spreadsheet, and the gain or loss by each student and the class as a whole can be seen. The students see that overall most lose money and only a couple of students make high gains. The session concludes with a member of the Salvation Army leading a discussion about gambling and its effects on people and families in particular.

An additional activity could be an ethical dilemma story based on the lives of a family who have a family member adversely affected by gambling. This ethical dilemma story could be staged at the end of the unit. The various steps of the story could lead the students to perform calculations and make judgments based on their calculations or their personal values. A possible scenario could be that a family member, for example, a sister, has to decide whether or not to loan money to a much-loved brother who is convinced he can win more at a casino to help him pay off an outstanding debt on an expensive car he bought from a friend.

I am now sharing with College staff the success of my use of the Torn at the Genes story and encouraging them to consider using other ethical dilemma stories in their teaching. My hope is to investigate and implement ethical dilemma story pedagogy in a variety of curriculum areas with the support of the Director of Learning. Once the use of ethical dilemma stories is established in the College, there is the possibility of expansion to other schools in our local region. Toowoomba, being a major regional city, is home to a number of schools. There are three public schools and a few private boarding schools that support the rural communities of southwestern Queensland.

SUGGESTIONS FOR FURTHER RESEARCH

There are a number of questions arising from this study that could be the focus of future research:

- What is the relationship between ethical dilemma story pedagogy and achievement of science concepts?
- Is there an increase in engagement with senior science subjects when ethical dilemma story pedagogy is presented consistently to middle years students?
- How can science educators help students develop personal reflective writing in science?
- How can ethical dilemma story pedagogy be introduced across the curriculum?
- What other strategies can be taught to students to help them confidently make evidence-based ethical decisions in science?

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APPENDICES

APPENDICES FOR CHAPTER 2

- Appendix 2A: Semi-Structured Interview Questions
- Appendix 2B: Pre-VLES Survey
- Appendix 2C: Post-VLES Survey
- Appendix 2D: Reflection Instructions Provided for the Students
- Appendix 2E: Reflection Questions Provided to the Students in the Worksheet
- Appendix 2F: Sample List of Nodes
- Appendix 2G: Sample Interview with Coding
- Appendix 2H: Sample Memo from Dilemma Story - 2013

Appendix 2A – Semi-Structured Interview Questions

Semi-Structured Interview Questions - Students

1. Interest in science
    a. Are you interested in science?
    b. Do you like science?
    c. Do your future plans/goals beyond school involve science?
2. What do you think/feel about ethical dilemma units in science?
    a. For you?
    b. For your teacher?
    c. For science?
    d. For morals/values?
3. Did this process help you think about making decisions? How/why?
4. How did it go in your group?
    a. Having your voice heard?
    b. Differences in opinion?
    c. Conflict and resolution (if any)?
5. Did the dilemma approach help you learn?
    a. Apply science knowledge?
    b. Consolidate (use knowledge already known) science knowledge?
6. Did you 'struggle' with the two sides of the dilemma?
    a. Did you consider each side of the dilemma for a long time, thinking a lot about it, discussing with other students before reaching a decision?
    b. Or did you quickly decide on one side or the other?
7. Did you find it easy to make a decision regarding the dilemma?
    a. Did the strategies such as Decision Making Matrix, or the Extent Barometer help you with your decision making?
    b. Do you think that you considered the dilemma in depth?

Appendix 2B – Pre-VLES survey

Working in a Science Class

1. What is this about?

- we want to know what it was like for you working in a science class
- there are no right or wrong answers
- this is not a test and your answers will not affect your assessment
- your answers will be treated privately and we won't publish your name
- what you tell us will help improve science teaching

2. How to answer each question

consider the following statement and choose one answer

	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Doing lots of practicals is a good way to learn	5	4	3	2	1

- if you chose strongly agree circle 5
- or if you chose strongly disagree circle 1
- or if chose another then circle 2, 3 or 4

3. How to change an answer

if you want to change your mind, cross out the old number and circle a new number

	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Doing lots of practicals is a good way to learn	~~5~~	④	3	2	1

4. My details

please provide the following details

a. my name:	b. my school:
c. my year level:	d. my sex:

now turn the page and answer all questions

1. Science as a subject

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
i	I find science relevant to everyday life.	5	4	3	2	1
ii	I feel curious about science.	5	4	3	2	1
iii	I can make good sense of the problems in the story.	5	4	3	2	1
iv	I was keen to solve the problems in the story.	5	4	3	2	1

2. The teacher

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
v	The teacher stimulates my thinking.	5	4	3	2	1
vi	The teacher encourages me to participate.	5	4	3	2	1
vii	The teacher makes it feel ok to express my views.	5	4	3	2	1
viii	The teacher helped me to accept other students' views.	5	4	3	2	1

3. Learning to work together

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
ix	I carefully explain my ideas to other students.	5	4	3	2	1
x	I ask other students to explain their ideas.	5	4	3	2	1
xi	I discuss with other students how to solve the problems.	5	4	3	2	1
xii	I work closely with other students to reach agreement.	5	4	3	2	1

4. Learning to listen

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
xiii	I am open to other students' opinions.	5	4	3	2	1
xiv	I respect ideas different from my own.	5	4	3	2	1
xv	I am able to put myself into someone else's position.	5	4	3	2	1
xvi	I relate to other students' feelings.	5	4	3	2	1

5. Learning to think

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
xvii	I think carefully about my own ideas.	5	4	3	2	1
xviii	I have questioned my own views.	5	4	3	2	1
xix	I have become clearer about my own views.	5	4	3	2	1
xx	I have become more aware of what is important to me.	5	4	3	2	1

Appendix 2C – Post –VLES Survey

Working with the dilemma story

1. What is this about?

- we want to know what it was like for you working with the dilemma story
- there are no right or wrong answers
- this is not a test and your answers will not affect your assessment
- your answers will be treated privately and we won't publish your name
- what you tell us will help improve science teaching

2. How to answer each question

consider the following statement and choose one answer

Working with the dilemma story	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
was a good way to learn	5	4	3	2	1

- if you chose strongly agree circle 5
- or if you chose strongly disagree circle 1
- or if chose another then circle 2, 3 or 4

3. How to change an answer

if you want to change your mind, cross out the old number and circle a new number

Working with the dilemma story	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
was a good way to learn	⑤	④	3	2	1

4. My details

please provide the following details

a. my name:	b. my school:
c. my year level:	d. my sex:

now turn the page and answer all questions

1. The dilemma story

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
i	I found the story relevant to everyday life.	5	4	3	2	1
ii	I felt curious about the story.	5	4	3	2	1
iii	I made good sense of the problems in the story.	5	4	3	2	1
iv	I was keen to solve the problems in the story.	5	4	3	2	1

2. The teacher

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
v	The teacher stimulated my thinking.	5	4	3	2	1
vi	The teacher encouraged me to participate.	5	4	3	2	1
vii	The teacher made it feel ok to express my views.	5	4	3	2	1
viii	The teacher helped me to accept other students' views.	5	4	3	2	1

3. Learning to work together

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
ix	I carefully explained my ideas to other students.	5	4	3	2	1
x	I asked other students to explain their ideas.	5	4	3	2	1
xi	I discussed with other students how to solve the problems.	5	4	3	2	1
xii	I worked closely with other students to reach agreement.	5	4	3	2	1

4. Learning to listen

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
xiii	I was open to other students' opinions.	5	4	3	2	1
xiv	I respected ideas different from my own.	5	4	3	2	1
xv	I was able to put myself into someone else's position.	5	4	3	2	1
xvi	I related to other students' feelings.	5	4	3	2	1

5. Learning to think

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
xvii	I began to think carefully about my own ideas.	5	4	3	2	1
xviii	I began to question my own views.	5	4	3	2	1
xix	I became clearer about my own views.	5	4	3	2	1
xx	I became more aware of what is important to me.	5	4	3	2	1

6. Learning about science

		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
xxi	I learned that misuse of science can harm life.	5	4	3	2	1
xxii	I learned that misuse of science can have negative outcomes.	5	4	3	2	1
xxiii	I learned that misuse of science can have long-term effects.	5	4	3	2	1
xxiv	I learned how being ignorant about science can be dangerous.	5	4	3	2	1

Appendix 2D – Reflection instructions provided for the students.

Journal

Each member of the wiki has their own journal which can only be viewed and edited by the owner of the journal and teacher. You will not be able to see other students' journals and they will not be able to see yours!

You are expected to write in your journal at least once a week. **Please put the date of your journal entry!**

Ideas for reflection in your journal (you do not have to write about every point below, they are just there to give you a starting point)

- I have found that ..... has been challenging because.....
- What problems have you encountered? How did you solve them?
- How well is your team working together? Is one person dominating? Is there a person who doesn't seem to be doing much?
- What have you found easy about the topic so far? Why?
- What have you found hard about the topic so far? Why?
- Have you decided whether or not genetically modified crops can be used in food? Do you find the decisions easy or hard?
- What factors are you considering when you are thinking about your decisions?
- Are your decisions the same as others in your team or class?
- I have learnt....
- I feel that....

Appendix 2E– Reflection questions provided to students in the worksheet.

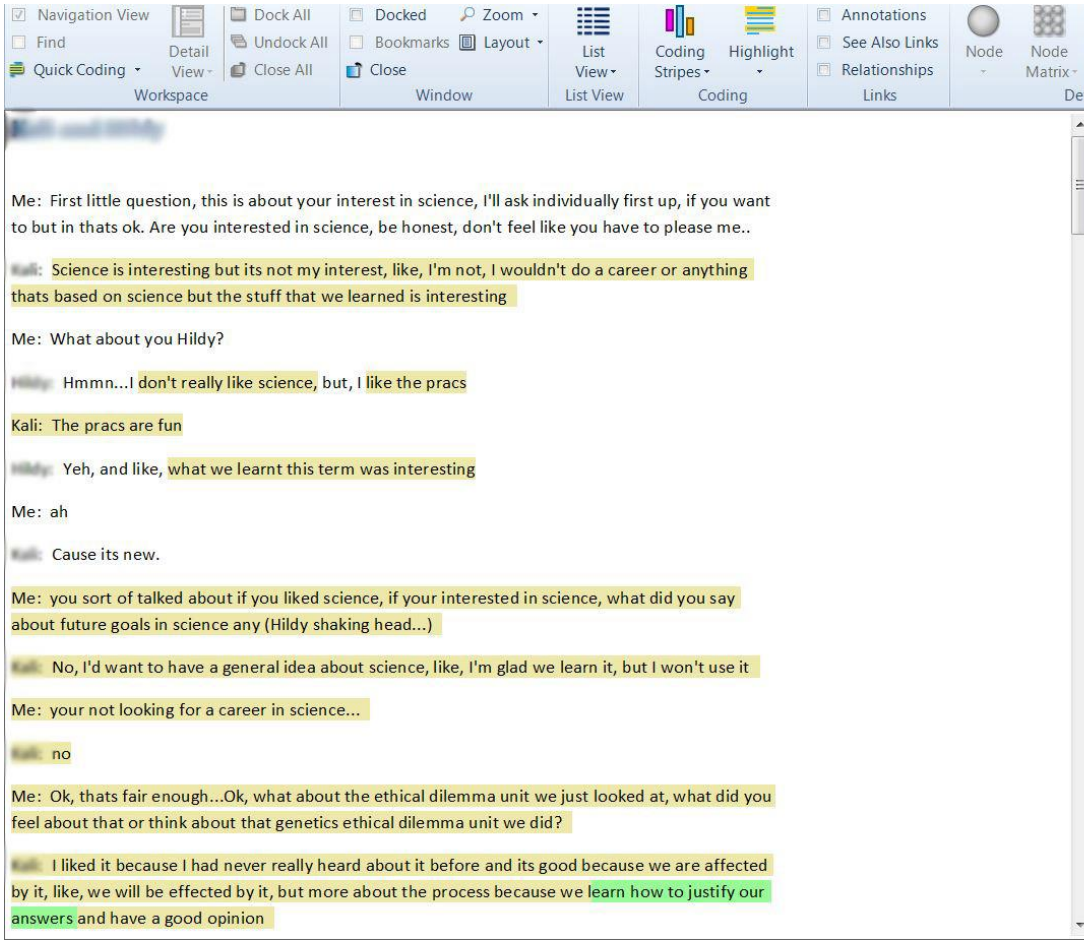
1. Remembering: What did I do?
    a. What was the assignment
2. Understanding: What was important about what I did?
    a. Did I understand the parts of the assignment?
3. Application: When did I do this before? Where could I use this again?
    a. How was this assignment similar to other assignments?
    b. Where could I use this content/process in my life?
4. Analysis: Do I see patterns or relationships in what I did?
    a. What strategies, skills and procedures did I use effectively for this assignment?
    b. Do I see a pattern in how the approach I used – was it efficient, or could I have eliminated or reorganised steps?
5. Evaluation: How well did I do? What worked? What do I need to improve?
    a. What are we learning and is it important?
    b. Did I do an effective job of communicating my learning to others?
    c. What have I learned about my strengths and my areas in need of improvement?
6. Creation: What should I do next?
    a. How can I best use my strengths to improve?
    b. What suggestions do I have for my teacher or my peers to improve our learning environment?
    c. How can I adapt this content or skill to make a difference in my life?

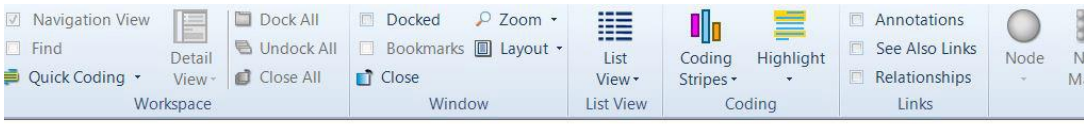
Appendix 2F– Sample list of Nodes

Nodes

Name	Sources	References
Story	6	15
Science Interest	0	0
Like science	10	15
Interest in science	6	10
Career in Science	4	5
Morals and Values	7	7
Kali	4	25
Joel	5	29
Science content learning	0	0
Learing Process	3	8
Interview analysis	0	0
Engagment in dilemma thinking	5	20
Higher order thinking	14	33
Thinking tools	9	18
Persistance	1	1
Developing Opinion	1	2
Consider dilemma in depth	6	10
Group Interactions	0	0
Resolution	3	5
Own Voice	5	8
opinion	5	10
Group work cooperation	8	15
Difference in opinion	6	10
Conflict	2	5
Feelings	1	1
Developing Ideas	1	2

Appendix 2G – Sample Interview with Coding





Me: Yep, that sounds fair, what about you Hildy?

Hildy: Umm...I liked it, I have heard of it before so it was sort of like interest to find out more about it

Me: Ah, do you think it is related to science?

