

Science and Mathematics Education Centre

Engaging Students Through The Use of Dilemma Stories

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**This thesis is presented for the degree of
Master of Science (Science Education)
of
Curtin University**

March 2012

Declaration

This thesis contains no material which has been accepted for any other award in any tertiary institution.

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

Signature:

Mei Ling Chow

Date: 20 February 2012

Acknowledgements

I would like to take this opportunity to acknowledge and thank the following people who have made my learning journey and the completion of my Masters thesis possible.

Firstly I would like to express my deepest gratitude and thankfulness to both my supervisors, A/Prof Peter Taylor and Dr. Lily Taylor, for your support from the very beginning of my learning journey to the end. You guys have been wonderful to talk to and have constantly stimulated my mind with ideas.

Many thanks to all my past and present wonderful students at Hopefield College, for you are the main reason for the start of my learning journey. Without you, I would not even begin to question my being of being a teacher.

Last but not least, I thank my wonderful family: mom, dad, sister and my husband for their love and encouragements in my education journey.

Abstract

This study investigated students' engagement in dilemma story activities designed to enable them to explore their personal values. This inquiry was conducted within the constructivist and critical paradigms which seek to explore and communicate the multiple realities of the participants, with the goal of forming a deeper understanding of the impact of dilemma stories on students. The findings are that dilemma stories can contribute to a stronger learning experience for students in science.

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Chapter One – Introduction

Introduction

The purpose of this chapter is to outline the research problem and questions addresses by this thesis. It also provides insight into the background, teaching and research methodologies and significance of the study. The chapter concludes with an overview of the thesis, outlining the structure and content of the subsequent chapters.

My Passions

As an educator, I am passionate about issues of environmental pollution and sustainability. I feel that students are not given enough opportunities in school to deeply explore these issues. Yes, there might be the odd lessons that teach about pollution and recycling, but how often do the students treat it seriously? For many, it is just another science topic, especially in schools where students come from low socioeconomic backgrounds; science education is often seen as irrelevant to their lives. Why would they bother about it considering that there are so many other things in their lives that are more important to them? As a teacher in such a school, I have often found it very difficult to keep my students engaged in science topics. They complain about being bored, with the boys complaining that they are not doing enough experiments that ‘blow things up’. You see, science to them should be a fun thing: you make things and you blow them up. They are not particularly interested in the scientific theory behind it, and whatever the knowledge they gain is soon forgotten.

Therefore, as a teacher in such a school, I am always looking for innovative ways of teaching that will enable my students to view science as important to them. I want to help them to develop scientific literacy skills, to make a difference in their future lives. Thus, the aim of this research was to investigate whether giving my students an exciting opportunity to explore their personal values in a science topic

would help them to find science more interesting and relevant to the world around them. In particular, I was interested in helping them develop important scientific literacy skills needed as future citizens capable of participating in well-informed decision-making about the ethical use of developments in science and technology.

My Journey into Teaching

I think it is very important that my readers get to understand the intention behind my research. As a young person, my ambition in life is to be someone who is able to contribute positively to society, more importantly to be able to help people. When I failed to enter the medicine course at university, I took up neuroscience, hoping that it would eventually lead me into the medical field.

Fate eventually decided that I was to become a teacher. It was at the beginning of my science honours research that I happened to come across a Buddhist club. It is funny that a thing like this happened at time when I needed it most. My involvement with the Buddhist club led me to read books on Buddhism, and it was then that I realised that helping people comes in many different forms. One of the ways that I can help people is by becoming an effective teacher. The Buddha was a teacher who inspired many people during the course of his life through educating them in the proper way of life. This became my dream – to become a teacher who will be able to reach out to the kids in school, and hopefully to be able to inspire them through education.

This new understanding marked the beginning of my journey into school education. I wanted to be like the Buddha, to inspire many students and to make them into better persons. As with the law of attraction, whatever you seek you will get. Thus it was no coincidence that I was placed in a middle school called Hopefield College. I couldn't be placed in any better school to fulfil my dream.

Hopefield College (a pseudonym) is an innovative middle school in an Australian city. This school is situated in a low socio-economic area in the metropolitan area

and the ethos of the school is to promote a small and caring learning environment with strong links to the community. Students at this school are organised in year groups which are taught by teacher teams with a strong focus on pastoral care.

Most of my students come from single parent families for whom meeting end-needs is an ongoing issue. Low self-esteem is the norm and school, for most students, is not a major focus of their lives.

Quote from one student when we were having an informal conversion on camp: “Do you know Miss that my sister just had her 8th baby to the 8th person that she is no longer with”...“Oh and I just dumped my boyfriend this morning, and now I’m going out with a 16 year old boy who is unemployed and doesn’t go to school.” They seem to be trapped in a cycle that they see as the norm.

Socially Responsible Education

It was in 2009 that I was involved in a program called Socially Responsible Mathematics. Teachers in this program implemented a mathematics program to engage their students in critical social thinking using mathematical concepts. I found this way of teaching very innovative and it was this involvement that led me into a new frame of mind for educating my students. Instead of teaching kids only the content of the curriculum, I now wanted to include a focus on critical social thinking. I developed and implemented the McDonalds project, which enabled students to analyse the nutritional level and economics of the food sold in McDonalds and to weigh up the pros and cons of eating at the fast food restaurant.

My Year 10 students at that time were very engaged in the project. We had lively discussions about the type of meat used in chicken nuggets, the type of charity work that McDonalds was involved in, and most importantly whether the students supported the McDonalds organisation after finding out the cost of food in McDonalds’ take-away shops.

It was fate again that I got to know my current research supervisors who introduced me to the innovative world of dilemma teaching. And surprising, they were involved in a project called Socially Responsible Science Education for Sustainability. Socially Responsible Science Education for Sustainability revolves around ethical dilemma stories. Dilemma-stories are not just ‘stories’ as they represent a genre and are characterised by ethical dilemma situations. The purpose of telling dilemma stories is to introduce students to a moral dilemma situation in which choices have to be made by the characters in the story. The language of the stories is kept simple, is usually open-ended and is presented in several parts, interrupted by several dilemma-situations.

And because I am a teacher who is open to new ideas, I immediately saw the great potential of implementing dilemma stories in the context of sustainability in my classroom. My inclination towards issues about pollution and sustainability excited me enough to undertake the role of teacher-researcher.

During the first few years of my teaching career, I have many times come across the term ‘action research’, but I was too busy at the time polishing my skills of classroom management and lesson planning to really have time for action research. It was only last year that I had more time in my teaching career to consider the new role of being a teacher-researcher.

Students at my school, who come from low socio-economic backgrounds, often view science as useless to their life and therefore don’t participate well in it. And because they are so poor in their literacy skills they will be disadvantaged in terms of “making a difference” to their life. I wanted to give them the opportunity in class to think for themselves and to let them know that they can, in fact, make a difference to their life.

And because I feel that the issue of climate change will almost certainly affect their generation, it is very important for me as an educator that my students are exposed to the ideas of sustainability in my science lessons. Dilemma stories

seemed to be an excellent pedagogical tool to provide my students with rich opportunities to explore environmental issues.

Values are an ongoing topic within Australian schools. Schools have been given the responsibility to teach our future citizens “Australian Values” (DEST, 2005). The National Science Curriculum states that the new science curriculum will provide a basis for learning science that engages students in meaningful ways and, with the support of teachers, helps them to develop their science understanding so that they can function effectively in a scientifically and technologically advanced society (National Curriculum Board, 2009). One of the aims of the National Science Curriculum is to foster an interest in science and a curiosity and willingness to speculate about and explore the world. Students should be able to engage in communication of and about science, value evidence and scepticism, and question scientific claims made by others. They should be able to identify and investigate scientific questions, draw evidence-based conclusions, and make informed decisions about their own health and wellbeing.

The rationale for the National Science Curriculum, which will be implemented in 2012, outlines that science education should provide opportunities for students to develop scientific knowledge, understandings and skills to make informed decisions about local, national and global issues (ACARA website). In addition, one of its aims is to ensure that students have the ability to solve problems and make informed decisions about current and future applications of science while taking into account ethical and social implications of decisions.

The Australian Science Curriculum has three interrelated strands. They are identified as:

1. Science Understanding,
2. Science as a Human Endeavour
3. Science Inquiry Skills.

The second strand “Science as a Human Endeavour” states explicitly that good science education “explores how science knowledge and applications affect peoples’ lives, including their work, and how science is influenced by society and can be used to inform decisions and actions” (ACARA website).

It is very clear that there is more to contemporary science teaching than just imparting science knowledge to students in classes. Science education should involve teaching students critical thinking skills and, more importantly, provide opportunities for students to participate in well-informed decision-making activities about the ethical use of developments in science and technology.

One of the aims of the Australian Science Curriculum is to ensure that students develop the 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. It also requires students to develop an ability to communicate scientific understanding and findings to a range of audiences, to justify ideas on the basis of evidence, and to evaluate and debate scientific arguments and claims

It is thus quite a coincidence that ethical dilemma stories fit nicely into the Australian Science Curriculum to be implemented in 2012. Critical thinking skills is a by-product of the skills gained by the students in the process of engaging in decision making while putting themselves into the shoes of the main character in the dilemma story.

Teaching and Research Methodologies

The underlying learning theory in ethical dilemma story pedagogy is critical constructivism – a combination of social constructivism and critical theory (Settelmaier, 2009). Settelmaier has been engaged in ethics research in science classrooms for about 15 years. This is a new area of research, with Settelmaier’s PhD leading to an Australian Government teaching development grant (ASISTM)

to engage teachers in designing and trialling ethical dilemma stories in Western Australian classrooms. This led to the current project, a three-year study funded by the Australian Research Council (ARC), which my research is part of.