Kali: yes, because of the process that is involved

Me: Same?

Hildy: Yep

Me: Thats Ok. What about morals and values? Do you think there is any relationship or what did you think about the ethic, the dilemma unit we did, the story, and morals and values any relation to it? is there a link, did you see a connection?

Kali: I saw a little bit of a connection maybe with the um, some poeple think its like playing God and that we shouldn't be interferring with creation and stuff, that was kinda with the creation story?

Me: Yes, do you have anything to add to that Hildy? (Hildy said no), well Ok, fair enough. Alright do you think, Hildy, do you think its safe to use genetically modified food in our cr... no...genetically modified crops in our food

Hildy: No, I don't think so

Me: Why? Because..um...animals, I read, that animals were force fed the foods and like they got cancers and stuff and they died and like in like I don't know how long, but yeh, so I don't think.... so it doesn't seem safe if the animals died...OK, what about you...

Kali: I am kinda mixed opinions but I'm more OK with it because people are doing heaps of research and there is so many regulations that they have to pass if they want to, like, mess around with it and I think we're, like, we have all the stuff we have today in technology because people experimented and people we're not afraid to, like, have change, and, I'm sure some people would have been abit ify ab out new technology and everything but I think its just part of our future, that we just need to

Appendix 2H – Sample Memo from Dilemma Story - 2013

Node	Wade	Amanda
Attitude	Overall Wade seems to have a positive attitude: Wade said that he likes science - especially Chemistry and experimenting with the chemicals. He doesn't have a plan to have a career in science, but rather the Army. He said that he enjoyed the genetics unit overall - even though parts were confusing to him, but he thought it was fun and he felt that he learnt alot He thought that the story made it (science) more interesting (interview)	Seems to have a positive attitude to science and learning "I have found the research very interesting" (blog) (interview) - "likes learning about it", "its interesting" this was talking about science in general, even though she is not sure about a career in science - she appears to like learing about how "everything works", "what we are made up of" et c
Context	Sustainablity concepts - Wade discusses reduced pesticide use because of GM crops. Also discusses issue of the superweed problem, with herbicide and glyophosphate resitant weeds (assignment) (interview) Not sure if there is a hint of sustainability or global concern, but possibly consequences..."making a tiny mistake" can destroy "life" or not have the "best life"...comments that "they still don't understand the full extent of it" (it being GM I assume, but he has talked about gender selection?) He realises the need to find out more information, test the theories	Sustainablility - GM crops using less chemicals, GM crops - food with vaccines and medicines. Also helpling to feed the worlds population. Contrasts with disadvantages that she discusses - cross-fertilisation, local food chain balance, allergies. She also discusses possibility of monopoly of seed supply. She also mentions this in terms of Ethics - monopolisation of the world food market, intellectual property etc, She has discussed much more...see her assignment (assignment) Amanda, in her blog identifies various sustainability issues - long term effects - on human, environment and economy. (blog) (booklet)

	He realises there is a risk but doesn't communication this effectively, seems like a mixture of science concepts that are not understand are mentioned in this response "you think what if the genes were stable what if like the genetics that they put into it are stable and what if like I have eaten this food what if its not stable and it combines, it actually attaches itself to your body then like as crazy as it may be, it could be possible, also its, can be something thats dangerous because of how we haven't had much time to test it and also because of ... at first its like oh its genetically modified food, its stopping this from happening but there is more of risk to it than people think and that should be ..." He discusses a bit later in the interview - possible problems with allergies - mentions putting a peanut gene... (decision part of interview)	Amanda, raises the question early in the unit, questioning what genes have been added or used and wonders if there is a chance of health problems and what they would be. She seems to have a "future orientated" mind...in a PCQ she asks the question "If it doesn't effect us now, Wade it in the future", (this is after the 2 pt of the story). She has identified that it could affect the human body and that there could be consequences. Again in her booklet she raises the concern of global awareness. As part of the PCQ at Pt XX of the story she says that long term effects need to have an opportunity to be studied and comments that people may react in different ways and at different levels. She then questions - "who declares GM foods to be safe?" She asks - "what evidence and credentials do they have to back up what they are saying? - is this a trust issue? Booklet (pt 7 of story), in her PCQ - "harmful to the environment, has points about the effects of genetic modification - disrupting the cycle of life. She raises the question "what effects do the chemicals currently being used have on the environment?" She obviously has environmental and consequence issues in mind. Her "con" sentence for this part of the story - "There are very realistic efects that GM foods could have on nature. Ecosystems and food chains disrupted, unknown long term effects, control over food supply. Theses are all viable effects and Karen has a right to be concerned" Evidence of her wide range of consideration of sustainability issues - "Are the effects of the chemicals currently being used on crops greater than GM?" - Realising here that current chemicals (pesticides etc) harm the environment - would that be better or worse with GM crops? (I think that is what she is saying)

		Pt 8 of the story - she realises that there benefits to GM but is unsure of the "unknown". She has witten a pro sentence and a con sentence (p17) (interview) discusses her values more - recognises that sources of information have their own bias - need to sort out "truth" from propaganda
Critical Thinking	(interview) Wade comments that he found material that he would have liked to use, but decided not to as it was not a reliable source (he didn't use those words - his words - not a proper referenced thing....)	
Decision	(assignment) decided against GM foods - with conditions - full testing/more testing. He says that GM foods should be banned in australia until further research is done and it is proved to be safe (interview) Wade said that he first thought it was OK but when he saw that there was some uncertaintity, he started "leaning" straight away to not using it. (he had some crazy mixed up ideas in his description "it attaches itself to your body" Another reference in the interview - he first thought it was ok but when more information came he decided the other way and not to eat it. He didn't think that the benifits for the tomator were that great, but the uncertainity and risks were a greater threat	(blog) Week 4- "I am still not sure what my views are. Both sides of the debate have valid points" Week 5 -"I still haven't made a decision as to what side I am going to take for my assignmetn, I can see that both sides have strong points, but I think I Wade take the negative side. GM produce doesn't quite align with some of my ethics, especially crossing animals and plants" (check her values - christian - don't mess with God's creation) "Once I have research these questions substantially, I Wade make my decision" (assignment) does not make a "decision" but suggests a "precautionary principle" (interview)

		Amanda thought that the story helped in her decision making - it provided "sides which was helpful for the decision making She says -"I am not good at making decisions" - saying she did not find it easy to make a decision (which is supported by her assignment recommendation), but she says she was "against" it from the start as "it just didn't sit right". She says again that she could see the positives and negatives...but it didn't support her christian values - "it is not how God created it to be"
Struggle to make decision		(booklet) Amanda said that leaned towards the negative side "but I'm not sure"..wants to do more research.
Change mind	(interview) indicates that Wade changed his mind - from it's OK, to its not - based on new info he recieved. See (Decision section)..he mentions this four times in the interview.)	
Group Work	(interview) Wade said that he like working in the group, he felt it was good to give an opinion and then discuss it, but he expressed that some his points were not used in group summaries. He goes on to say that the group would seem to take his points into consideration, but ignore them..his words (they would just leave it there) and then they would come up with something else. I sense frustration at this. He recognises that the points the group came up with were good points, but he felt that his points would have helped as well.	(booklet) After pt 1 of story - Amanda group said that they would not eat the tomato. Pt2 story - her group - concerned about unknown health risks and loss of nutrition Pt X story - Amanda group believes that scientists would not declare something safe if it wasn't, but still expressed concern about longer term effects, how it might affect different people. Pt X story - Amanda group thinks that GM crops that are not being consumed (cotton) are fine, but realise GM products have sig impact on the environment. Pt X story - Amandas group recognises that Karen is argumentative and not open minded, but also said she had good points that should be considered.

		Pt X story - Group says there are positives and negatives - four major questions though....environment, health, can it be reversed, bible (interview) Amanda said that her group agreed most of the time, but she made a comment which gave some indication that other members of the group did not do fair share. She said she was interested in there reasoning. She also made a comment about the repetative nature of the activities. Amanda commented that as a whole they did not much basic knowledge of the topic, but she felt it was obvious that other members of her group did not have much knowledge that their opinions were based on....(her background knowledge I think would have been pretty good...) Another confirmation that her group agreed most of the time.
Collaboration	(interview) as said before - "pretty good to work in group" - could provide opinion and discuss it wasn't much disagreement in group, but if someone disagreed they would discuss it - asking why and then majority rules	(interview) discussing in groups was a good idea
Conflict	(interview) Wade said that wasn't much disagreement - but when there was discussion occured and majority rules. No one stuck to there guns and didn't go with what the group was saying.	(interview) She said that there was not much conflict at all
Frustration	(interview).. As mentioned earlier, Wade seemed frustrated/annoyed that his points in group discussions were not taken seriously....I wonder why they were not - does this match up with Amanda who	

	seemed to think that the other group members did not have much background knowledge and hence Wades points were not all that valid????	
HOT - depth	(interview) Wade said that he wanted to go into more depth and he noticed that when he did find material, "it was not a proper referenced thing" (I assume here he means a credible source). He mentioned sites were "a maybe". Not sure of what he means, I think he wanted to think one way, but sites were causeing him to thinking another way. He said more depth with "evidential proof" would have been good. His assignment lack depth and evidence, mostly opinion without the background knowledge.	(interview). Amanda went into quite a bit of depth when one looks at her assignmet, she covered quite a few areas...(she seem uncertain though what was meant by the question.) She says that one could search endless about a topic such as these and this raise a question for me - how do students who are keen know when to stop for their assignments?? Evidence of HOT - Amanda recognises that this is bias in material that she reads - even if the bias is not intentional. She said that lots of sites (sources) were very biased and the challenge is finding the truth/facts without being effected by the bias.
HOT - thinking tools	(interview) - PCQ - did Wade find it useful? Yes - one reason is that he could go back to it (I assume refer to it when doing his assignment), it also acts as a prompt to remind him why he change his opinion, as there was evidence for it	(interview) When asked to outline the process to come up with a decision, Amanda said that she used lots of research but says that it bascially came down to here morals and beliefs and as she researched she found it easier to argue and she felt that this reinforced her own thoughts. When asked if she used any of the Thinking Tools, she said she didn't really...as she had done most of the assignment before it was covered in class. Amanda said that she found the PCQ in the booklet helpful as it helped to bring up points that they could use in their assignment and raise questions about what they didn't know. (she could have been referring to the KWHL?)

Knowledge Aquistion	(blog) This is what Wade said he learnt..."as well as learn how they swap DNA with other DNA to make something grow better in the snow" (interview) Wade was asked in the interview to give some examples of what he has learnt (he said that he had learnt alot) This is his response... **As much as I don't know about how they cross they actually did interchange like something with the plant interchanged with the weeds, to create a superweed and that, in the end genetically modified stuff isn't actually ...its ..nothing really different about it from the other one except that they have another plant in it and they have a different growth way.** This indicates to me that his knowledge base is not that strong. Another comment about knowledge - indicating that Wade possibly thinks he knows material, but doesn't really, or is he trying to cover up this?? Yes, the background gave us, we know what we are doing and we have and if we didn't we got, started to listen to the story like what's going on and quite didn't understand but when we had the background genetics we learnt what they were, what DNA was and how they combined it.	(interview) Amanda has identified the following concepts "you don't know what specific genes are being used in the processes and like crossing with plants and animals, bacteria,"
Classwork_Learning		(blog) Amanda said that she learnt alot from a powerpoint that I went though on genetic engineering techniques. This is an interesting statement from Amanda : "We are still in the research stage, and we are meant to research in groups, and upload what we find to a Wiki. This is a good stragegy in theory,

		but won't and doesn't work, when all the group members don't put in equal effort. I prefer working by myself so I know exactly what I have done and what I need to do" (interview) relating to her quote above (check timing...) Amanda felt it was obvious that they did or didn't have much knowledge to base their opinions on. Amanda felt that we (class/group) needed more knowledge before we started the story, which would have helped with the research... This is confirmed when I ask Amanda and Georgia if it would have been better to have more knowledge before we started. Amanda thought that if we had covered more genetics, deeper into the genetics first. She thought the online work was good and suited certain people but not all people.
Confusion	(interview) Wade said, that while he enjoyed the unit, he found it confusing saying he didn't get how genes combine.	
Genetics Unit of Work	(interview) Wade said, that while he enjoyed the unit, he thought it was fun and that he learnt alot.	(interview) Amanda thought it was good in that, before the unit she said that she had no idea or had thought about genetics and genetic modification. She said that she had never considered the problems GM could have
Repetative		(interview) Amanda thought (along with some other students) that the unit was repetative - a lot of similar questions. She wondered if things were done slightly differently.
Student Engagment	(interview) Wade said he enjoyed it, thought it was fun (the unit of work)	(interview) Is his evidence of student engagment - Amanda thought it was good in that, before the unit she said that she had no idea or

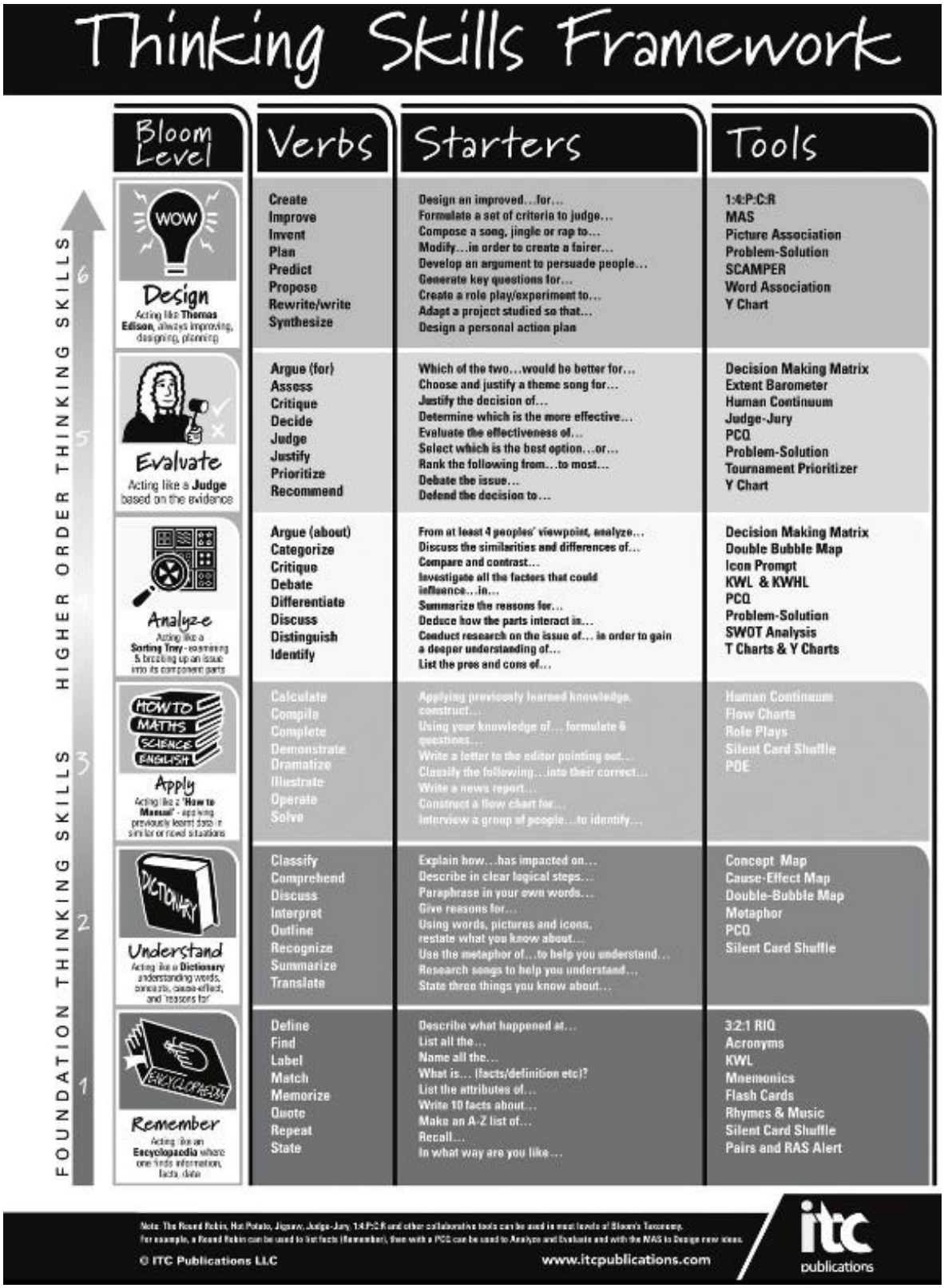
	Story - Wade thought it made it more interesting	had thought about genetics and genetic modification. She said that she had never considered the problems GM could have
Science	(interview) Wade says that he likes science, especially Chemistry and experimenting with chemicals. He is planning to go the Army though, not a career in science	(interview) Amanda says that she is not sure if she wants a career in science, but likes finding out how "everything" works and how and what things are made up of
Apply Science	(interview) Wade thought that the dilemma approach helped him to use the science knowledge that he was developing. He thought it caused him to think about what he knew and didn't know and then he needed to research	(interview) Amanda thought that the story was helpful, it caused her to think about the issue and choose a side, which helped her with her decision making. It helped her clarify her opinion
Story	(interview) Wade thought he did learn alot from using the story, he thought it related to his family, as they discuss each others opinion etc	(interview) Amanda thought that a lot of questions in the story were repetative. She also thought if we read the story more continually - she suggested reading it all and then discussed each opinion as a class rather than in bits.... Amanda thought more knowledge about genetics would have been useful
Story again	(interview) Wade thought that having the background genetics first was good. He thought the story made it more interesting - he thought - "oh there is something happening here..."	(interview) some more knowledge before the story would have been good as she felt that they didn't really know much about it - to know what to research?? Amanda wasn't sure if having a story in another unit would be a good idea - she said "Umnn" , maybe with different questions Amanda wasn't sure if the story would help less motivated students to achieve
Values and sustainability...	(interview) Wade thought that if something is created (creation), we shouldn't change it and he brought up issues like the gender of	(blog) Amanda believes that crossing animal and plant genes is not ethical and is against God's word.

	a baby, concerned about mistakes destroying life and poor choice could be detrimental	"Gm produce doesn't quite alighn with some of my ethics, espcially crossing animals and plants" She wonders - "What does the Bible say in regards to issues like this?" (booklet) Amanda said she doesn't think teenagers always go for things that are new and that in terms of ethical decisions, there Wade be split opinions. (interview) Amanda said she didn't know why she had a problem with the GM, she just sort of knew it wasn't right, since she thinks it is based on evolution (and the principles behind it) and her moral compass based on Christianity, so she thought fundamentally it was against her beliefs

APPENDICES FOR CHAPTER 3

- Appendix 3A: The 'Torn at the Genes' story
- Appendix 3B: The Thinking Skills Framework
- Appendix 3C: Torn at the Genes – Teaching Sequence
- Appendix 3D: The Student Booklet used in Torn at the Genes – 2013
- Appendix 3E: The Padlet Page
- Appendix 3F: Genetics Unit Plan for Year 10 Science – 2012/2013

Appendix 3A: The Thinking Skills Framework



Appendix 3B - Torn at the Genes – Teaching Sequence

Wk	Focus	Learning Experiences	Resources
1	Intro	• Wikispaces log in • Explain Alpha ladder • Pts -1-4 Story	Torn at the Genes story
3	DNA • Model • DNA replication	• Pt 5 Story • Create wiki article about DNA - work in teams, compare with other teams, produce final article • Explain **alpha ladder** • Powerpoint - DNA structure	Wikispaces - DNA Project

4	Inheritance
	• Dominant, recessive traits
	• Blood type, eye colour
		Monday
		• Notes- Genetics (powerpoint)
		  • Inheriting characteristics
		  • Genetic terminology
		  • Dominance and recessiveness
		  • Genetic conventions
		  • Punnet squares
		• KWL - Noisy Round Robin - are GM food safe?
		• DNA extraction
		Thursday
		• Youtube - Genetics 101 Part 1: What are genes?
		• Youtube - How to draw a Punnett Square
		• Laptops - Punnett square interactive
		• DNA Project
		Friday
		• DNA Project
		• Compare and contrast inheritance of eye colour and blood type - **Double Bubble Map**
			Genetics powerpoint
			Notes to go with powerpoint

5	Human Inheritance
	• Discontinuous and continuous variation
	• Pedigrees
	• Gender of child
	• Sex-linked disorders, inherited diseases
		Thursday
		• Sex Chromosomes
		  ○ Boy or girl
		  ○ Sex-linked diseases
		  • 321RIQ
		• Pedigree chart
		Friday
		• Prac - Vegetable babies (p179 SW2)
			Science Ways 2

6	Controlling inheritance • Selective breeding • Genetic engineering • Gene technology	**Monday** Story - pt 6 - genetic engineering, marker gene • Think - individually - recording pros, cons, questions about Jims point of view. • Pair - continue with PCQ • Share - get into teams, discuss, develop group response to share with rest of class. • H/W - reflection in journal ○ What is your response to the question? ○ What was your groups response? ○ Do you agree with your group - why or why not? ○ Youtube - Genetic Modification ○ Controlling inheritance - selective breeding, gene technology ○ Complete concept map from reading p 186-187 ○ Double bubble map - selective breeding, gene technology ○ Team jigsaw - How gene technology works. • Biotechnology online ▪ Finding the gene you want ▪ Cutting and pasting genes ▪ Moving genes ▪ Cloning a gene **Thursday** ○ Work on team jigsaw **Friday** ○ Work on team jigsaw ○ Work on assignment	
7		**Monday** • Story part 7 ○ Antibiotics, resistance to toxins, mutations, environmental concerns • Think - individually - recording pros, cons, questions about Jims point of view. • Pair - continue with PCQ • Share - get into teams, discuss, develop group response to share with rest of class. • H/W - reflection in journal ○ What is your response to the question? ○ What was your groups response?	

		○ Do you agree with your group - why or why not? • Start Powerpoints - Cotton and Canola stories **Thursday and Friday** • Work on powerpoint stories • If finished - work on assignments	
8	GM Food/Crops • Gene technology • Humans and environment	**Monday** • Work on assignment • Decision making tools - PCQ extension,Decision Making Matrix, SWOT **Thursday** • Talk by Peter Stone **Friday** • Work on assignment	
9	GM Food/Crops continued	**Monday** • Work on assignment **Thursday** • Work on assignment **Friday** • Work on assignment	
10		ERT due: "Would you allow the use of genetically modified crops in our food?" "Would you allow parents to select the gender of their child?"	

Appendix 3C - The Student Booklet used in Torn at the Genes - 2013

Torn at the Genes:
One Family's Debate Over Genetically Altered Plants

1. If you were Sonia, how would you feel about the tomato? Would you eat it?

Think **(Individual)**: What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.

P C Q Topic:

Pros	Cons	Questions
		What if...? I wonder... It would be interesting to know...

- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

.....

.....

Con sentence:

.....

.....

Question sentence:

.....

.....

Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

MyCoct Website: https://my.coct.qld.edu.au

10 Science:Genetics:Term 2

Torn at the Genes:
One Family's Debate Over Genetically Altered Plants

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

.....

.....

.....

.....

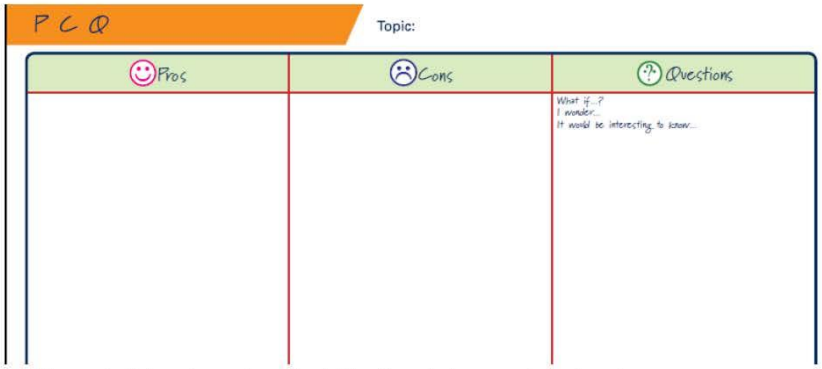
.....

.....

2. Does genetically modified in your view equals better quality? Answer as Sonia and as yourself

Think **(Individual)**: What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.



- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

.....

.....

Con sentence:

.....

.....

Question sentence:

.....

.....

Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

.....

.....

.....

.....

.....

.....

KWHL – Genetically Modified – Better Quality?

K W H L Topic:

What I know (K)	What I want to know (W)	How will I find out? (H)	What have I learnt? (L)

Investigate further...

- Go to MyCOCT, there are some websites there for you to check out regarding genetic modification – see the section on "Higher Price – Better Quality?".
  - Record any important information in your transfer booklet and in the "What I have learnt" column above.

Share (Group) – Get together in your group and look at the information other group members have collected.

- **What** does your **group** think? Reconsider your group response and rewrite your group response in the space below.

.....

.....

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.....

3. Do you feel that all teenagers always want what's new and trendy?

Think **(Individual)**: What do you think/believe? Why do you think this? Write your response in the space below.

.....

.....

.....

.....

.....

Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

.....

.....

.....

.....

.....

.....

4. Who in the family do you most identify with? Why?

Think **(Individual)**: What do you think/believe? Why do you think this? Write your response in the space below.

.....

.....

.....

.....

.....

Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

.....

.....

.....

.....

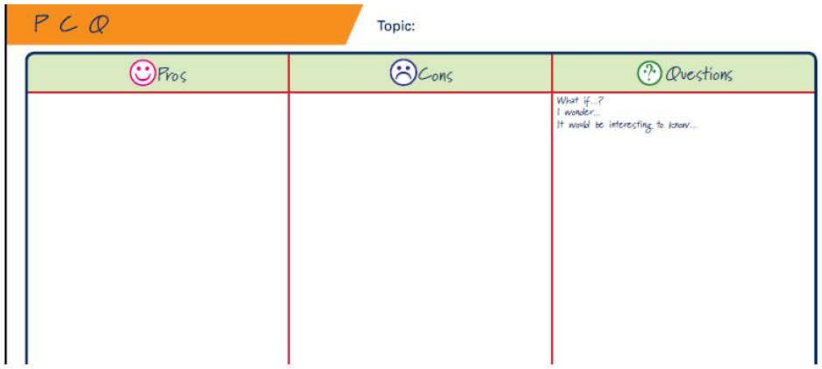
.....

.....

5. Was Sonia over reacting by not using the tomato?

Think (Individual): What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.



- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

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Con sentence:

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Question sentence:

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Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

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KWHL – How do they do it – genetically modify food?

K W H L Topic:

What I know (K)	What I want to know (W)	How will I find out? (H)	What have I learnt? (L)

Investigate further...

- Go to MyCOCT, there are some websites there for you to check out regarding genetic modification – see the section – "Genetic Engineering – Overreacting?"
    - Record any important information in your transfer booklet and in the "What I have learnt" column above.

Share (Group) – Get together in your group and look at the information other group members have collected.

-
- **What** does your **group** think? Reconsider your group response and rewrite your group response in the space below.

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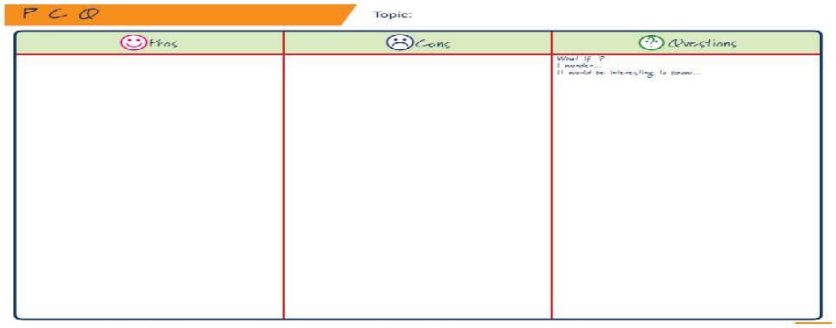
6. Do you agree with Jim who is saying that the GM foods are safe?

Think (Individual): What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.



- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

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Con sentence:

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Question sentence:

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Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

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KWHL – How do they do it – genetically modify food?

K W H L Topic:

What I know (K)	What I want to know (W)	How will I find out? (H)	What have I learnt? (L)

Investigate further…

- Go to MyCOCT, there are some websites there for you to check out regarding genetic modification – see the section – "Jim – GM is safe?"
    - Record any important information in your transfer booklet and in the "What I have learnt" column above.
    - Add to your PCQ above any new ideas/questions etc. **Use a different colour pen**.

Share (Group) – Get together in your group and look at the information other group members have collected.

-
- **What** does your **group** think? Reconsider your group response and rewrite your group response in the space below.

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7. Do you think that Karen is just being over cautious, or does she have a point?

Think (Individual): What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.

P C Q Topic:

Pros	Cons	Questions
		What if...? I wonder... It would be interesting to know...

- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

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Con sentence:

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Torn at the Genes:
One Family's Debate Over Genetically Altered Plants

Question sentence:

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Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

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DOCTOR FUN

What we have to look forward to from genetic engineering.