Results from the ASISTM funded project, ‘Socially Responsible Science’, indicate that a majority of students across the sample schools engaged positively in a socially responsible science classroom learning environment that afforded development of critical scientific literacy skills, but that student engagement was dependent on (i) the perceived relevance of dilemma stories to students’ lives and (ii) the facilitative role of the teacher in supporting students (Settelmaier, Taylor & Hill, 2010).

Positive engagement was evidenced in the results of the Values Learning Environment Survey (VLES) and interviews with the students. The VLES was developed with three specific goals: (a) to promote values learning, (b) to assess the quality of students’ engagement in values learning, and (c) to monitor values learning (Settelmaier, Taylor & Hill, 2010). The VLES was designed to measure students’ perceptions of six key factors of the classroom conducive to values learning: *critical self-reflection, empathic communication, critical social thinking, deep engagement, collaborative decision-making, teacher support* (more details in Chapter 2).

As part of my research, I designed and taught two ethical dilemma stories as part of the normal Science program to a group of students, one in Year 9 and the second in Year 10. I also administered the VLES to obtain measures of students’ perceptions of selected key factors of the classroom learning environment that earlier research (Settelmaier, 2009) shows are conducive to values learning (more details in Chapter 2). Using research methods drawn largely from the interpretive and critical paradigms, I constructed case studies of student engagement in dilemma story learning (see Chapters 3 and 4). This research provides unique insight into my students’ and my own perceptions, as their

teacher, of ethical dilemma story teaching, a strategy that explicitly teaches values in the science classroom.

After having given much thought to how I am going to present my results and reading up papers on the different research paradigms, I decided on autobiographical research writing / self-study (with a critical reflective intent) and attending to particular quality standards so that it will be scholarly. The fourth generation evaluation standards of Guba and Lincoln (1989) support the researcher's role as a learner, require the use of the researcher's (first-person) voice in commenting on the analyses, and also serve to regulate 'authentic' (democratic) participation by key stakeholders in all aspects of the study (Taylor & Settelmaier, 2003).

The aim of my self-study research is moral as it is to gain understanding necessary to make increasingly educative the interaction between the researcher's self and others who share a commitment to the development and nurturance of the young (Taylor & Settelmaier, 2003).

Research Objectives and Questions

I had two objectives in mind when I started this research. The first objective was to investigate how students' engagement in science is affected when given an opportunity to voice their values on science issues. I was particularly interested in those students who were usually not engaged in science and wondered if dilemma stories with a flavour of real-life situations would improve their engagement in science learning. My research questions were:

- Does dilemma story teaching induce a change in my students' thinking and deepen their understanding of the concept of sustainability?
- Can my students see the value of engaging in ethical dilemma stories in science?

The second objective was to reflect critically on my own teaching practice in order to better understand how it facilitates and/or restrains development of dilemma thinking in the science curriculum. On the dilemma website associated with the broader research program - www.dilemmas.net.au - there is a variety of ethical dilemma stories developed by several West Australian science teachers, which had been implemented and evaluated as part of the ASISTM project. I considered these dilemma stories and decided to write my own in order to better fit the science curriculum at my school and my students' lifeworld interests. My research questions were:

- Will my stories be engaging enough to tap into my students' current way of thinking?
- Is there a 'best way' of engaging students in ethical dilemma stories?

Significance

The results of my research on dilemma stories, a strategy for explicitly teaching values within science education, will provide teachers with a greater understanding of how values education and science communication can be achieved. This research may be significant for:

- the Western Australian education system because it provides insights into a practising teacher's perceptions of a strategy which may enhance socially responsible science education; and
- Science teachers, as they may be assisted in determining whether the implementation of ethical dilemma stories would be a suitable strategy for teaching values in their classrooms.

Structure of the Thesis

The subsequent chapters in this thesis are as follows:

- Chapter Two – *Teacher-Researcher Methodology* – outlines my ontological and epistemological stance with regards to this study. The teaching and research methodologies, including data collection and analysis methods, are described. It also introduces the participants, the setting and ethical considerations in relation to this research.
- Chapter Three – *My first dilemma story journey in 2010 – The Prime Minister Dilemma story*. In this chapter, I discuss the reasons for choosing to write this particular dilemma story and the results of the questionnaire that was used to choose students as case study participants. Case studies are presented, and I reflect on the results that shaped how I wrote and taught the next dilemma story.
- Chapter Four - *My second dilemma story journey in 2011 – The Mining Dilemma story*. This chapter unfolds my shift from the positivist research paradigm to the interpretive and critical paradigms. It outlines the difference in my teaching approach compared to the first dilemma story, and how it impacted on students' learning. My new learnings are discussed in this chapter.
- Chapter Five – *Discussion and Conclusion* – this chapter considers the after effects of dilemma story learning on my students' views, values and perceptions of environmental issues as well as the implications for my future teaching practice.

Chapter Two – Teacher-Researcher Methodology

Introduction

This chapter outlines my ontological and epistemological stance with regards to this study. This chapter is divided into two sections. The first section explains the teaching methodology of using dilemma stories in my science classes, and the second section explains my role as a teacher researcher. The methodology, data collection and analysis are described and also the participants, the setting and ethical considerations in relation to this research.

Teaching Methodology

The purpose of this study was to investigate the impact on students of an innovative science teaching approach that enables them to explore their personal values in a given science topic. To do this, I designed and implemented two ethical dilemma stories related to the science topic students were learning in class at that time.

Previous research found that in an innovative secondary school in Austria values learning outcomes in science classrooms are strongly influenced by the classroom learning environment (Settelmaier, 2009). Key learning environment factors found to be highly conducive to values learning amongst students include deep engagement in critical social thinking, critical self-reflection, collaborative decision-making and empathic communication (as an expression of emotional intelligence) in small-group and whole-class discussion. Most importantly, the supportive role of the teacher and students' attitudes towards the values learning activities (involving ethical dilemma stories) were found to be of prime importance.

Dilemma-stories are characterised by ethical dilemma situations and have been used recently as a pedagogical tool in values education. The purpose of telling

dilemma stories within moral education is to introduce students to a moral dilemma situation in which choices have to be made by the characters in the story. The language of the stories is kept simple in order to allow for ample associations. Dilemma stories are usually open-ended and typically presented in several parts, interrupted by several dilemma situations.

Most dilemma stories contain several dilemmas with a main dilemma towards the end of the teaching unit, but there are variations as to how these dilemma stories can be adapted to the different learning styles of the students and sometimes the teacher.

During a dilemma unit, students are confronted with one or more dilemma questions specially designed to initiate a cognitive disequilibrium and thus a reflective process. Students are asked to identify with the main character in the story having the dilemma, and to reflect individually on how they would solve the problem. The individual reflection phase is followed closely by dialogue, where students are asked to discuss their views with their classmates, eventually concluding with a whole-class discussion. There are phases where participants work individually or in groups (see Figure 1).

The facilitative role of the teacher is very important in providing students with clarification of the dilemma presented in the story and prompting their thinking further. Due to the nature of the students in my class, I facilitated the dilemma story activity by constantly talking to individuals or small groups of students, keeping them on-task, checking for understanding, and when students were stuck or could not be bothered making their decision, I retold the story, encouraging them to come up with a decision and sometimes helping them to tease out the reasons for making that decision (see Chapter 3). It was amazing to discover that different students come to a different understanding when they were taught in the same way.

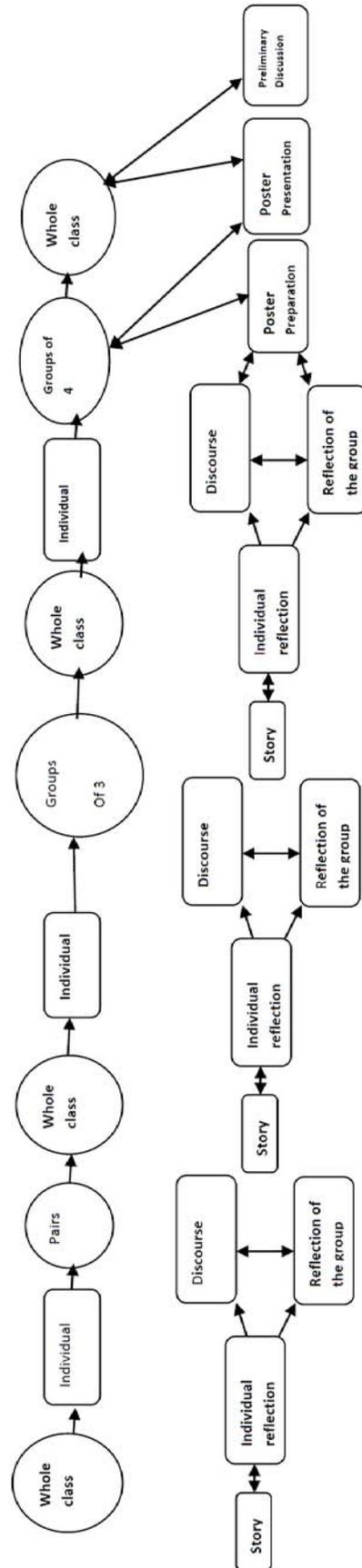


Figure 1: Activities during a 'typical' dilemma unit as suggested by Gschweilt, Mattner-Begusch, Neumayr, and Schwetz (1998).

The Prime Minister Dilemma Story

In 2010, I designed a dilemma story titled “The Prime Minister Dilemma Story” especially for my Year 9 students in Term 4 (refer to Figure 2 in Chapter 3). I was always intrigued by the amount of money spent on outer space research. Is it really important for humans to know what’s out there when we cannot even solve our own problems on Earth? Reportedly, we have polluted the Earth to the extent that we have caused climate change (IPCC, 2011). There are people around the world who worry about basic necessities on a day by day basis in order to survive. And on the other hand, we have governments spending huge amounts of money on space research. To me, this doesn’t make good moral sense! Well, it might be my own personal value, but I wanted to put this dilemma forward to my students to see where they stand on the issue.