KWHL – How do they do it – genetically modify food?

K W H L Topic:

What I know (K)	What I want to know (W)	How will I find out? (H)	What have I learnt? (L)

Investigate further…

- Go to MyCOCT, there are some websites there for you to check out regarding genetic modification – see the section – "Possible Problems?"
    - Record any important information in your transfer booklet and in the "What I have learnt" column above.
    - Add to your PCQ above any new ideas/questions etc. **Use a different colour pen**.

Share (Group) – Get together in your group and look at the information other group members have collected.

-
- **What** does your **group** think? Reconsider your group response and rewrite your group response in the space below.

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At harvest time Ted's ethical objections to the use of frog genes in potato breeding were conveniently forgotten.

8. What would you decide? Would you allow the use of genetically modified crops in our food?

Think (Individual): What do you think/believe? Why do you think this?

- Use the PCQ table below to help you analyse.

P C Q Topic:

Pros	Cons	Questions
		What if...? I wonder... It would be interesting to know...

- Use each of the columns from the PCQ table to help you write at least 3 sentences to answer the question.

Pro sentence:

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Con sentence:

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Question sentence:

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Pair In pairs, look at what each has written. Note any differences or similarities between you and your partner in the space below.

Share (Group) – Get together in your group and look at each other's responses.

- **What** does your **group** think? Write down your group response in the space below.

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"First, we'll need a sample of your DNA."

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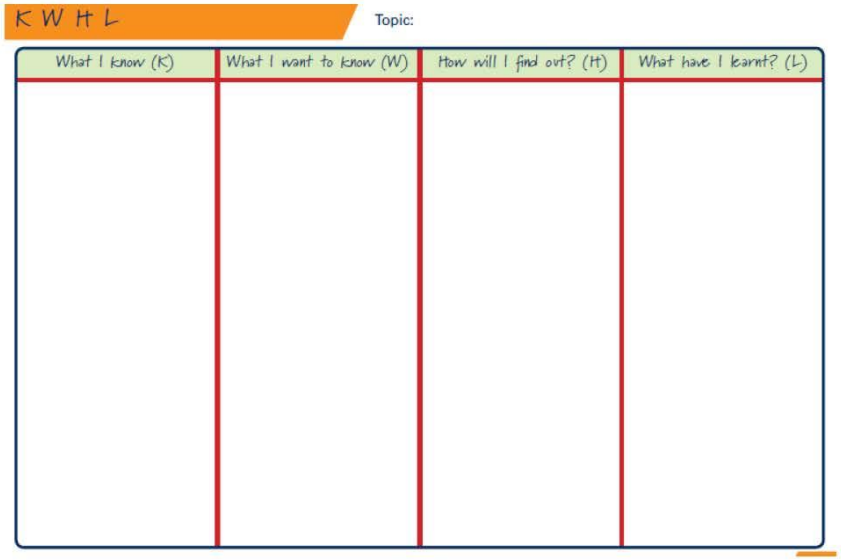
KWHL – How do they do it – genetically modify food?



Investigate further…

- Go to MyCOCT, there are some websites there for you to check out regarding genetic modification – see the section – "Would you allow GM foods?" section
    - Record any important information in your transfer booklet and in the "What I have learnt" column above.
    - Add to your PCQ above any new ideas/questions etc. **Use a different colour pen**.

Share (Group) – Get together in your group and look at the information other group members have collected.

-
- **What** does your **group** think? Reconsider your group response and rewrite your group response in the space below.

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Assignment – Would you allow the use of genetically modified crops in our food?

Consider carefully

- Read the article – **Ethics** – found on MYCOCT. Write in the space provided what issues/ideas you need to keep in mind as you write your assignment in regards to the ethics of the issue.

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- Read the article – **Recognising Dodgy Arguments** – found on MYCOCT. Write in the space provided how you can avoid writing a "dodgy argument" for your assignment.

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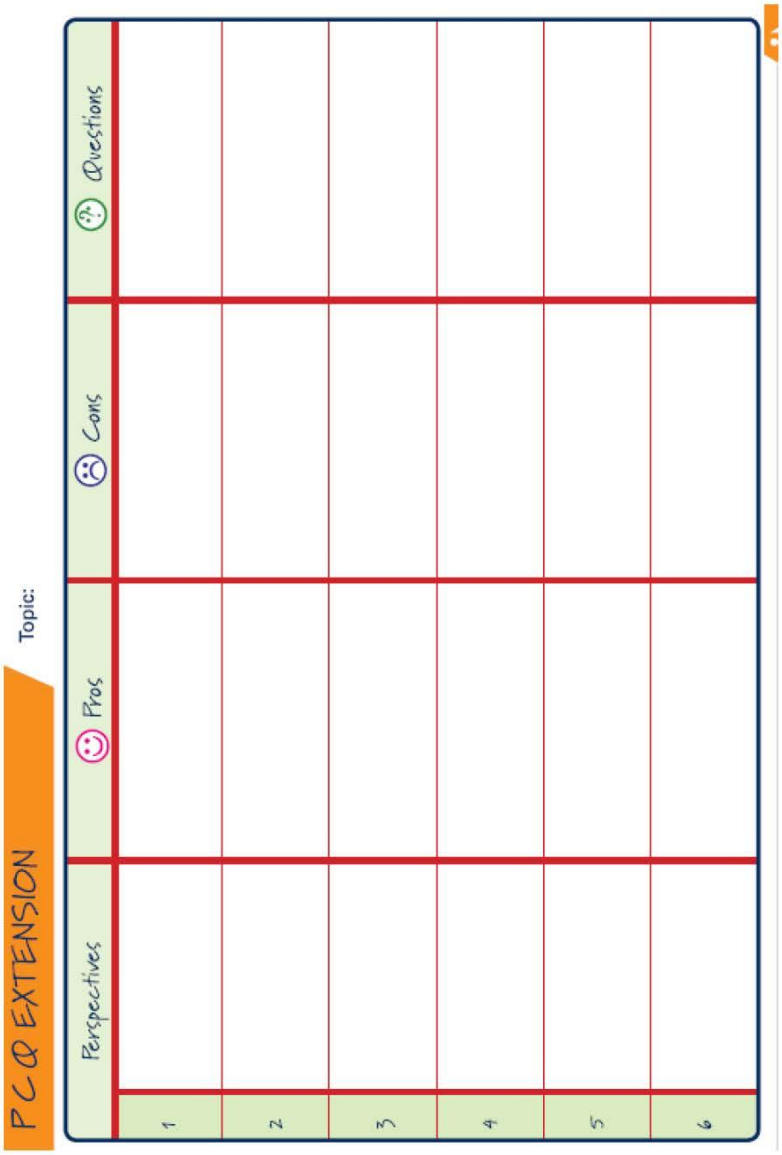
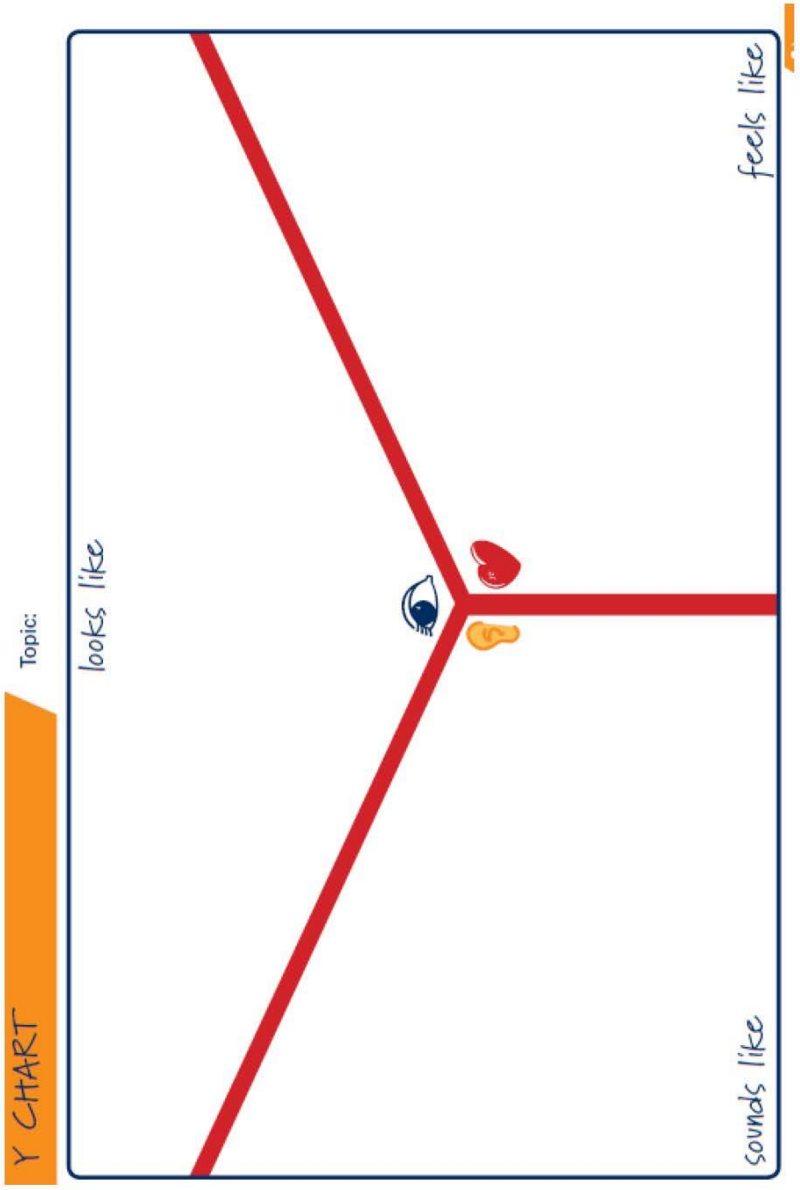
Templates to help you evaluate the issue and make a decision.

(These are available on MYCOCT)