At that time, I was teaching the outcomes of ‘Earth and Beyond’, where I focussed on science concepts relating to the solar system, eclipses and space travel. The Prime Minister Dilemma Story was taught towards the end of the term, as a means of enabling my students to personalise and solidify their learning by linking it to space exploration and environmental sustainability, which are the outcomes for ‘Earth and Beyond’ in the Western Australia science curriculum (Curriculum Council, 1998). The story fits well in the curriculum as it deals with issues of environmental sustainability and also allows students the freedom to investigate space travel as part of their project. The Prime Minister Dilemma Story is introduced in Chapter 3 and was taught to all of my Year 9 students during science classes in Term 4, 2010 (more details in Chapter 3).

The Mining Dilemma Story

In 2011, I designed and implemented a new dilemma story titled “The Mining Dilemma Story”. While on the plane back from Toowoomba to Perth, where I had just returned from a three-week retreat at a Buddhist temple, I saw some mine sites along the way. It disgusted me when I saw the scars these mine sites have

left on the Earth, and I felt sad that nobody seems to care because it is either too far away or too remote to be seen or for the impact to be felt. This is my Buddhist values kicking in from my subconscious to my conscious mind.

In Buddhism, we are reminded to love and care for all living things and the natural environment. We are all interconnected and impacting one will definitely create an effect on the other. In Buddhism, this is called the law of cause and effect. The law of cause and effect is a relatively simple but powerful concept in Buddhism. It means whatever seeds you sow, you will reap. If you kill a living thing by causing grief to it, and it even applies to trees, you will eventually experience the same grief when the seed you have sown is reaped. A ‘killing’ seed will reap a ‘killing’ experience that will impact you. Therefore, when companies create mine sites and in the process destroy the natural environment, either by chopping down trees or impacting the wildlife by its toxic tailings, they are sowing the seeds that will have unfavourable effects in the future.

Furthermore, every time I go shopping I am amazed by the range of new products popping up on the shelves with all sorts of packaging to entice us, the consumers; old products getting cheaper leading to people throwing out stuff, replacing the not so old for new. This also disgusts me. Our resources on Earth are finite. They do not go on forever. There may come a time when people realise that we have no more resources to sustain our current lifestyles, especially if we do not stop this wasteful consumerism. In Buddhism, wasteful consumption is just as bad as the mining companies creating destructive mine sites. There will come a time for the wasteful consumer where they may have a change in their current financial situation and can no longer afford to spend on luxury goods or to throw away stuff that is still useable.

This was the impetus for the birth of The Mining Dilemma Story. This story was delivered to the same cohort of students; however, by this time they had been promoted to Year 10 and were streamed into three classes of different academic ability. I found it really interesting how the different classes responded to the

same dilemma story. Based on my observations and the interview responses from previous Year 9 students, I changed how I delivered The Mining Dilemma Story to my students. Instead of having the dilemma story at the end of the term, I integrated it into their science curriculum. Reasons for that and the story are discussed in Chapter 4. The Mining Dilemma Story was delivered as part of the outcomes of “Natural and Processed Materials”, where students were learning about the chemistry behind extraction of metals and mining.

My Role as the Teacher Researcher

At the onset, I felt that it was important to differentiate between my roles as a teacher and a researcher. Many times during the start of my journey as a researcher I questioned myself: Would I do this if I was teaching the class purely as a science teacher? But what should I do if I need to get results for my research? Should I deliver my lessons this way so students will find it engaging and thus make the results on my questionnaire better? I was in a very confused state about the relationship between my teaching and research roles!

I eventually resolved the conundrum after coming to the realisation that I am in a unique position. On the one hand, I am a teacher with a duty of care for the students in my class, making sure that they are still learning what is required of them as outlined in the curriculum. On the other hand, I am a researcher and so I will observe my students in class, interview them in order to clarify their reactions to the dilemma stories, and finally reflect on what this all means for improving my teaching practice.

Thus my role in this study involved being an active participant as a researcher, teacher and learner. Britzman (2003) points out that we cannot study the experience of learning to teach without returning and reflecting on our own experiences of education and particularly teacher education. All that I think about, all decisions, questions, and all that I write in this research text is mine,

written from my perspective. In this way I shall achieve transferability of this research by writing narratives for a professional audience.

Research Methodology

As this research was conducted within my own classrooms with my students as the natural participants in this action research, the role of teacher-researcher afforded me the opportunity to enhance my professional judgement making, which is a well-established practitioner methodology within the social sciences. There are different types of research paradigms discussed in the current literature, including positivist, interpretive and critical paradigms (Taylor & Medina, 2011; Taylor & Wallace, 2007; Bullough & Pinnegar, 2001; Guba & Lincoln, 1989). And then I came across terms such as ‘mixed paradigm’ and ‘multi-paradigmatic transformative research’, and I was perplexed when the same terms are slightly altered to include ‘post positivism’ and ‘pluralism’ (Taylor, Taylor, & Luitel, 2012).

I wondered why social science research needs to be so confusing!! Coming from a science research background, where I had completed my honours research, I was mostly engaged in the positivist paradigm, a straight-forward and common methodology used in the physical sciences. Thinking back, even at high school and university, lab reports are taught and written in the positivist paradigm. This is even true for my own teaching practice at Hopefield College. When assessing students in the investigation component of the science curriculum, I teach according to the positivist paradigm, where students record results on experiments and justify their hypothesis based on the results obtained.

Reading through the literature, I found the mixed paradigm research approach which allowed me to engage in reflective practice, drawing on the quality standards of self-study set by Bullough and Pinnegar (2001) and Brookfield (2000). The nine guidelines set out by Bullough and Pinnegar (2001) are as follows.

Guideline 1: *Autobiographical self-studies should ring true and enable connection.*

Guideline 2: *Self-studies should promote insight and interpretation.*

Guideline 3: *Autobiographical self-study research must engage history forthrightly and the author must take an honest stand.*

Guideline 4: *Biographical and autobiographical self-studies in teacher education are about the problems and issues that make someone an educator.*

Guideline 5: *Authentic voice is a necessary but not sufficient condition for the scholarly standing of a biographical self-study.*

Guideline 6: *The autobiographical self-study researcher has an ineluctable obligation to seek to improve the learning situation not only for the self but for the other.*

Guideline 7: *Powerful autobiographical self-studies portray character development and include dramatic action: Something genuine is at stake in the story.*

Guideline 8: *Quality autobiographical self-studies attend carefully to persons in context or setting.*

Guideline 9: *Quality autobiographical self-studies offer fresh perspectives on established truths.*

As part of my transformative research using critical autobiography, I endeavoured to adhere to these guidelines to ensure the quality standard of my research. As put nicely by Taylor, Taylor and Luitel (2012), “transformative research involves a process of examining critically our personal and professional values and beliefs, exploring how our lifeworlds have been governed, appreciate our own complicity in enculturating uncritically our students into similar lifeworlds, and committing to transform science education curricula and/or pedagogical practices within our own institutions”. I found myself to be doing all of the above in my learning journey. It was exciting to find out that my learning journey had a more exciting term – ‘transformative research’ – in the field of the social sciences and that critical autobiographical research is a powerful means of fuelling the political

endeavour to make science classrooms more culturally relevant and personally meaningful to students worldwide (Taylor & Settelmaier, 2003).

Ethical Issues

Throughout this research I observed the principles of fairness, beneficence and non-maleficence (Cohen et al., 2000). Year 9 and 10 Science students enrolled in Hopefield College were recruited for this study. Potential research participants were approached in February 2011 and I explained the voluntary process of the study and the time needed for participation. Students volunteered for the research component as the dilemma story learning was compulsory for all students in science.

At Hopefield College, teachers have huge curriculum freedom. Being the only science teacher in my team, I am solely in charge and responsible for my own science curriculum. Thus dilemma story learning became compulsory for all students as I could see the value of implementing ethical learning into the science curriculum. I fully informed students and their parents about the nature and purpose of this research, orally and in writing, so that they had a full and frank understanding of this research. The information sheet is in Appendix A.

A consent form was distributed and volunteer participants were required to return the form prior to the start of the research. Participants were made aware that they may withdraw from the research at any time without any negative consequence for their school results. Assurance of anonymity and confidentiality of participants was given in writing. Students' identities and the school's name were protected through the use of pseudonyms in accordance with the ethical protocol of the research. Permission to conduct the research was also obtained from Hopefield College.

Collecting Evidence

Research participants were drawn from Year 10 students, males and females, between the ages of 15–16 years old, enrolled at Hopefield College. These students were from both my Year 9 and 10 science classes, who had completed both The Prime Minister Dilemma Story and The Mining Dilemma Story in 2010 and 2011, respectively.

Data were obtained from unstructured and semi-structured participant interviews, pre- and post-surveys and my own journal writing. Clandinin and Connelly (1990) describe journals as powerful ways for individuals to give accounts of their experiences. Comments in journals were sometimes used as starting points for my interviews with students. A range of research methods was employed.

Student Observations

As the teacher-researcher, I reflected in my journal upon the teaching and research process. According to Lincoln and Guba (1985), a reflective journal is a diary in which the investigator records information about him- or herself that provides information about the researcher's insights, methodological decisions, and questions related to the study. I included quotes from students that I remembered from previous science lessons or observations.

Pre and Post Questionnaire

In 2009, I administered a questionnaire before the teaching dilemma activity. The Values Learning Environment Survey (VLES) questionnaire, developed by Taylor and Settelmaier, which was used in this study is part of a larger multi-school research project (funded by an ARC grant) that is using the VLES. The questionnaire was designed to obtain measures of students' attitudes towards dilemma story learning and of their perceptions of key aspects of the learning environment, especially the extent to which they engaged in supported and meaningful learning, reflective thinking, empathic communication and collaborative decision-making. I also administered the VLES on completion of the dilemma activity, with the initial purpose of conducting the research in the

positivist paradigm, seeking to measure changes in the learning environment due to dilemma learning.

The VLES generated measures of students' perceptions of key factors of the classroom learning environment that are conducive to ethical dilemma learning (Settelmaier, 2009). For readability purposes, the factors were re-named on the questionnaire: 'How I feel about this class' (deep engagement), 'The teacher' (teacher support), 'Learning to work together' (collaborative decision-making), 'Learning to listen' (empathic communication), 'Learning to think' (critical self-reflection), 'Learning about science' (critical social thinking), and 'The story'. A copy of the VLES is in Appendices B and C.

The VLES has a 5-item Likert-type frequency response scale, ranging from 'almost always' (5) to 'almost never' (1). Statistical analyses were confined to calculation of the class mean score and standard deviation for each scale; and individual item analyses were conducted to help generate 'thick descriptions' of selected students. In Chapter 3, the VLES results are discussed for selected students. For my case study participants, I focussed on two of the factors in the VLES questionnaire, namely, 'How I feel about this class' (deep engagement) and 'Learning to think' (critical self-reflection).

Interviews

Results of the VLES, especially measures of students' attitude to dilemma learning, were used to identify a sample of students for interview. Interviews of selected students occurred 2 – 3 times throughout the study. Students who were chosen reported attitudes ('How I feel about this class') ranging from favourable to unfavourable. Individual student interviews of 20-30 minutes duration were conducted by either myself, my supervisor or a research assistant during a spare period. The interviews were audio-tape recorded and transcribed by the research assistant and entered into an NVIVO database. Open-ended questions about students' VLES responses were used to explore students' experiences of dilemma learning.

Shift of Paradigms

As a science educator, I was particularly interested in two of the factors in the VLES questionnaire, namely, students' attitudes to dilemma learning (How I feel about this class) and their engagement in reflective thinking (Learning to think). Initially I was interested in measuring the extent to which introduction of the dilemma story had a positive impact on the students. I wondered, 'how reliable are the pre and post questionnaire results in determining the success of dilemma stories in science?' According to the positivist paradigm, a large difference between pre and the post scores would indicate success! The positivist paradigm is a 'scientific' research paradigm which strives to investigate, confirm and predict law-like patterns of behavior, and is commonly used to test theories or hypotheses (Taylor & Medina, 2011).

From this perspective, one might argue why not compare the pre and post test results to prove the success (or otherwise) of the dilemma stories in engaging the whole class? This was actually my initial research method for my first dilemma story (The Prime Minister Dilemma Story). However, throughout my learning journey, and having been through the second dilemma story (The Mining Dilemma Story), which I outline in Chapter 4, I found that not all students were necessarily giving honest and truthful feedback in the questionnaires due to their low literacy level and dislike for filling in the same questionnaire numerous times (four times for two dilemma stories). Questioning some of the students later confirmed my suspicion that they were not considering their responses to the questionnaire in a serious manner. This was confirmed when I asked specific students and the issue also came up in the student interviews.

This is the main reason why subsequently I decided to embrace the interpretive and critical paradigms, and why I am no longer enthralled by the data generated in the questionnaire, especially as an end in itself. That is not to say that the data generated by the questionnaire became useless. It was useful in giving an indication of how the whole class and individual students had reacted to the dilemma story activity. As a teacher I am, however, much more interested in what

the students had to say in their interviews regarding the quality of their learning and engagement in the dilemma activity and in the discussions I had with them in the process of the activity.

My movement from the positivist paradigm in *The Prime Minister Dilemma Story* to the interpretive and critical paradigms in *The Mining Dilemma Story* was an interesting experience and an eye-opener for me as I became more aware of other research methodologies.

My interest in understanding my students is a hallmark of the interpretive research paradigm which uses ethnographic methods of informal interviewing, participant observation and establishing ethically sound relationships to construct trustworthy and authentic accounts of the cultural other (Taylor & Medina, 2011). Applied to educational research, this paradigm enables researchers to build rich local understandings of the life-world experiences of teachers and students and of the cultures of classrooms, schools and the communities they serve.

And my interest in empowering my students to take their place as active citizens with decision-making skills to participate in society is a characteristic of the critical research paradigm which enables the researcher to practice ‘deep democracy’ (Kincheloe & McLaren, 2000). This activist research role involves identifying and transforming socially unjust social structures, policies, beliefs and practices (Taylor & Medina, 2011). In other words, the critical researcher raises his/her own critical consciousness (Brookfield, 2000) and passes it onto others to help construct a better society.

The critical paradigm fits nicely in my teacher-researcher role because, as mentioned before, I am passionate not only in teaching science but also in empowering my students, to develop their skills to think and reflect on their decisions and, most importantly, for them to be able to see science as relevant to their lives. Students at my school, who come from a low socio-economic background, often view science as useless to their life, and therefore don’t

participate well in it. And because they are so weak in their literacy skills, they will be disadvantaged in terms of “making a difference” to their lives. I want to give my students the opportunity in class to think for themselves, to let them know that they can, in fact, make a difference to their lives through the decisions they make.

Analysis of Data

This investigation of dilemma story teaching was shaped mainly by the interpretive and critical paradigms of social science research aiming to engage students in higher-order learning via ethical dilemma story teaching and to understand its impact on students’ engagement in the science classroom. In particular, I wanted to understand the impact of this innovative pedagogy on (i) my students’ attitude to learning, (ii) their abilities to reflect critically on their ethical values, and (iii) their awareness of the impact on society of the misuse of science and technology which gives rise to ethical dilemmas confronting society.

Thus the interpretative data analysis process was regulated by the quality standards of member checking, thick description and transferability. Member checking is an important contributor to the credibility of inferences made about others’ thought, beliefs, values, intentions, and Erlandson, Harris, Skipper and Allen (1993, p. 31) describe it as an “imperative.” Regular informal member checking was conducted throughout the interview process and the numerous informal conversations I had with my students as I asked them to verify emerging interpretations and clarify misunderstandings.

Thick description is the rich, detailed description of “everything that a reader may need to know in order to understand the findings” (Erlandson et al., 1993, p. 145). I have included descriptions of the selected students, the context of Hopefield College, and have incorporated an abundance of students’ quotes with the aim of drawing the reader into the construction of this research. This allows the reader to determine the possibility of transferability for their own context.

Unlike traditional research in which the responsibility lies with the researcher “to ensure the findings can be generalized to the population,” interpretive research posits the responsibility for demonstrating transferability “to those who would apply it to the received context” (Erlandson et al., 1993, p. 33). Together, this research utilised the techniques of member checking and thick description to facilitate transferability

Case studies

As described by Cohen, Manion, and Morrison (2000), there are several types of case study, with different authors identifying it differently, giving it a different names. Yin (1984) identified three types of case studies in terms of their outcome – exploratory (as a pilot to other studies), descriptive (providing narrative accounts) and explanatory (testing theories). I found my research to incorporate all the above. For example, my case studies in Chapter 3 are both exploratory and descriptive and in Chapter 4 my case studies are both descriptive and explanatory.

Cohen, Manion and Morrison (2000) also suggested that significance rather than frequency is a hallmark of case studies, offering the researcher an insight into the real dynamics of situations and people. This is what I intended to achieve in my case studies. In Chapter 3 I have 4 case study participants - Andrew, Dominic, Gordon and Patrick. In Chapter 4 I have 2 case study participants – Yody and Alice.

Chapter Summary

This chapter has established a methodological framework for my research. The first section introduces the reasons behind using dilemma stories in the research. The second section explicates the data generation process, whereby the methods used to generate data in this research rely on both the quantitative results generated by the VLES pre-post questionnaire, and the qualitative data generated through students’ interviews and classroom observations. It also outlines my shift

from the positivist paradigm to the interpretive and critical paradigms of social science research, with reference to the quality standards set by Bullough and Pinnegar (2001).

Chapter Three – My First Dilemma Story Journey

Introduction

This chapter describes my initial journey into this innovative way of using ethical dilemma story teaching in science and is divided into three sections. The first section addresses the reasons why I chose to write up The Prime Minister's Dilemma Story, how I delivered the story to my students and the challenges I faced along the way. The second section looks at the overall class results of the students' VLES pre and post questionnaires, which was important for determining how I chose my case study participants. The third section presents some of the in-class observations of the students and focuses on four students – Andrew, Dominic, Gordon and Patrick – who were interviewed and analysed using rich descriptions. All names used for students are pseudonyms in order to maintain privacy and anonymity.

My Starting Journey

As mentioned in Chapter One, most of my students at Hopefield College come from low socio-economic backgrounds, with 47% of the school population being Aboriginal students. Science education seems to be largely irrelevant to them as they appear to have the perception that either they already have it all worked out, or that science is not going to be any use for them in their future!!

As a science teacher in such a school, it is very important that I have activities that are engaging and purposeful at the same time. When I was first introduced to dilemma story teaching I immediately saw the potential of engaging my students in a topic that might interest them. I believed that this innovative teaching approach might help me connect with their interest in topical issues in the world beyond school, while at the same time connecting with the Science curriculum. I really liked the idea of tapping into the students' personal values in an attempt to engage them in learning science.

In 2010, my Year 9 science class had recently completed the outcomes in the topic ‘Earth and Beyond’, where we looked at science concepts relating to the solar system, eclipses and space travel. This was the impetus for the design and implementation of ‘The Prime Minister Dilemma Story’ (see Figure 2). As a kid, I was always intrigued by the amount of money being spent by the American government on the NASA project, when at the same time there are poor and starving people in America itself. How can such a situation be happening? Is it possible that space exploration is more important than solving the current problems the country is facing?

The implementation of The Prime Minister Dilemma Story was intended to enable my students to personalise their learning by linking it to space exploration and environmental sustainability, which are the outcomes for ‘Earth and Beyond’ in the Western Australian curriculum. The Prime Minister Dilemma Story was taught to all three of my Year 9 science classes during Term 4 in 2010.