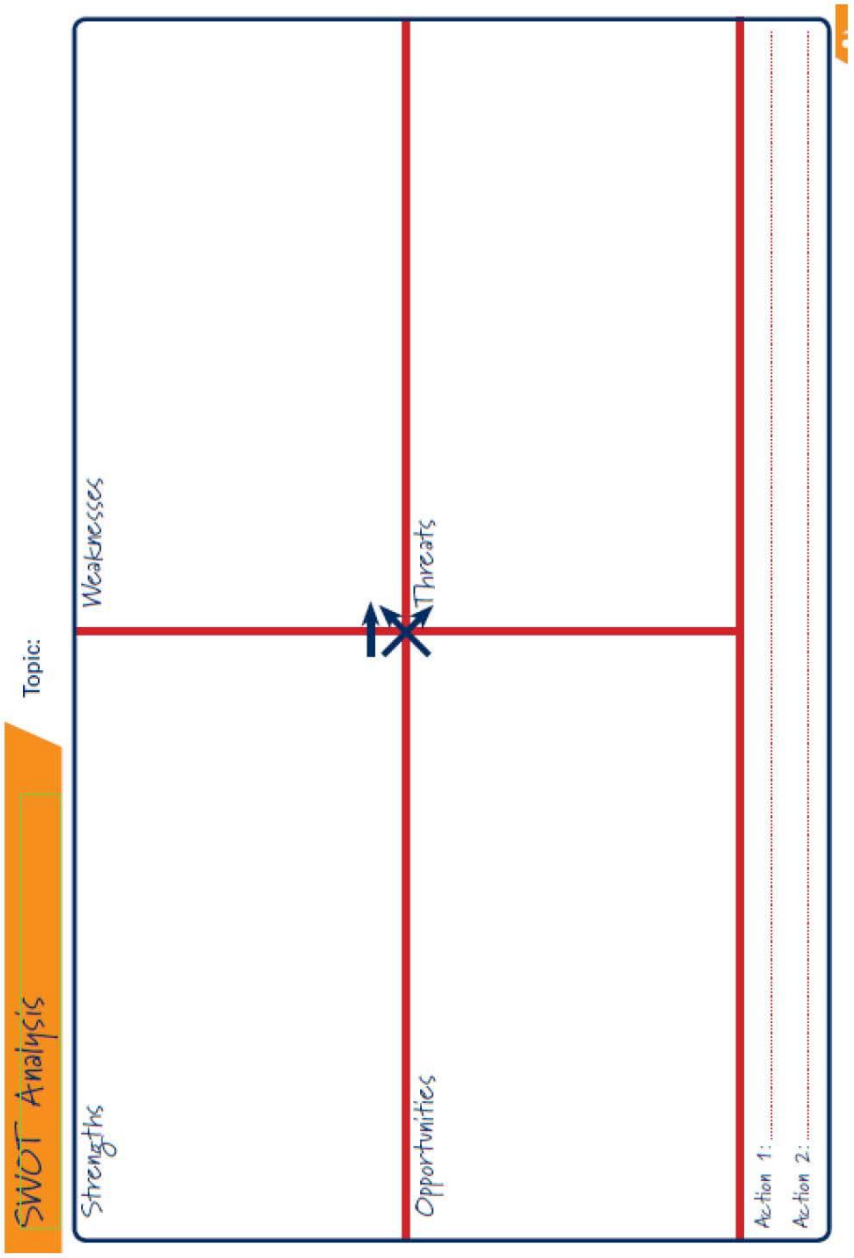
PCQ – Extension


Topic:
PCQ EXTENSION
Perspectives
Pros
Cons
Questions
1
2
3
4
5
6

Y-Chart

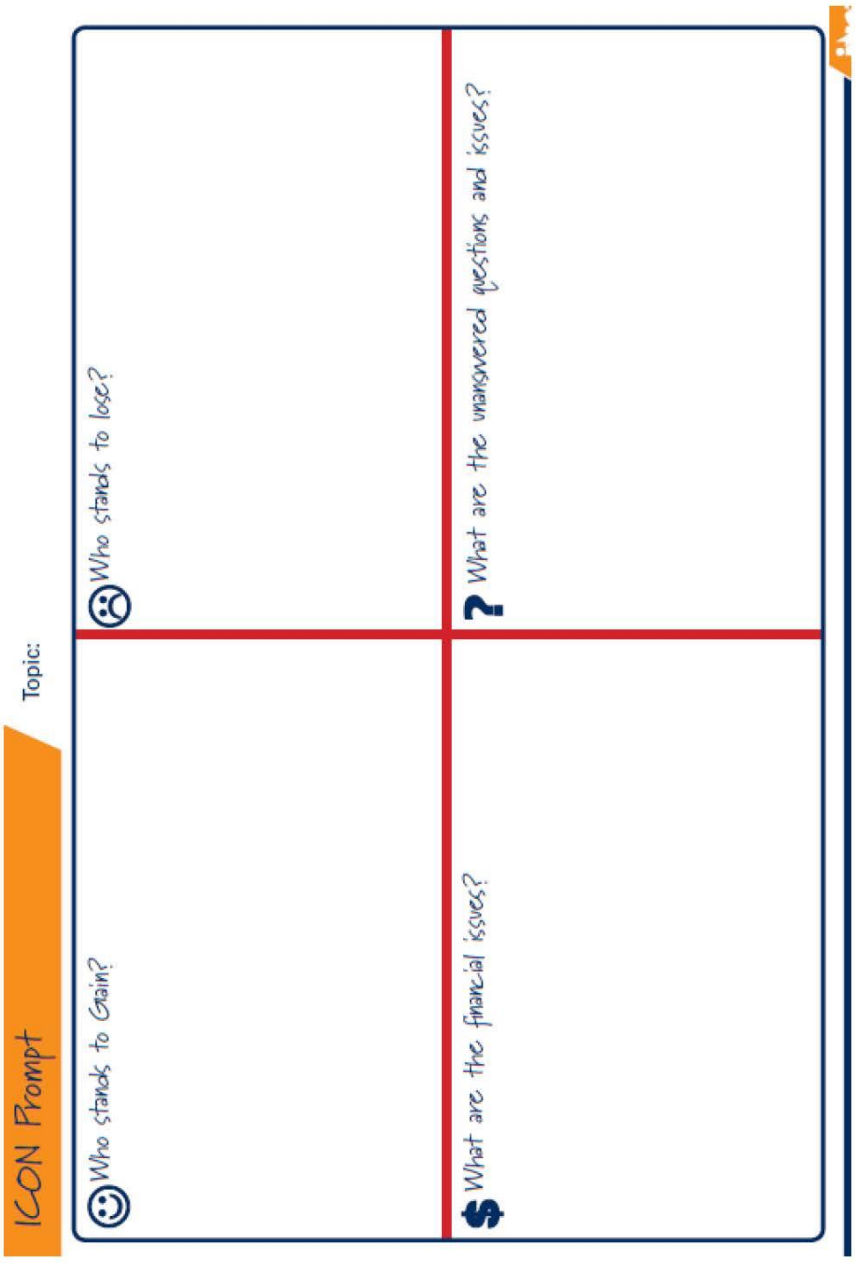

Topic:
Y CHART
looks like
feels like
sounds like

SWOT Analysis


SWOT Analysis
Topic:
Strengths
Weaknesses
Opportunities
Threats
Action 1:
Action 2:

Icon Prompt

Torn at the Genes:
One Family's Debate Over Genetically Altered Plants

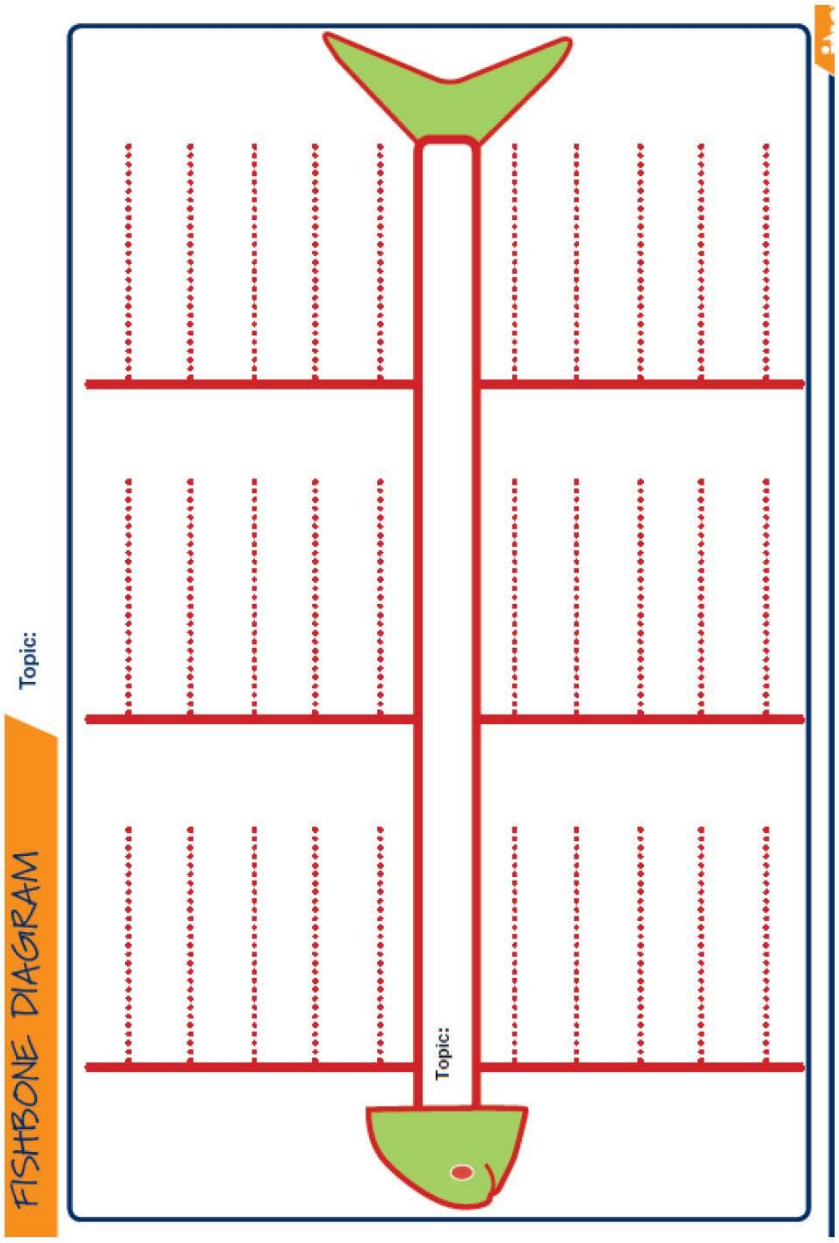


32

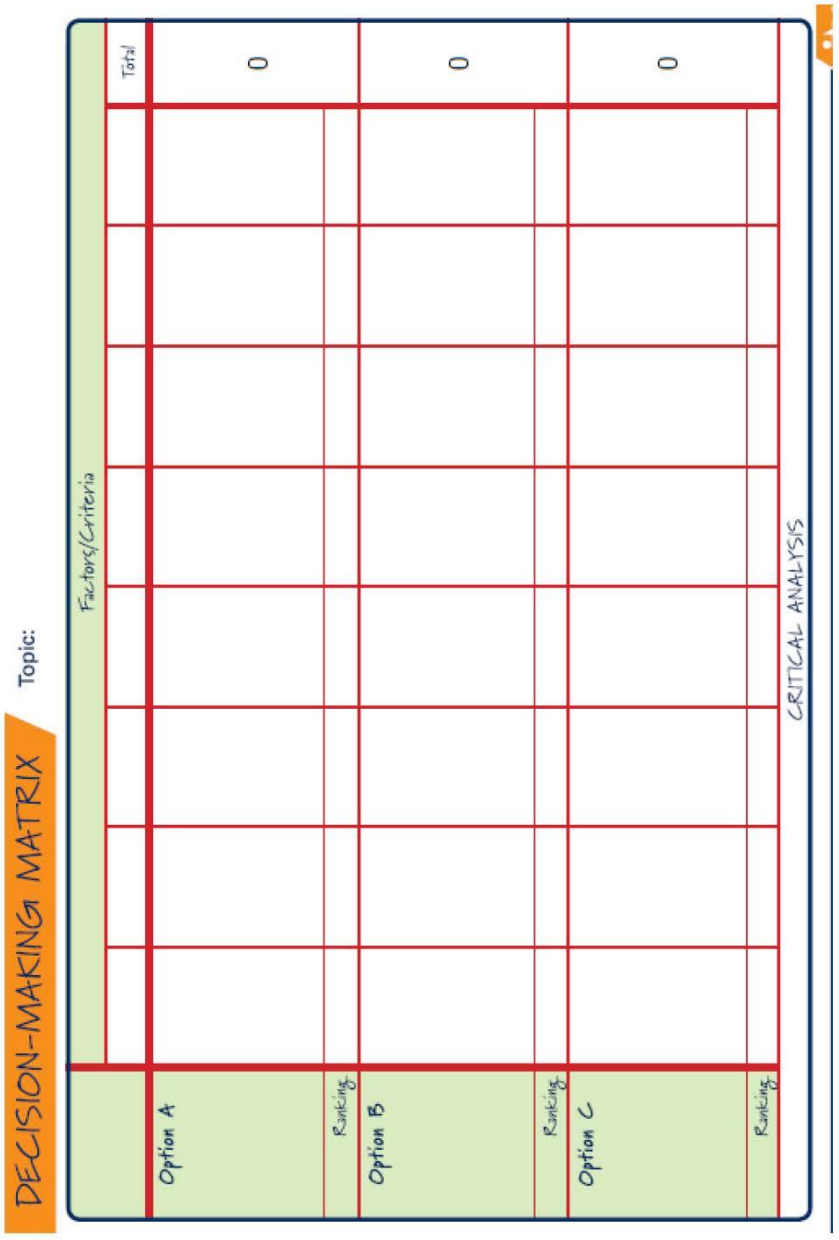
MyCoct Website: https://my.coct.qld.edu.au

10 Science:Genetics:Term 2

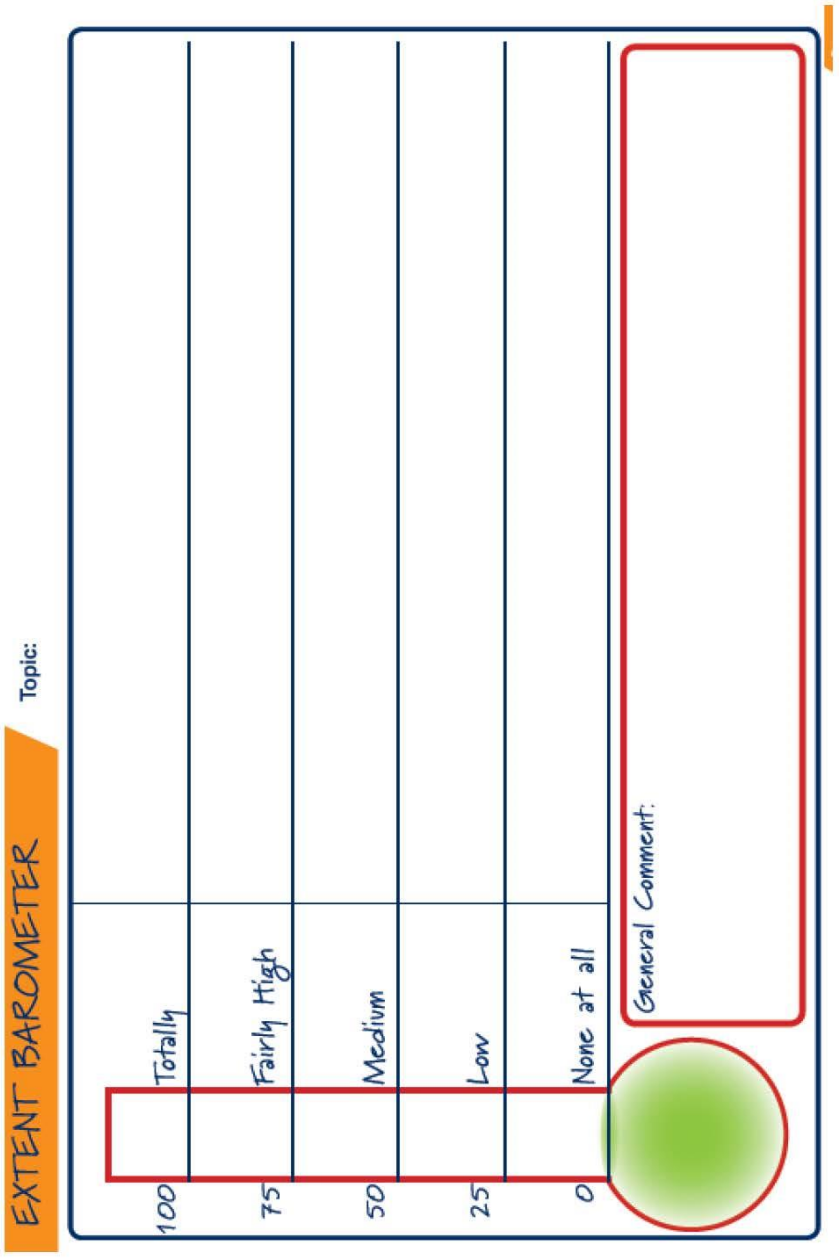
Fishbone Diagram


Topic:
FISHBONE DIAGRAM
Topic:

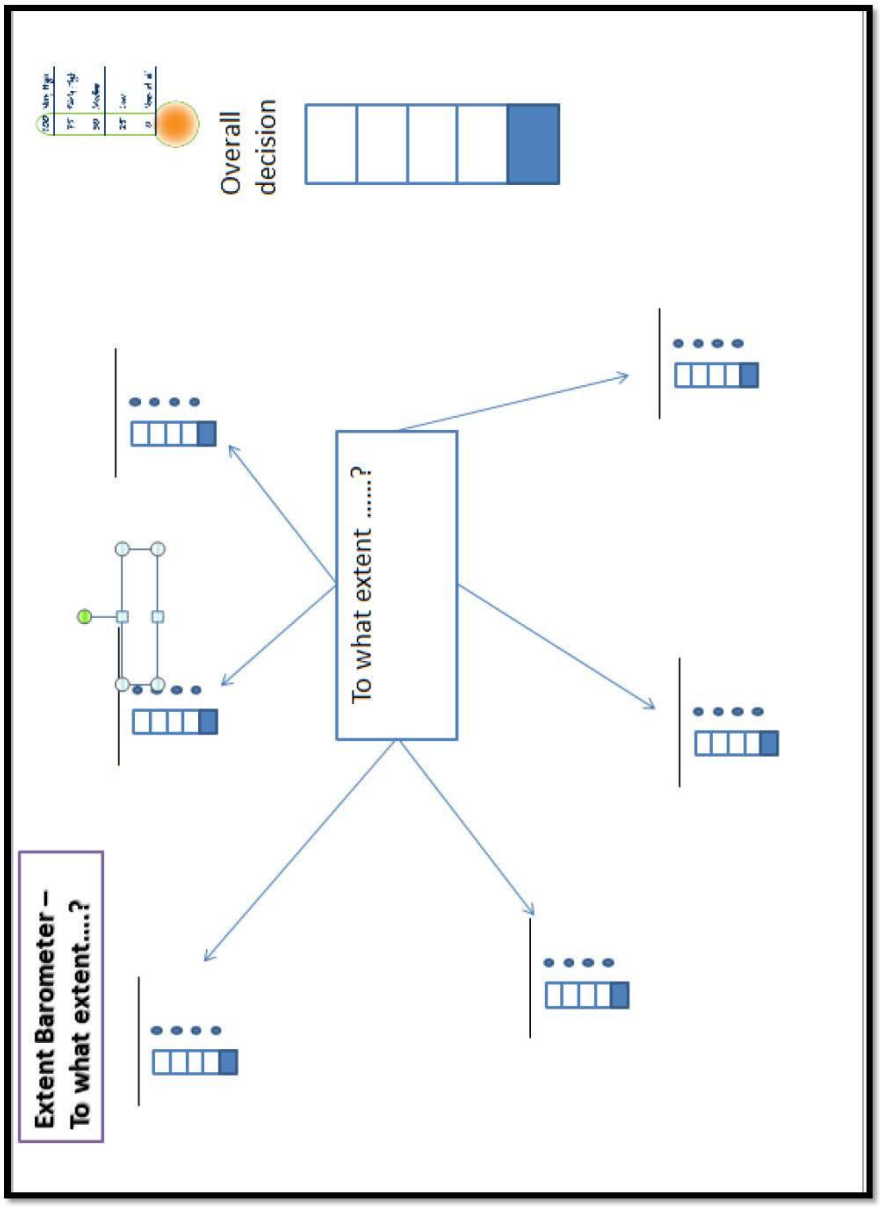
Decision Making Matrix


DECISION-MAKING MATRIX
Topic:
Factors/Criteria
Total
Option A
Ranking
Option B
Ranking
Option C
Ranking
0
0
0
CRITICAL ANALYSIS