The story encourages students to put themselves in the position of the Prime Minister of Australia. The Prime Minister must invest money either (i) to further the needs of a small proportion of the population through space exploration (thereby improving Australian livelihoods) or (ii) to provide aid to underdeveloped societies and in doing so address issues of global poverty and disease.

This ‘rich task’ learning activity aims to provoke a greater understanding of social justice and social and environmental sustainability by encouraging students to consider the long-term and short-term implications in conjunction with decision-making.

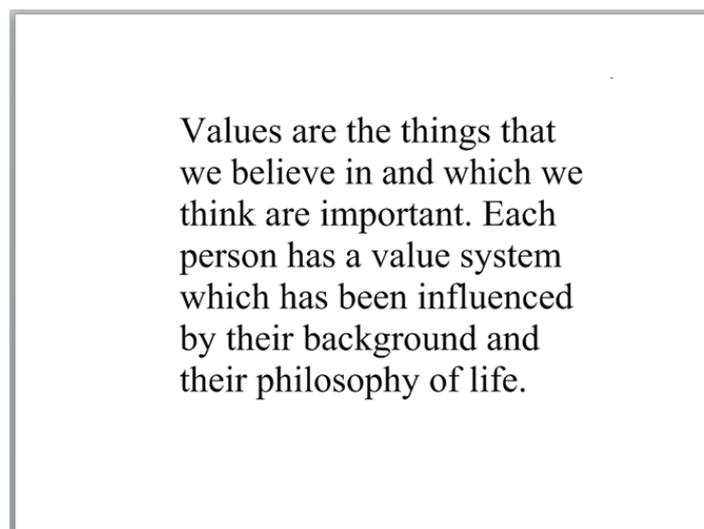
In terms of environmental sustainability, the Prime Minister Dilemma Story seems at first to be ‘outer space’ related, but on a deeper level it indirectly teaches the students about environmental sustainability. First, that resources are finite. In the activity students may allocate the money to only one of the organisations and

so the other will necessarily miss out. Second, when they research the pros and cons of the two organisations they learn about conditions in Third World countries and how people living in Australia and other First World countries are being environmentally unsustainable in terms of the amount of wastage produced, natural resources used and pollution being created.

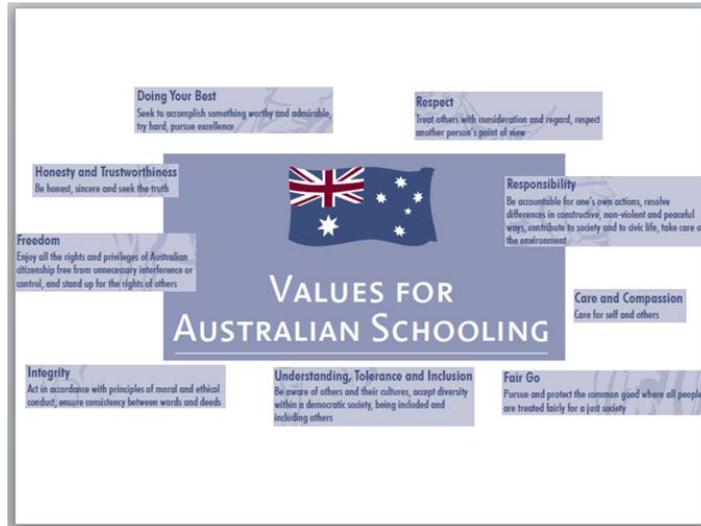
The Prime Minister Dilemma Story



Slide 1



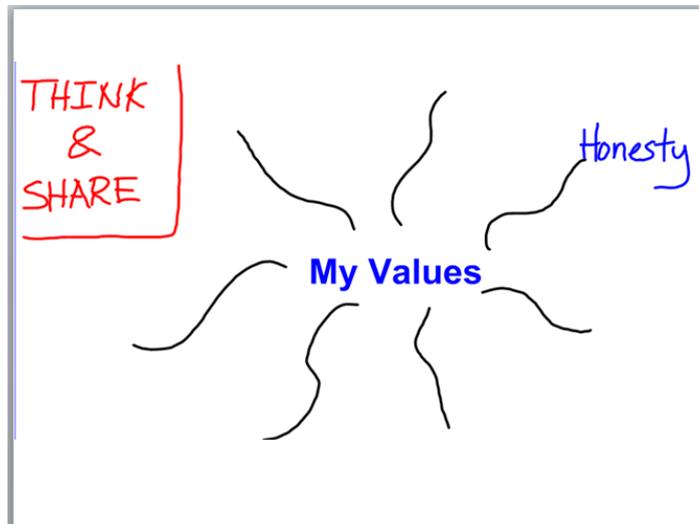
Slide 2



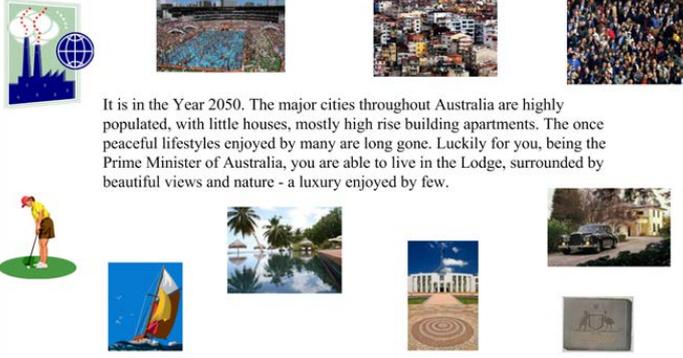
Slide 3

Justice (fairness, honesty)	Peace of Mind (freedom from inner conflict)
Intelligence (ability to understand)	Self-Determination (power to control own life)
Wealth (material comfort and security)	Happiness (satisfaction, joy, contentment)
Friendship (trust, companionship)	Self Respect (pride, confidence in yourself)
Excitement (adventure, travel, interest)	Authority (total order, confidence in leadership)
Social Recognition (respect, admiration, fame, status)	Environment (appreciation of nature)
Achievement (contribution to society)	Freedom (power to do what you want to do)
Eternal Life (Heaven, life after death)	Learning and growing as a person
Peace (freedom from war and personal conflict)	Service (giving/doing to others)
Pleasure (enjoyment, comfort)	Popularity (being liked, respected)
Beauty (appreciation of nice things)	Belonging (being accepted by others, not isolated)
Security (personal and national protection)	Glamour (attractive lifestyle, excitement, not mundane)
Equality (opportunity for everyone)	Power (able to make changes, influence, control)
Love (closeness, intimacy, self-giving)	Stability (lack of sudden unexpected changes)
Family (security, care, closeness)	Comfort (ease, pleasure, relaxation)

Slide 4



Slide 5



It is in the Year 2050. The major cities throughout Australia are highly populated, with little houses, mostly high rise building apartments. The once peaceful lifestyles enjoyed by many are long gone. Luckily for you, being the Prime Minister of Australia, you are able to live in the Lodge, surrounded by beautiful views and nature - a luxury enjoyed by few.

Slide 6

The Australian Government has a \$500 billion grant spanning 5 years, open to application for different organisations. The aim of this grant is to provide the winning organisation with the financial resources to make a difference to the human race. The \$500 billion grant is subject to renewal each year based on evidence of achievement in the project. There will be 7 panel members involving in the selection of the winning organisation, and you being the PM, will of course be one of the panel members.



Slide 7

**THINK
PAIR
SHARE**

Put your thinking cap on and decide which types of organisations should apply. You can make up your own organisation based on your values.

Organizations that should apply



Slide 8

Many organisations apply and there are 2 finalists:

1) Space exploration - finding the unknown in space. What's out there? Are there any living beings out there? Any sustainable place for the overcrowding human population in Australia?





Slide 9

2) Third world countries help organisation - providing aid to third world countries, solving problems such as spreading of AIDS, unclean water, safe waste disposal etc.











Slide 10

You are one of the 7 panel members that will hand down the decision as to which organisation will receive the grant. At the moment, 3 panel members support space exploration, while the other 3 members supported the third world countries help centre. You are now left with the power to decide which the winning organisation is.

Which organisation will you vote? Explain and justify your decision to the rest of the panel member.





Slide 11

THINK
 3 pairs
 SHARE

My original vote: _____

Group members votes: _____

My final vote : _____

Reasons: _____

Slide 12



As it turned out, space exploration won the \$500 billion grant as one of the panel member changed his mind and four out of the seven panel members voted for space exploration. In the first year the space company - discovered a planet not too far from Earth that has the same living environment. This would mean that humans would be able to move to this new planet and start afresh. However the catch is that only half of the Australian population would be able to move to this new planet. Reason being that the size of this new planet is only one tenth of the size of the Earth. The researchers are confident that within the next 2 years, they would be able to start transporting people to the new planet. You are very excited by the prospect of this news.







Slide 13





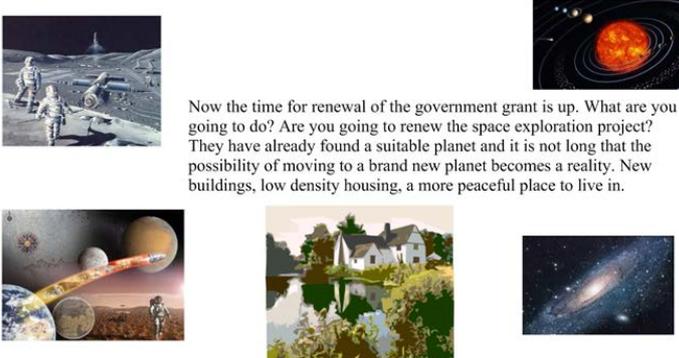






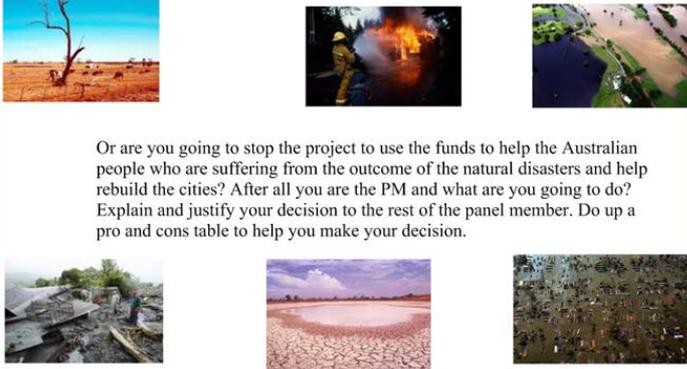

Unfortunately due to climate change, Australia was hit by a series of natural disasters such as heat waves, tsunamis, storms and bush fires during the year. Many Australians are badly scarred by this experience and needed medical attention and counselling due to the loss of family members. The country is in such a bad shape that rebuilding the major cities is going to take a long long time (approximately 10 years)

Slide 14



Now the time for renewal of the government grant is up. What are you going to do? Are you going to renew the space exploration project? They have already found a suitable planet and it is not long that the possibility of moving to a brand new planet becomes a reality. New buildings, low density housing, a more peaceful place to live in.

Slide 15



Or are you going to stop the project to use the funds to help the Australian people who are suffering from the outcome of the natural disasters and help rebuild the cities? After all you are the PM and what are you going to do? Explain and justify your decision to the rest of the panel member. Do up a pro and cons table to help you make your decision.

Slide 16

THINK
4 Pairs
SHARE

My decision: _____

Reasons: _____

Group's Pros & Cons table:

Pros	Cons
------	------

My final decision: _____

Slide 17

An unexpected twist. The rest of the Australian government decided that all Australian should be allowed to have a say in this important decision as it will impact on them. This decision should not lie in the hands of those 7 panel members. You suddenly feel a sense of relief.

When this news was made public, there was a mixed reaction from the Australian people. People from wealthy and power-position background wanted to vote for the renewal of the space exploration project as they see there is no point in rebuilding Australia when people can move into a new planet within 2 years.

On the other hand, people from disaster-stricken background do not support the space exploration project, saying that what's the point of the project continuing if only half of the Australian population are going to be living there? What is going to happen to the other half? Are they expected to live in ruins and left to fend for themselves?



Slide 18

Meanwhile, the United Nations are not providing any monetary aid to Australia after learning about its \$500 billion grant. The United Nation reckons that if Australia has that amount of money, it would be able to help itself.



What are you going to do now? The Australian people would like an answer from you in one week. What is your plan of action? You will need to justify your decisions and action to the Australian people.

Slide 19

As a group or individually, design a newspaper advertisement promoting the Government decision

colours pictures A3 size

clear + concise Bold headings

Slide 20

Figure 2: Original SMARTBoard slides used in the delivery of *The Prime Minister Dilemma Story*.

Teaching the Prime Minister Dilemma Story

The Prime Minister Dilemma Story was delivered using the new technology we have in the science lab – the SMARTBoard. The SMARTBoard is a combination of an electronic whiteboard and a data projector. Lessons can be designed using the SMARTBoard software, a content delivery platform similar in style to Microsoft PowerPoint, for building lesson activities and presentations. A projector connected to the computer displays the computer's desktop image on the interactive whiteboard.

Figure 2 shows a series of original slides that I used with my Year 9 students when introducing The Prime Minister Dilemma Story to the science class. In conjunction with the SMARTBoard lesson, I also designed a worksheet given to each student so that they could write their responses to the four dilemmas presented in the story (refer to Appendix D).

Taking into account the rationale of dilemma story teaching, which involves teaching values in the science classroom, I introduced students to the idea of values (refer to slides 2 and 3 in Figure 2) by showing them the types of values the Department of Education has intended students to gain in their school education as an essential part of effective schooling in Australia (Department of Education, Science and Training, 2005).

I then directed them to think about their personal values, using a Think-Pair-Share strategy, with the purpose that this will guide them in making their decision when they encounter dilemma questions in The Prime Minister Dilemma Story (refer to the slides 4 and 5 in Figure 2). Think-Pair-Share was first proposed by Lyman (1981) as a teaching strategy to induce cooperative learning and promote higher-level thinking. A question is posed whereby students have to consider alone (Think) and then pair up with a partner to discuss their answers (Pair) before having to share with the whole class (Share). This can be a great way to motivate students, especially students with low academic ability as it is a relatively low-risk and short collaborative learning structure.

The Prime Minister Dilemma Story was divided into three parts, with a Think-Pair-Share component in each. This model of teaching was adapted from Settelmaier's ideal model of teaching dilemma stories (see Figure 1 for details).

In the first part of The Prime Minister Dilemma Story, students were asked to decide which types of organisations should apply for the government grant (refer to slides 7 and 8 in Figure 2). This was quite a challenging task for them as they had to come up with at least three organisations. The thinking part became quite short, literally lasting for 15 seconds, before the students turned to their partners for discussion. While circulating around the classroom, I found that students were struggling to come up with organisations, and therefore I spent time with each group, helping them along the way by asking them what they were most interested in and asking them to look at their values in order to come up with organisations in line with their personal values. The initial struggle to suggest types of organisations was observed in all three of my science classes.

The second part of the story (refer to slides 9 – 12 in Figure 2), asked students to vote on which of the two organisations – Planet *Xplorer* or *AUSworld* – should receive the grant. The aim of each organisation is explained on slides 9 and 10. It was a relatively easy task, and the Think-Pair-Share strategy worked well.

The third part introduced a twist to the story whereby Australia was hit by a series of natural disasters, so the students' next dilemma was to decide whether to continue funding Planet *Xplorer* or to use the remaining grant to save Australia by helping the Australian people suffering from the impact of the natural disasters (refer to slides 13 – 17 in Figure 2). Most students seemed to find this decision making relatively straightforward, with only a few struggling with the dilemma of putting themselves in the Prime Minister's shoes and making a decision that goes against their personal belief. An example was when a student asked me "So Miss, since I am the PM, I have to help Australia don't I, even if I really want to continue funding space exploration?"

I ended the lesson by collecting the sheets students had been writing on and told them that they will be making a poster in their next science lesson (refer to slide 20 in Figure 2). They could choose to either work in groups or individually.

Making the Poster

The purpose of having the students design a poster came from Settelmaier's original idea. In Settelmaier's doctoral thesis, she ended a dilemma story with a poster making session with the idea of having the students present their views on a poster (Settelmaier, 2003). Initially I was not convinced that this would be the best way to end the dilemma story but I decided to 'stick to the rules' and gave it a shot anyway.

A difficulty I encountered in the poster making sessions was that not all of the students had been present when I had delivered the dilemma story on the SMARTboard and, due to the length of the dilemma story, most of the students were not able to remember all the details of the story. To make it simpler and easier for everyone, I shortened the story (see Figure 3) and retold the story verbally (without use of the SMARTBoard) so students needed only to decide between space exploration or helping out Australia when disasters hit. The shortened version is basically a combination of slides 6 – 11 in Figure 2. After discussion with some of my students, I gave them the freedom to choose their preferred form of presentation. They could either present it in the form of a speech, a newspaper advertisement or a poster, outlining the pros and cons of their decision. To make the poster-making sessions more accountable and challenging, I told the students that they will be standing up in front of the whole Year 9 cohort presenting their posters and their point of view in the next Year 9 assembly.

In summary, the approach to ethical dilemma teaching involved individual reflection followed by small-group discussion using the Think-Pair-Share strategy. This culminated in a poster-making activity, where students either worked in pairs or individually to design a newspaper advertisement promoting the Government's decision.

It is in the Year 2050. The major cities throughout Australia are highly populated, with little houses, mostly high rise building apartments. The once peaceful lifestyles enjoyed by many are long gone. Luckily for you, being the Prime Minister of Australia, you are able to live in the Lodge, surrounded by beautiful views and nature – a luxury enjoyed by few.

The Australian Government has a \$500 million grant spanning 5 years, open to application for different organizations. The \$500 million grant is subject to renewal each year based on evidence of achievement in the project. There will be 7 panel members involving in the selection of the winning organization, and you being the PM, will of course be one of the panel members.

Many organizations applied and it came down to 2 final ones:

- 1. Planet Xplorer – finding the unknown in space. What's out there? Are there any living things out there? Any sustainable place for the overcrowded human population in Australia?*
- 2. AUSworld – providing aid to Third World countries, solving problems such as spreading of AIDS, unclean water, safe waste disposal, etc.*

You are one of the 7 panel members that will hand down the decision as to which organization will receive the grant. At the moment, 3 panel members support space exploration, while the other 3 members support the Third World countries help centre. You are now left with the power to decide which is the winning organization.

Which organization will you vote for? Explain and justify your decision to the rest of the panel members.

Figure 3: Shortened version of *The Prime Minister Dilemma Story*.

Classroom Observations

“Good morning guys, today we are doing something different, It is still part of science but I will be telling you a story instead”....and the lesson went on... “Why are we doing this, Miss?” asked a boy with a puzzled look on his face. “Give me a chance to finish the story and you will find out soon”....and the lesson continued... “Ok, now this is your chance to put yourself in the shoes of the Prime Minister and make a decision”... “Eek, I don’t want to be Julia Gillard!!” shouted one boy, followed by his supporters “Yeah, me too, do we have to do this? This is gay”.... “This is boring Miss, can we doing normal science instead”

As a teacher-researcher, my observations of the three classes indicated that students generally were initially somewhat confused about being the Prime Minister when I delivered The Prime Minister Dilemma Story. I needed to repeat some aspects of the story when students needed to make their decision about choosing between Planet Xplorer or AUSworld. This was similar in all three classes. The story also seemed to be a bit too complicated for my students to comprehend and, due to low self-esteem related issues, most seemed to find it difficult to imagine placing themselves in the role of the Prime Minister.