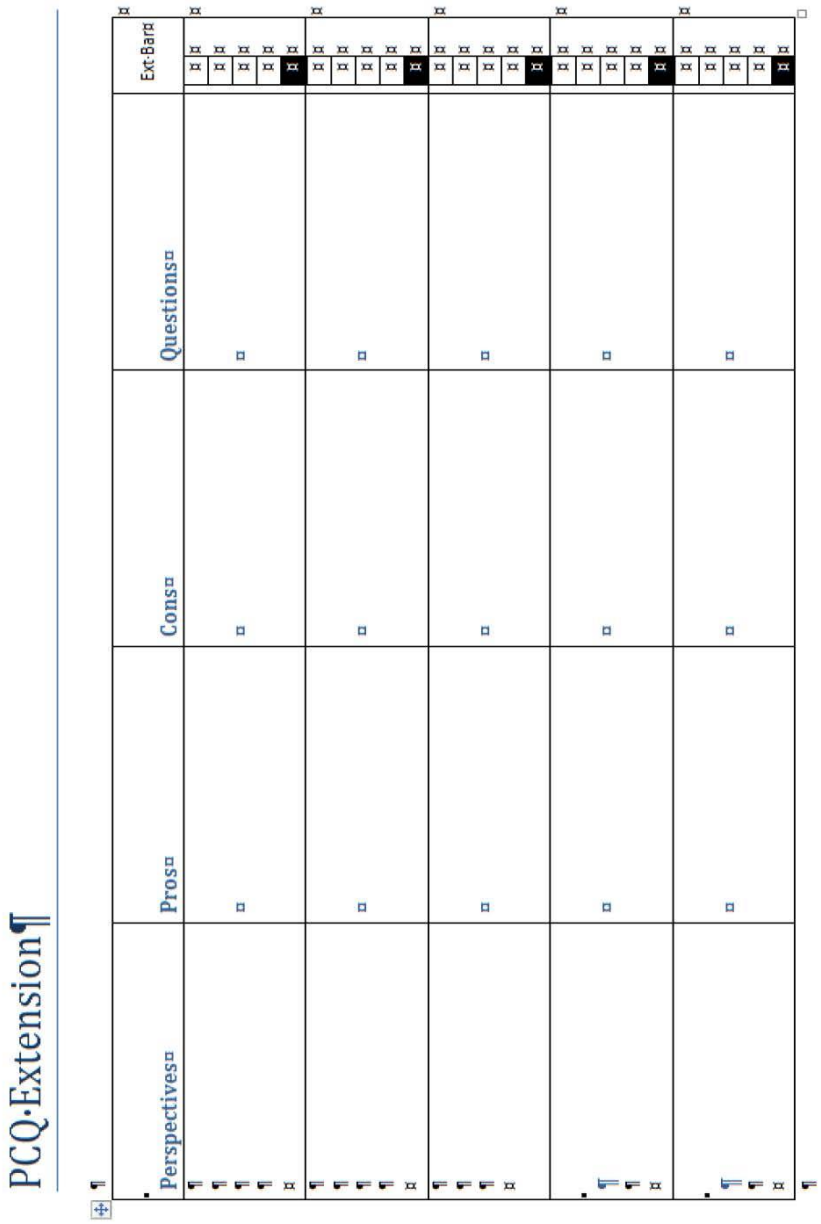
Extent Barometer


Topic:
EXTENT BAROMETER
Totally
Fairly High
Medium
Low
None at all
100
75
50
25
0
General Comment:

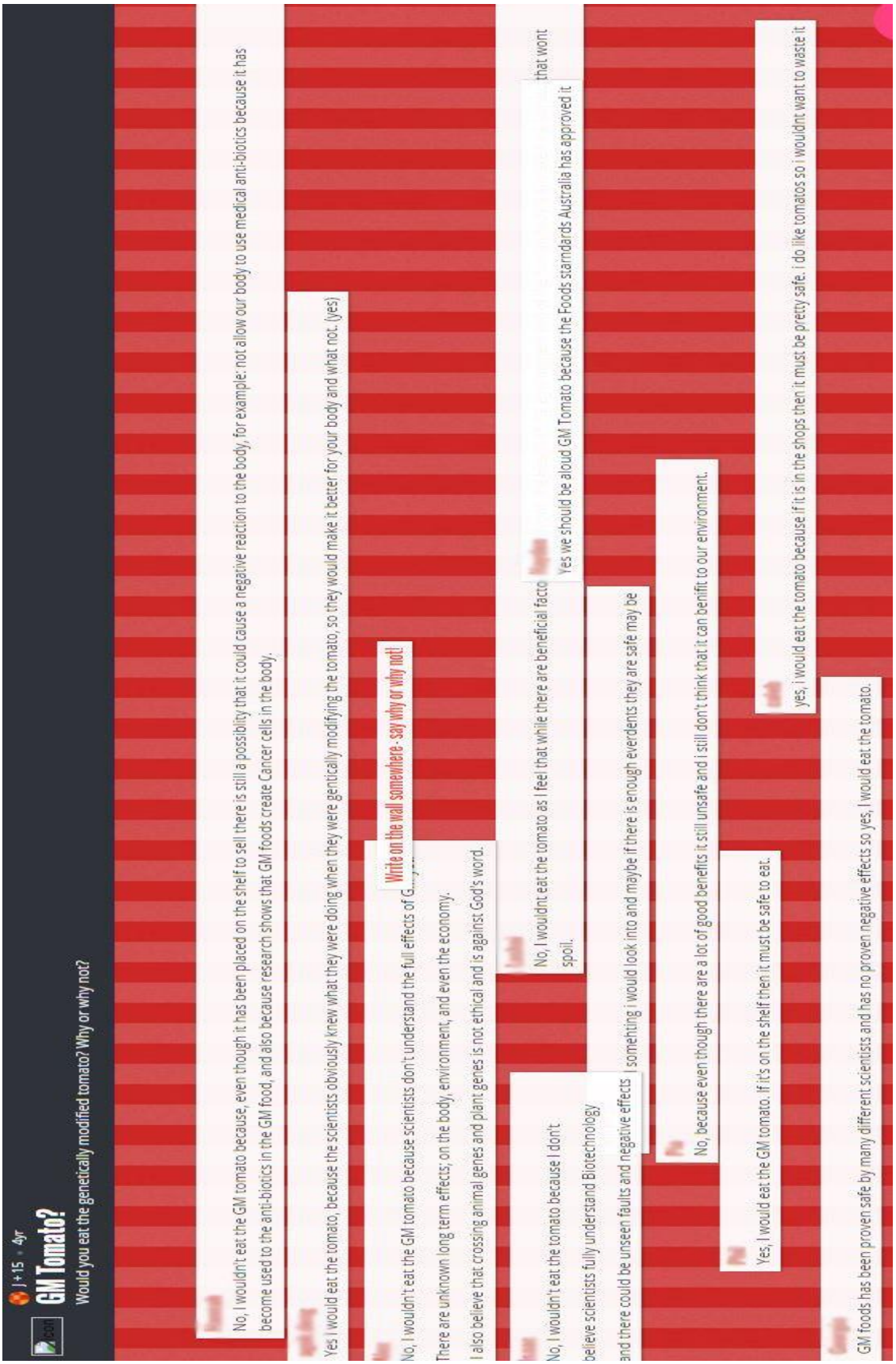
Extent Barometer – To What Extent?


Overall decision
To what extent .....?
Extent Barometer – To what extent....?

PCQ Extension (II)


Ext-Bard
Questions
Cons
Pros
Perspectives
PCQ·Extension

Appendix 3D – The Padlet Page



Appendix 3E: Genetics Unit Plan for Year 10 Science – 2012/2013

Year 10 Science unit overview — Australian Curriculum: Science

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA), *Australian Curriculum v3.0: Science for Foundation–10*, <www.australiancurriculum.edu.au/Science/Curriculum/F-10>.

School name	Unit title	Duration of unit
Christian Outreach College	Are Genetically Modified foods safe?	One Term

Unit outline

Are Genetically Modified foods safe?

During this term students build on concepts learned in the Biological sciences and Earth and space sciences sub-strands across Years 6–9 and explore genetics

Students will:

- understand relevant terminology, such as genotype, phenotype, gene, allele, dominant, recessive, karyotype, chromosome, variation, hereditary, competition, adaptation, analogous and homologous structures, convergent and divergent evolution, and geographical distribution
- use models and diagrams to represent the relationship between DNA, genes and chromosomes
- perform a DNA extraction
- recognise that genetic information passed on to offspring through sexual reproduction is from both parents by meiosis and fertilisation
- predict ratios of offspring genotypes and phenotypes in crosses involving dominant/recessive alleles or in genes that are sex-linked
- describe mutations as changes in DNA or chromosomes and outline the factors that contribute to causing mutations
- investigate the applications of gene technologies such as gene therapy and genetic engineering
- consider the use of genetic testing for decisions such as genetic counselling, embryo selection and insurance
- relate genetic characteristics to survival and reproductive rates

.

Identify curriculum			
Content descriptions to be taught			**General capabilities and cross-curriculum priorities**
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**	
The transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184) • Describing the role of DNA as the blueprint for controlling the characteristics of organisms • Using models and diagrams to represent the relationship between DNA, genes and chromosomes • Representing patterns of inheritance of a simple dominant/recessive characteristic through generations of a family • Predicting simple ratios of offspring genotypes and phenotypes in crosses involving dominant/recessive gene pairs or in genes that are sex-linked • Describing mutations as changes in DNA or chromosomes and outlining factors that contribute to causing mutations.	Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community (ACSHE191) • Investigating the development of the Watson and Crick double helix model for the structure of DNA • Investigating the history and impact of developments in genetic knowledge People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions (ACSHE194) • Describing how science is used in the media to explain or justify people's actions Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities (ACSHE195) • Investigating the applications of gene technologies such as	Formulate questions or hypotheses that can be investigated scientifically (ACSIS198) • Using internet research to identify problems that can be investigated • Formulating questions that can be investigated within the scope of the classroom or field with available resources • Evaluating information from secondary sources as part of the research process Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203) • Exploring relationships between variables using spreadsheets, databases, tables, charts, graphs and statistics Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)	**Literacy** • Write scientific reports • Hypothesise • Use appropriate technical terminology **Numeracy** • Recognise the role of probability in genetics **ICT capability** • Use the internet and online databases to research science concepts • Analyse data using a spreadsheet • Construct graphs using computer software **Critical and creative thinking** • Pose questions, speculate, make evidence-based decisions, analyse, evaluate secondary and primary sources, summarise information **Ethical behaviour**

Identify curriculum			
	gene therapy and genetic engineering The values and needs of contemporary society can influence the focus of scientific research (ACSHE230) • Considering the use of genetic testing for decisions such as genetic counselling, embryo selection, identification of carriers of genetic mutations and the use of this information for personal use or by organisation such as insurance companies or medical facilities	• Constructing a scientific argument showing how far their evidence supports their claim Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205) • Identifying alternative explanations that are also consistent with the evidence Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems (ACSIS206) • Describing how scientific arguments, as well as ethical, economic and social arguments are used to make decisions regarding personal and community issues Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)	• Evaluate a claim based on science • Make ethical decisions based on evidence based science **Personal and social capability** • Collaborate and work in teams to solve ethical dilemmas. **Sustainability** • Recognise the need to make sustainability based decisions

Identify curriculum			
		• Using the internet to facilitate collaboration in joint projects and discussions • Constructing evidence based arguments and engaging in debate about scientific ideas	

Achievement standard

Students explain the processes that underpin heredity and analyse how the models and theories they use have developed over time and discuss the factors that prompted their review. Students develop questions and hypotheses and explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.

Relevant prior curriculum	Curriculum working towards
Outline relevant previous curriculum content and standards (knowledge, skills and processes) that students need to succeed in this unit. Specify where this content occurs by identifying the curriculum document, year level and learning area.	Outline curriculum content (knowledge, skills and processes) that students are working towards. Specify where this content occurs by identifying the year level and learning area.
Bridging content	
Identify bridging content (knowledge, skills and processes) needed to address gaps in student understandings.	
Links to other learning areas	
Explain how this unit links to other learning areas.	

<table>
<tr><th colspan="2">Assessment</th><th>Make judgments</th></tr>
<tr><th>Describe the assessment</th><th>Assessment date</th><td rowspan="2">Identify content descriptions that are the focus of student learning within assessment in this unit.
List task-specific descriptors of quality. These include statements of desirable features in student work.
For further advice and guidelines on constructing guides to making judgments refer to the Learning area standard descriptors: www.qsa.qld.edu.au</td></tr>
<tr><td>Identify the evidence of learning that will be gathered during this unit (both formative and summative).
Identify what type of assessment will be used, e.g. teacher observations, projects, performances, written, oral or multimodal tasks, exhibitions, self and peer assessment.
Explain how the assessment is designed to cater for the varied needs and abilities of all students.
Specify where feedback strategies occur to allow students to evaluate their own work and identify ways to improve it.
Identify risk assessment strategies.
Concisely describe the purposes of the assessment.
State the conditions of the assessment, including the:
• format
• length
• scope
• resources required.</td><td>Specify when assessment will occur.</td></tr>
</table>

Teaching and learning	Supportive learning environment	
Teaching strategies and learning experiences	**Adjustments for needs of learners**	**Resources**
• ***Alpha Ladder*** – students build a working glossary of the keywords relevant to the study of genetics. This can be completed as a class Wiki, with students posting entries during the unit. This is can be done in groups. The Alpha Ladder can be printed a regular intervals (every two weeks) so that an updated wall poster is on display. • Construct a class wiki or online space for students to share class notes, independent research notes and other relevant information. **Inheritance** • Describe in clear logical steps the discoveries that Mendel made while trying to understand how characteristics are inherited. Create a ***concept map*** to summarise his discoveries. • Create a model to describe the relationship between genes, DNA, chromosomes, the nucleus and the cell • ***Silent Card Shuffle*** – Mitosis and Meiosis. Discuss the similarities and differences of mitosis and meiosis – ***Double Bubble Map*** • Prac: - observe mitosis using onion root tips • Model the process of Meiosis – eg using pipe cleaners • ***Double Bubble Map*** – Which is more important for the study of genetics – Genotype or Phenotype? • Construct Punnett squares to show the predicted inheritance. • Model inheritance using counters or beads **Human Inheritance** • Investigate dominant and recessive physical traits in humans • Explain how the blood type and eye colour of a new born child can be predicted.	Section 6 of the *Disability Standards for Education* (The Standards for Curriculum Development, Accreditation and Delivery) state that education providers, including class teachers, must take reasonable steps to ensure a course/program is designed to allow any student to participate and experience success in learning. The *Disability Standards for Education 2005* (Cwlth) is available from: <www.ag.gov.au> select Human rights and anti-discrimination > Disability standards for education. Explain the specific considerations that will be given to support individual learning and assessment. Explain adjustments that will be made to the learning experiences to cater for the varied needs, abilities, interests and experiences of students.	List the key people, resources and relationships needed to ensure the successful delivery of all key learning experiences and assessment. Identify risk assessment strategies.

Teaching and learning	Supportive learning environment	
Teaching strategies and learning experiences	**Adjustments for needs of learners**	**Resources**
• Compare and contrast inheritance of eye colour and blood type – ***Double Bubble Map*** • Compare and contrast discontinuous and continuous variation – ***Double Bubble Map*** • Analyse pedigree charts to determine with a characteristic is dominant or recessive. • Explain how the gender of a child is determined. • Research and report on a sex-linked disorder or inherited blood disease – working in groups on Wiki • Prac – create vegetable people according to dominant and recessive traits **DNA** • Construct a DNA model (using lego, cardboard, liquorice, jelly beans skewers) • Prac: Extracting DNA • DNA line dancing – Model the process of DNA replication by students assuming the role of a base in the DNA chain. • Evaluate the effective of DNA line dancing as a model – ***SWOT*** (Biotech Online) • Write complementary sequences to a given base sequence and then write the complementary sequence for this second sequence. • Research and investigate "When a gene code is altered". Working in groups, using WIKI. (diseases such as phenylketonuria, sickle cell anaemia, cystic fibrosis, thalassaemia, haemophilia) Prepare a presentation for the class or group. (Biotech Online) • Inquiry – understanding of how the code works in relation to DNA – students create codes using beads for each letter of alphabet and then create a sentence		

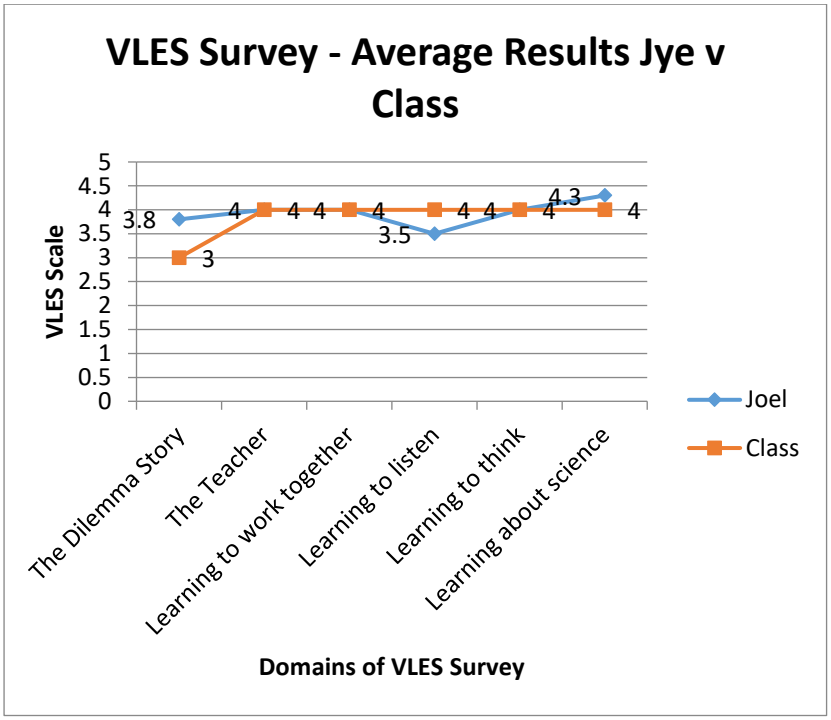
Teaching and learning	Supportive learning environment	
Teaching strategies and learning experiences	**Adjustments for needs of learners**	**Resources**
Controlling Inheritance • Create a ***Concept Map*** – outlining examples of selective breeding. • Summarise the reasons for changing genes using genetic engineering and gene technology – ***Icon Prompt*** • ***1:4:P:C:R*** Gene technology – which is the better process? (Using enzymes, Using bacteria or Transgenics) • ***PCQ*** – gene technology as part of the ***1:4:P:R*** • ***T-Chart*** - What I thought I knew/Fact – Prenatal test, forensic analysis, cloning **Genetically Modified Food/Crops** • ***Flowchart*** – how gene technology is carried out (Biotech online). Use WIKI for collaboration. • Research activity – What people know about genetically modified foods (Biotech online). Collaboration with WIKI • People do not agree about genetic modification of crops (Biotech online) – ***Judge-Jury*** • ***1:4:P:C:R –*** Growing GM crops in Australia? (Biotech online) – ***Judge-Jury*** • Butterflies and *Bt* (Biotech online) – Write a letter to persuade… • Humans and the environment – ethics (Biotech online) – Design a personal action plan regarding ethics of humans and the environment. • Should we interfere with nature? (Biotech online) - ***Judge-Jury***		

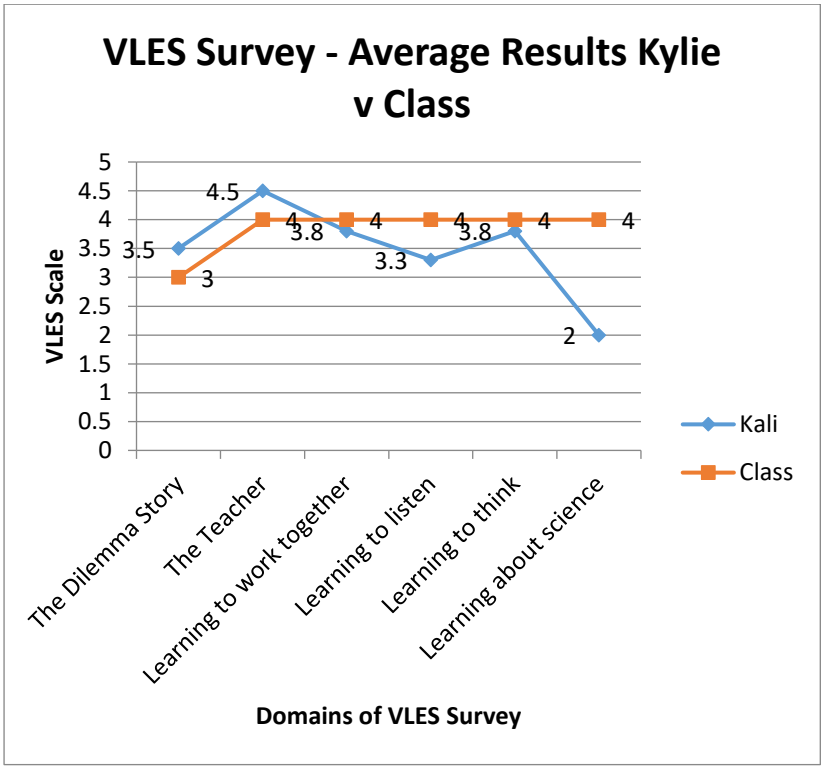
Use feedback	
Ways to monitor learning and assessment	Teachers meet to collaboratively plan the teaching, learning and assessment to meet the needs of all learners in each unit. Teachers create opportunities for discussion about levels of achievement to develop shared understandings; co-mark or cross mark at key points to ensure consistency of judgments; and participate in moderating samples of student work at school or cluster level to reach consensus and consistency.
Feedback to students	Teachers strategically plan opportunities and ways to provide ongoing feedback (both written and informal) and encouragement to children/students on their strengths and areas for improvement. Children/Students reflect on and discuss with their teachers or peers what they can do well and what they need to improve. Teachers reflect on and review learning opportunities to incorporate specific learning experiences and provide multiple opportunities for children to experience, practise and improve.
Reflection on the unit plan	Identify what worked well during and at the end of the unit, including: • activities that worked well and why • activities that could be improved and how • assessment that worked well and why • assessment that could be improved and how • common student misconceptions that need, or needed, to be clarified.

APPENDICES FOR CHAPTER 4

- Appendix 4A: Graph of perceptions of Jye and Kylie compared with the class
- Appendix 4B: Assignment Task Sheet

Appendix 4A – Graph of perceptions of Jye and Kyle compared with the class





Appendix 4B – Assignment task sheet

Christian Outreach College Toowoomba

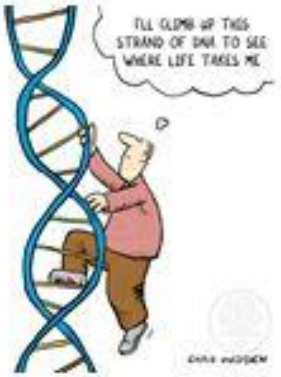
YEAR 10 SCIENCE

ASSESSMENT ITEM 2

Term 2 Extended Response Task
Semester 1, 2012

NAME: _____

TEACHER: _____



Time Allowed: 5 weeks
Weekly Progress checks
Evidence Check: 4/6/2012
Due Date: 12/6/12

This assessment assesses:
(1) Understanding
(2) Skills

Word Length: 1000 words (max)

Topic Areas:

- The transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)
- People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions (ACHE194(
- Advances in science and emerging sciences and technologies can significantly affect people's lives (ASCHE195)
- The values and needs of contemporary science can influence the focus of scientific research (ACSHE130)
- Formulating questions or hypotheses that can be investigated scientifically (ACSIS198)
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)
- Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations (ACSIS205)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)
- Ethical behaviour
    - Evaluate a claim based on science
    - Make ethical decisions based on evidence based science

Page 1

	A	B	C	D	E
	The folio of student work has the following characteristics:				
Understanding	Comprehensive description and explanation of scientific information, concepts and relationships	Significant description and explanation of scientific information, concepts and relationships	Description and identification of scientific information and concepts	Statements of scientific information and science knowledge	**Statements of isolated scientific facts**
	Use of science knowledge to generate solutions and reasoned explanations in a range of situations, including some that are complex and unfamiliar	Use of science knowledge to generate solutions and informed explanations in complex familiar situations	Use of science knowledge to generate solutions and explanations in simple familiar situations	Use of science knowledge to generate partial solutions and explanations	
	Systematic examination of social and technological factors that influence the development of science knowledge, and the effect of science on people's lives	Examination of social and technological factors that influence the development of science knowledge, and the effect of science on people's lives	Description of social and technological factors that influence the development of science knowledge, and the effect of science on people's lives	Statements about factors that influence science and its effects	Statements about the use of science
	Reasoned analysis of the development and review of scientific models and theories; and the use of scientific knowledge to test claims, explanations or predictions	Analysis of the development and review of scientific models and theories; and the use of scientific knowledge to test claims, explanations or predictions	Description of the development and review of scientific models and theories; and the use of scientific knowledge to test claims, explanations or predictions	Statements about scientific models and how science is used to test claims	
Skills	Comprehensive analysis of trends in data to explain relationships between variables and to develop justified conclusions	Significant analysis of trends in data to describe relationships between variables and to develop supported conclusions	Analysis of trends in data to identify relationships between variables and to develop conclusions	Description of trends in data and statements of conclusions	Listing of data and superficial statements of conclusions
	Clear and purposeful use of appropriate scientific language and representations to concisely communicate findings and ideas to specific audiences	Purposeful use of appropriate scientific language and representations to effectively communicate findings and ideas to specific audiences	Use of appropriate scientific language and representations to communicate findings and ideas to specific audiences	Use of aspects of scientific language and representations to communicate findings and ideas	Use of everyday language to communicate findings and ideas

Extended Response Task

Ethical Dilemmas in Genetics

Your task is to write a report that responds to **one** of the following questions related to genetic technology. You are required to make an ethically sound, evidence-based decision.

1. "Would you allow the use of genetically modified crops in our food?"
2. "Would you allow parents to select the gender of their child?"
3. "Would you agree to the cloning of animals for medical purposes?"