And when it came down to the crux of the story, which was choosing between Planet Xplorer or AUSworld, most students, being used to the perception that answers are always given to them, but now had to think by themselves, constantly asked me which one I would choose if I was the Prime Minister. This despite me having already refused to give them an answer and having reminded them that there are no right or wrong answers in a dilemma situation.

Honestly, I was taken aback by this reaction to The Prime Minister Dilemma Story. When I wrote up the story, I thought my students would love it, since it doesn’t involve much writing and they would participate in discussions. But the

dilemma decision making seemed to take them out of their comfort zone, evoking reactions that were evident in all three classes. (See Figure 4)

Common reactions by my Year 9 students:

- “Why are we doing this stuff?”
- “What is the correct answer?”
- “What would you choose, Miss?”
- “I don’t understand...why are we not doing science?”
- “Are we being assessed on this stuff?”
- “Can we do normal science?”
- “I’m not the Prime Minister and I don’t intend to be, so why do I have to do this?”

Figure 4: Common reactions by my Year 9 students to *The Prime Minister Dilemma Story*.

When it came to the next lesson, which was making the poster, I once again had to retell the story as students were unable to recall all parts of it. It could be that the participation in four Think-Pair-Share discussions might have muddled up their thinking!

Even though students needed lots of help with the posters, asking me what pictures they should put on it, what to write and which one I would choose if I was the Prime Minister, they seemed to be very engaged in the process of researching on the computers and getting their ideas onto the posters. It also seemed that the boys were more concerned about the types of pictures they were going to put on their poster than about their ideas, but overall there were almost no off-task behaviours. While students were making their posters, I was freed to walk around the class and have individual discussions with the various groups,

making sure they were on track with the dilemma activity. I was also fortunate to have a teacher assistant in the class and that helped a great deal. With one of the low literacy ability students, I needed to ask him to explain his ideas to me and help him type them as I knew that if I was to leave him he would probably have found making the poster too hard and would have gone onto games on the computers.

The poster-making sessions took two 55 minute lessons, and although ideally I would have liked to give the students more time, I was running out of time. The school term was almost finished and I had to make sure that there was enough time left for the students to present their posters and for me to interview the selected students.

Poster Presentation

Students were hesitant at the beginning to present their posters in front of the Year 9 cohort. This was a huge ‘shame factor’ for many and an awfully ‘uncool’ thing to do. However, at the encouragement of the other Year 9 teachers, students who had completed their posters stood up and presented their points of view. It was quite hard to hear some of the students as they were too shy and mumbled their words.

My idea of getting the students to present their posters was to get the rest of the cohort to listen to their peers’ point of view and also to expose the presenter to other presenters’ viewpoints. At the conclusion of the poster presentation, after hearing the reasons for and against, all students, including the teachers, voted for either Planet Xplorer or AUSworld. Only four of the audience chose AUSworld, declaring Planet Xplorer as the favourite choice among students and teachers.

I was and still am so proud of the students who stood up to read their posters to the class. It would have been impossible if it was not for the encouragement from the other teachers in the assembly. Some of the students came up to me afterwards and asked if they were going to get an A for their school report now that they had

presented their posters. Although it was an experience that many students would not like to go through again, it made a lasting impression on them.

Whole-Class Engagement in the Dilemma Activity

The Values Learning Environment Survey (VLES) questionnaire (see Appendices B and C) was administered to all three classes before and after implementation of The Prime Minister Dilemma Story activity. It yielded 18 useable student responses (of a total of 21 students who completed the questionnaire). As I started out with the initial purpose of conducting the research in the positivist paradigm, I used the pre and post VLES questionnaires as a mean of selecting students for interview who had shown either an increase or decrease in their level of engagement in the dilemma story.

I was particularly interested in two of the factors in the VLES questionnaire, namely, ‘How I Feel About This Class’ and ‘Learning to Think’. Each factor consisted of 4 items, and was responded to via a 5-item Likert-type frequency response scale, ranging from ‘almost always’ (5) to ‘almost never’ (1).

The ‘How I Feel About This Class’ factor measures attitude to the dilemma story activity. I was interested in this factor as I wanted an indication of students’ engagement in the dilemma story and whether it was enjoyable to them. I was also interested in the ‘Learning to Think’ factor, which measures critical reflective thinking, as my one of my aims as a teacher is to be able to impart thinking skills to my students. I don’t want them to leave school without gaining important critical thinking skills that will be useful to them in their future.

Attitude to the Dilemma Activity

Figures 5 and 6 illustrate results drawn from the post VLES questionnaire, where each student’s (A – R) total score (out of a maximum possible score of 20) is shown.

Figure 5 indicates that all 18 students found The Prime Minister Dilemma Story to be interesting and engaging, with all students indicating positive feelings towards the activity at least some of the time ($Y > 8$). Five students (A, E, G, I, Q) indicated higher levels of affective engagement, agreeing that they found the PM Dilemma Story activity to be often interesting and enjoyable ($Y > 16$), with the remaining 13 students indicating that it was sometimes interesting and enjoyable ($Y > 12$). No student indicated a highly unfavourable attitude.



Item 1: I looked forward to the activity.

Item 2: I found it really interesting.

Item 3: I enjoyed the activity.

Item 4: I felt confused during the activity.

Figure 5: Summary of individual students' responses to the "How I Felt" (attitude) scale in the post VLES, showing each student's total score on 4 items. The negatively worded item 4 was reverse scored. The y-axis represents frequency of occurrence, with 20 representing almost always, 16 often, 12 sometimes, 8 seldom, and 4 almost never. The x-axis represents the individual students (A – R).

My personal observations were that students seemed to enjoy the poster making sessions more than discussing the dilemma story. When The Prime Minister Dilemma Story was introduced to the class, students seemed more concerned with why they were doing it, rather than with the details of the story. However, in the poster making sessions, students asked clarifying questions such as “Can I only choose one organization and not help two at the same time?”

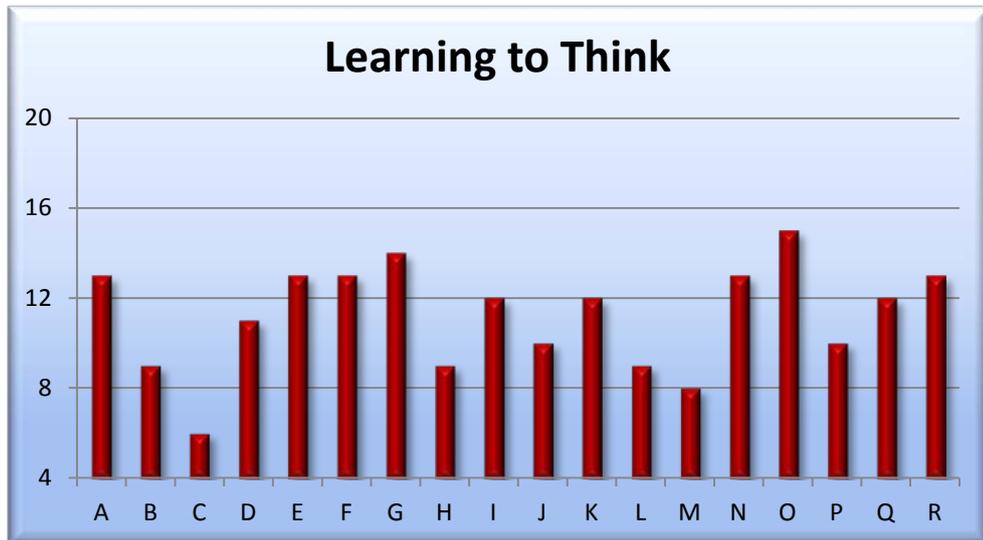
For me, as their science teacher, this is a very positive outcome, especially given that it was the first time these students had been presented with a dilemma story in Science. This is strong evidence that the dilemma story was a good resource for teaching Science to my academically low achieving students. Their overall positive engagement with the PM Dilemma Story was further confirmed during the subsequent interview I held with students and is also consistent with my classroom observations of the students engaging in the two poster making sessions.

Reflecting on the Dilemma Story

Figure 6 indicates that nearly all students (16/18) indicated that engagement in the Prime Minister Dilemma Story activity had stimulated deep thinking about their personal values. All except two students (C, M) indicated that they had reflected on their values at least some of the time ($Y > 8$). One student (M) was unsure about having engaged in self-reflective thinking and another student (C) indicated little or no higher-level thinking activity. Student C is a refugee and comes from an ESL background (English as a Second Language) with a very low level of literacy. Thus it was not surprising to find out that he did not engage in deep thinking as he most probably had trouble understanding some of the words in the story presented to him.

Comparing Figures 5 and 6, there appears to be a positive relationship between students' affective engagement in the dilemma activity (as measured by the attitude scale) and their reflective thinking experience (as measured by the reflective thinking scale). Generally, an increase in their engagement level

corresponds to an increase in their thinking level, although the increase is not uniform.



Item 17: I thought carefully about my own ideas.

Item 18: I questioned my own opinions.

Item 19: I thought about how to solve problems effecting life on Earth.

Item 20: I thought about anything but science.

Figure 6: Summary of individual students' responses to the "Learning to Think" (reflective thinking) scale in the post VLES, showing each student's total score on 4 items. The negatively worded item 4 was reverse scored. The y-axis represents frequency of occurrence, with 20 representing almost always, 16 often, 12 sometimes, 8 seldom, and 4 almost never. The x-axis represents the individual students (A – R).