In your report you must include the following:

- Introduction – summarising the issue
- Background information
  - This section *explains* the science of the genetics behind the issue.
  - ***Explain*** concepts such as genes, chromosomes, genotype, phenotype, dominant/recessive, inheritance, DNA etc
- Genetic Technology
  - ***Explain*** how your chosen genetic technology works and the history of its development.
- ***Evaluation*** of the Genetic Technology
  - Criteria used for evaluation
  - Advantages of the Genetic Technology
  - Disadvantages of the Genetic Technology
- Ethical issues associated with the technology
  - ***Analyse*** the ethical issues
- Recommendation
  - Your decision should be fully ***justified*** (explaining why you have made this decision)

Research Process

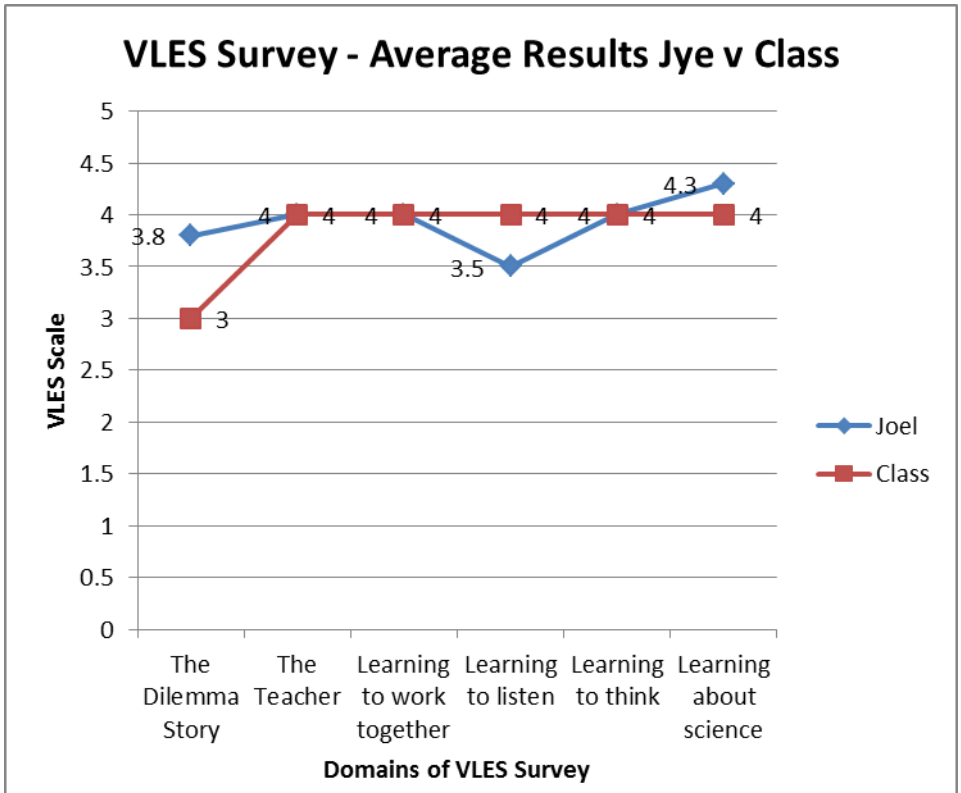
You are required to keep a journal to record your research notes and bibliographic information. Your teacher will provide suggestions to organise the journal.

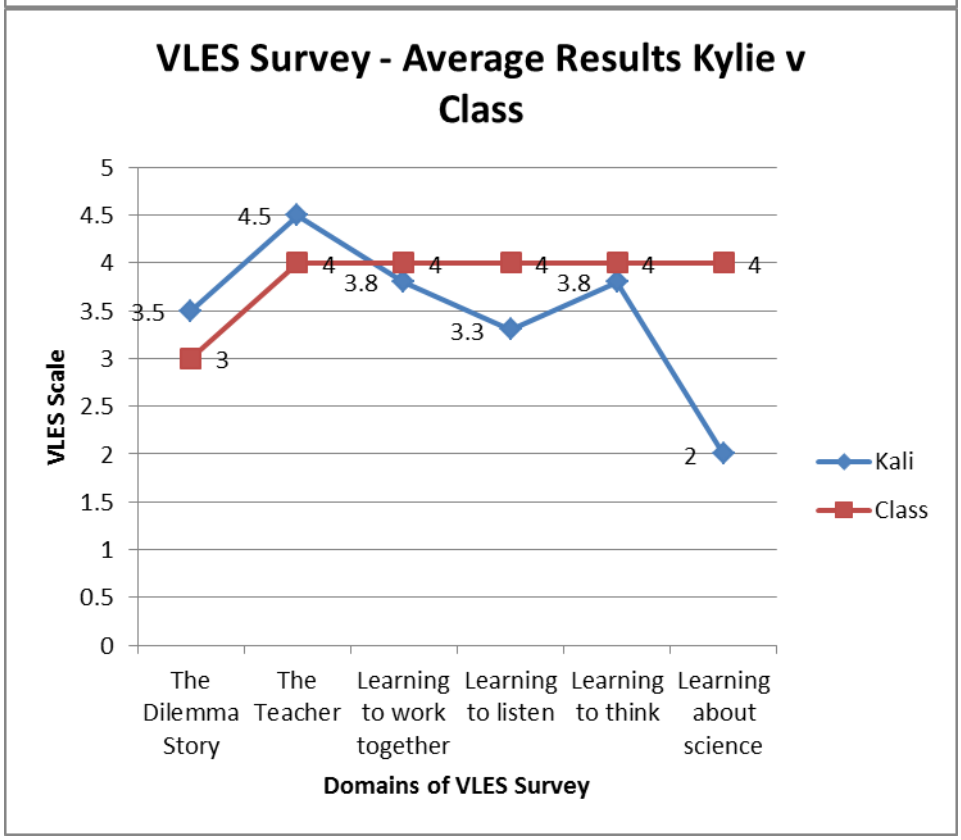
Referencing

You are required to reference the report in the normal manner, as outlined in the student diary. This means that any material that you gather from other sources such as textbook, website, journal article needs to be acknowledged in the report. Your teacher will provide a refresher on how to reference.

Glossary
Explain:
Analyse:
Justify:

Appendix 4C – Graphs of average VLES survey results for Jye and Kylie

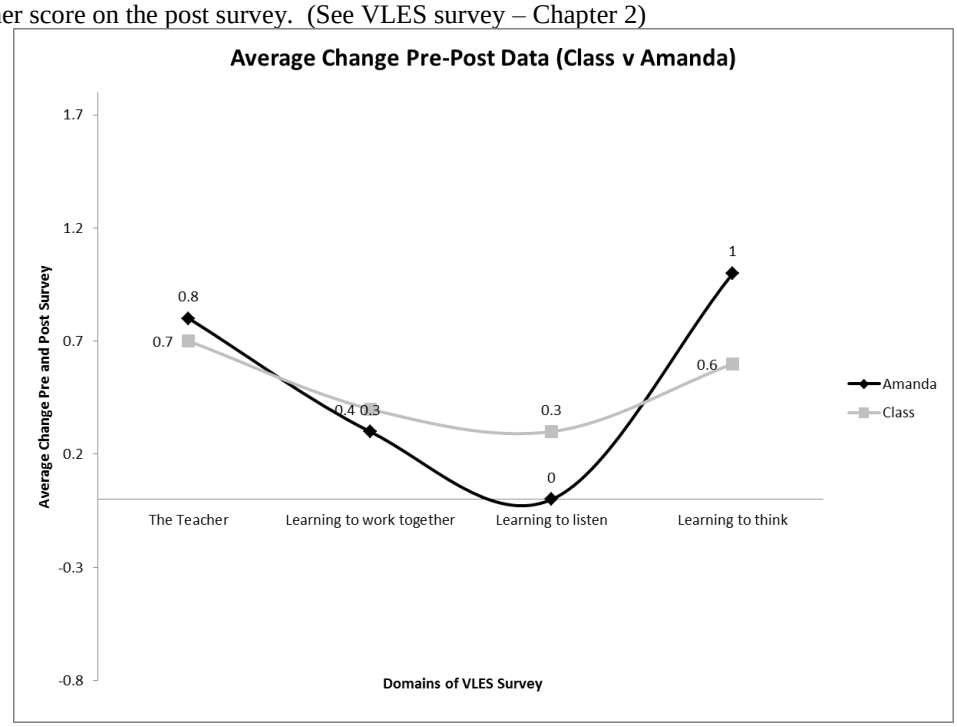


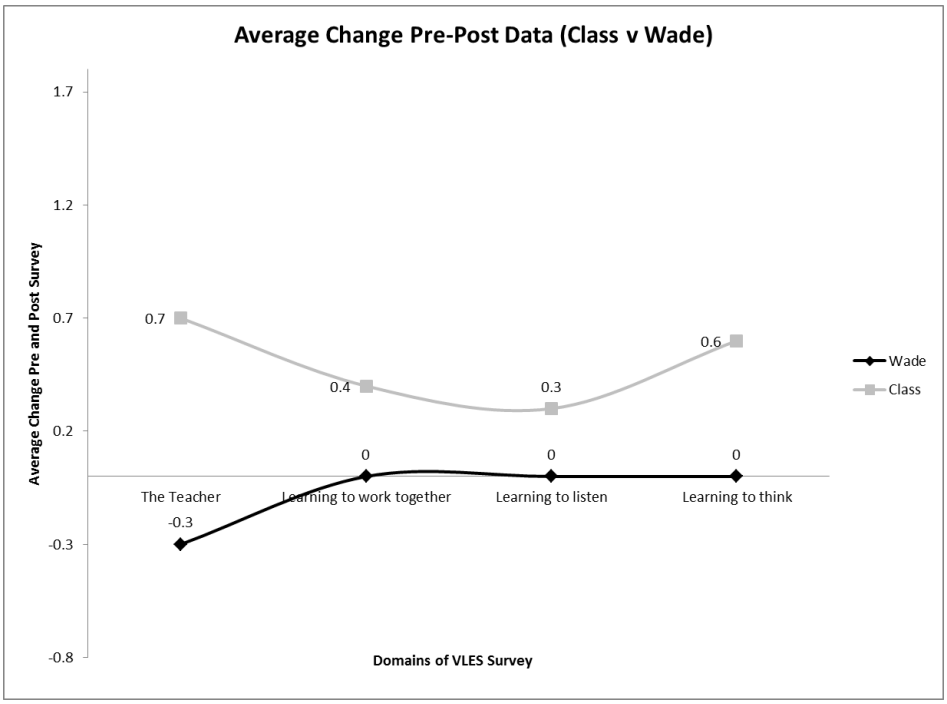


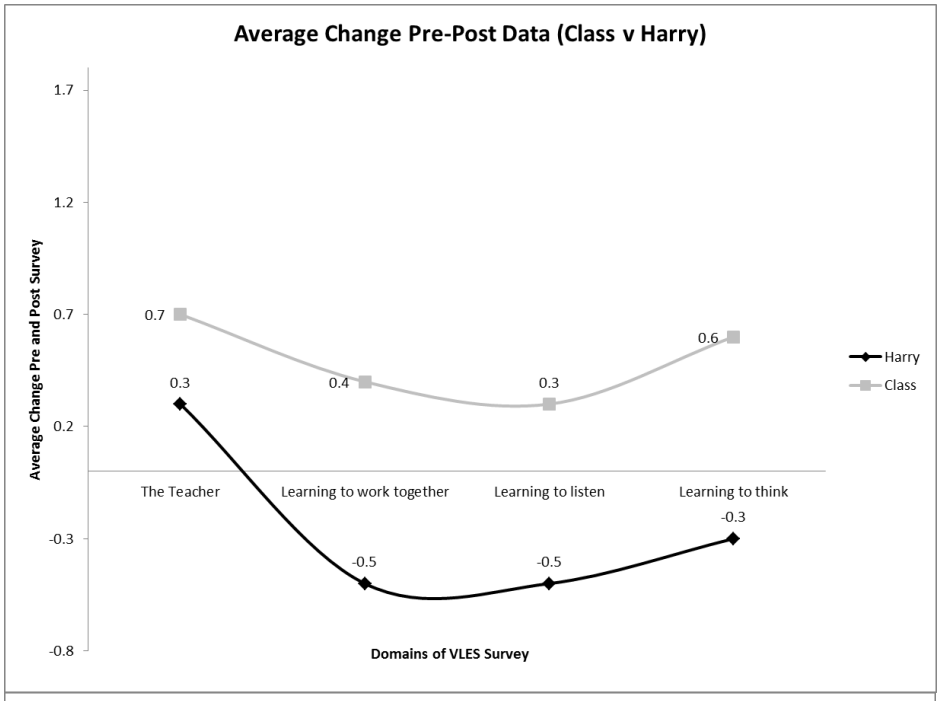
APPENDICES FOR CHAPTER 5

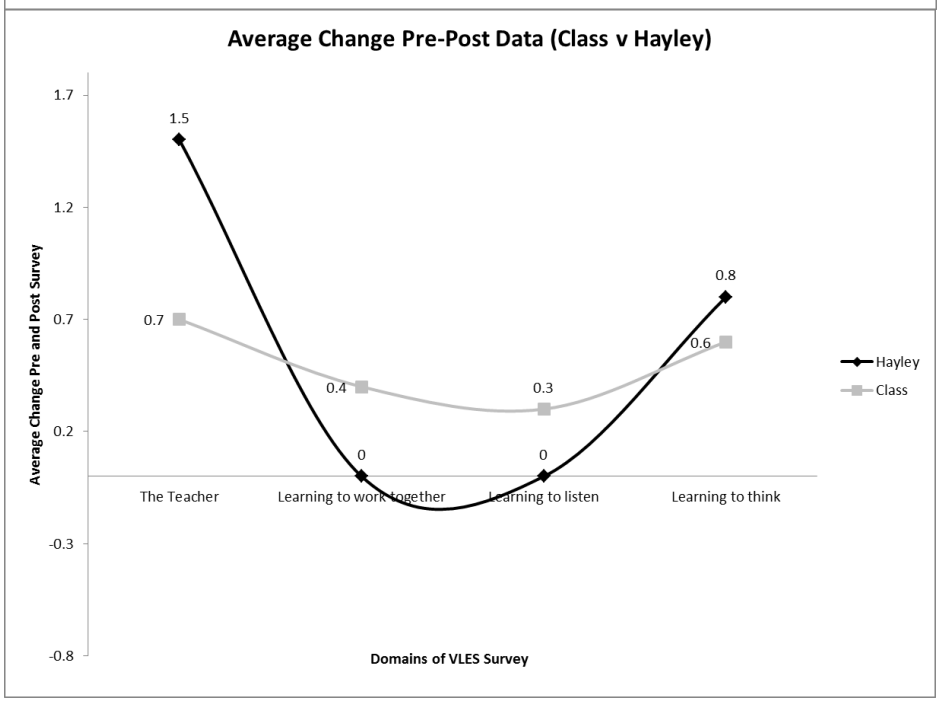
Appendix 5A - Average changes pre and post survey of case students compared to the cohort

The results for each question pre and post survey were subtracted from each other. The average of these results for each domain was graphed. A positive result indicates that on average the student had a higher score on the post survey. (See VLES survey – Chapter 2)






Average Change Pre-Post Data (Class v Harry)
1.7
1.2
0.7
0.2
-0.3
-0.8
Average Change Pre and Post Survey
0.7
0.4
0.3
0.6
0.3
-0.5
-0.5
-0.3
The Teacher
Learning to work together
Learning to listen
Learning to think
Domains of VLES Survey
Harry
Class


Average Change Pre-Post Data (Class v Hayley)
1.7
1.2
0.7
0.2
-0.3
-0.8
Average Change Pre and Post Survey
1.5
0.7
0.4
0.3
0.8
0.6
0
0
The Teacher
Learning to work together
Learning to listen
Learning to think
Domains of VLES Survey
Hayley
Class