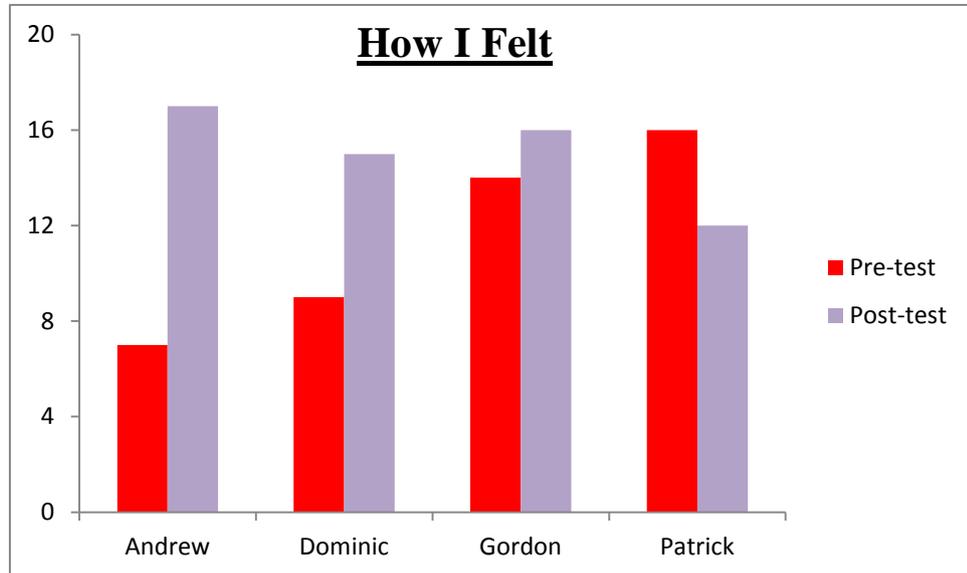
Choosing the Interview Sample

I started my learning journey as a positivist researcher, and this might have to do with my past experiences of being a science researcher where empirical reasoning requires me to look at and analyse quantitative trends in results. I calculated the difference in the whole-class mean scores of the pre and post questionnaire results, and compared the difference statistically, having the initial thought that this metric would ‘prove’ the success (or otherwise) of dilemma story teaching.

Choosing the sample of students to be interviewed was based on five criteria. Firstly, the student must have completed both the pre and post VLES questionnaire. Secondly, the student must have been involved in creating the poster. Thirdly, the student must have stood up and presented their views in the Year 9 assembly. Fourthly, the student needed to have had their interview permission form signed. And lastly, the students needed to have indicated either an increase or decrease in their level of engagement in The Prime Minister Dilemma Story, as obtained from the difference in the scores in the “How I Felt” (attitude) scale in the pre and post VLES questionnaire.

Based on the five criteria, I chose four students – Andrew (A), Dominic (D), Gordon (G) and Patrick (P) (pseudonyms). Andrew, Dominic and Gordon were chosen as they had indicated an increase in engagement; and Patrick was chosen as he had shown a decrease in engagement. Figures 7 and 8 illustrate the pre and post scores in the VLES questionnaire of the 4 students for the two factors I was particularly interested in, namely, ‘How I Feel About This Class’ (attitude) and ‘Learning to Think’ (critical reflective thinking).

Andrew (A), Dominic (D) and Gordon (G), who reported higher levels of affective engagement in The Prime Minister Dilemma Story, also indicated that it frequently stimulated their reflective thinking.



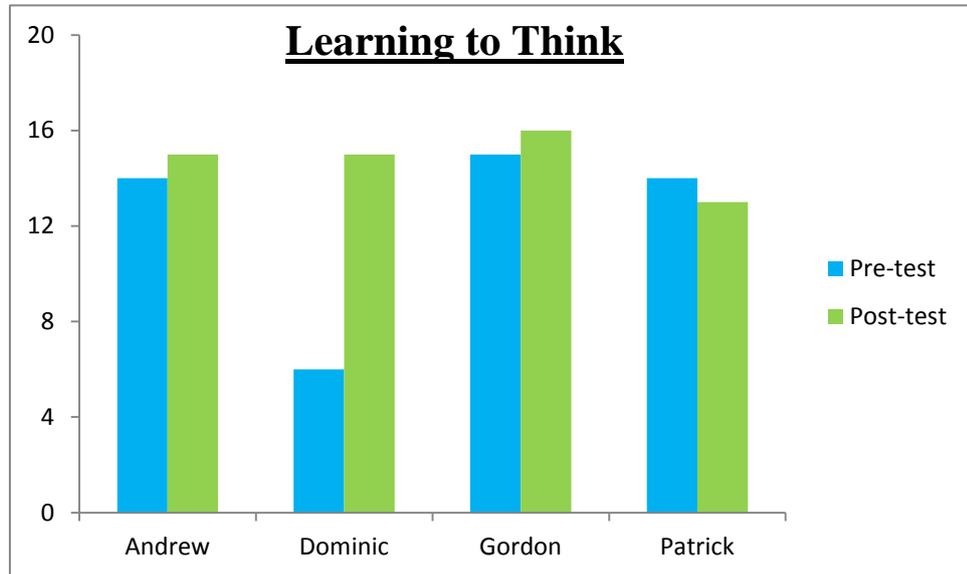
Item 1: I looked forward to the activity.

Item 2: I found it really interesting.

Item 3: I enjoyed the activity.

Item 4: I felt confused during the activity.

Figure 7: A comparison of the four selected students' responses to the "How I Felt" (attitude) scale in the pre and post VLES questionnaire, showing each student's total score on 4 questions. Item 4 was reverse scored. The y-axis represents frequency of occurrence, with 20 representing almost always, 16 often, 12 sometimes, 8 seldom, and 4 almost never. The x-axis represents the individual students.



Item 17: I thought carefully about my own ideas.

Item 18: I questioned my own opinions.

Item 19: I thought about how to solve problems effecting life on Earth.

Item 20: I thought about anything but science.

Figure 8: A comparison of the four selected students' responses to the "Learning to Think" (reflective thinking) scale in the pre and post VLES questionnaire, showing each student's total score on 4 questions. Item 4 was reverse scored. The y-axis represents frequency of occurrence, with 20 representing almost always, 16 often, 12 sometimes, 8 seldom, and 4 almost never. The x-axis represents the individual students.

Individual Student Engagement

Andrew (A), Dominic (D), Gordon (G) and Patrick (P) were interviewed after they had presented their poster in the assembly. Andrew and Gordon were interviewed individually, while Dominic and Patrick were interviewed together.

The interview questions were based on three themes – their likes or dislikes of The Prime Minister Dilemma Story, relevance of the Prime Minister Dilemma Story to their life, and discussion of The Prime Minister Dilemma Story at home. These themes relate to my interests in implementing programs. I enjoy making up interesting science programs and in this case as it was my first time writing a dilemma story with the aim of promoting critical thinking in my students, I wanted to know if students found it enjoyable and whether it excited them to the extent that they wanted to continue the discussions at home with their parents, and if the dilemma story had created any impact on their lives. This was the reason why I was particularly interested in the two factors in the VLES questionnaire, namely ‘How I Feel About This Class’ (attitude scale) and ‘Learning to Think’ (reflective thinking scale). Results for these two factors for the four students are illustrated in Figures 7 and 8. I will now introduce the selected interview participants individually.

Andrew

Andrew is a highly unmotivated fifteen year old Australian student. He is the sort of student who whinges when presented with any science work and constantly has to be pushed and sometimes threatened with lunch detention to produce work in class. Andrew aspires to get a job as a mechanic after finishing Year 12 and has the intention of working in the mines.

Andrew was absent on the day when the dilemma story was taught but when I explained it to him the next day he had no problem getting straight into the poster activity. No different from the other students, he asked questions such as “What would you choose, Miss?”

Being a person with low self-confidence, Andrew walked around the class hoping to get some ideas for his poster. He became intrigued with the space pictures that came up on Patrick’s computer screen and he sat with him going through the pictures that came up on Google images. Next to him, sat a student looking at pictures of Third World countries. “Andrew, have you made up your mind?” Miss Chow called across the classroom.

Figure 9 shows the poster that Andrew produced on that day. I recall him having trouble getting the poster done. He was too distracted looking at what the other students in the class were doing and also ‘catching up’ with his mates due to his absence from school the day before. I managed to get him to work on my laptop to lessen the distractions around him and at the same time helped with the spelling of the words he had trouble with.

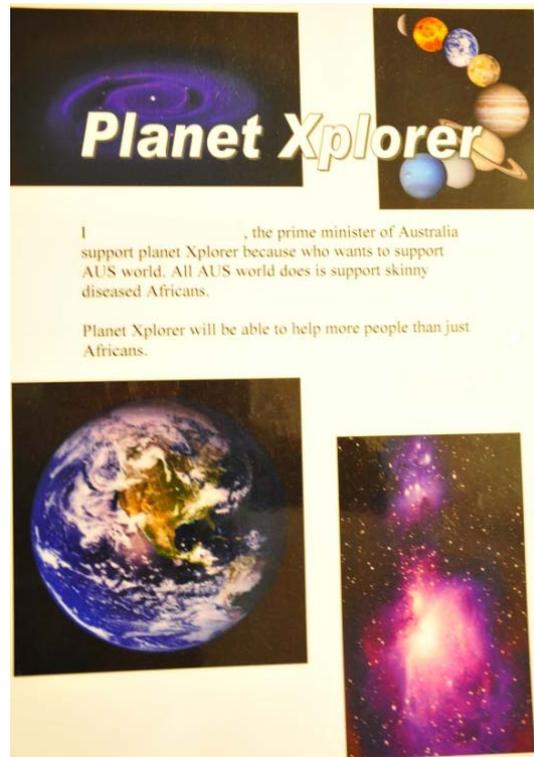


Figure 9: Andrew’s poster

In the interview, Andrew expressed that he ‘felt weird’ that the science class was doing dilemma stories and that it seemed strange to be doing this type of learning in science. However, he said “It’s pretty fun after a while.” When asked if the

story was relevant to his life, he replied “Yeah, because if I was the PM, I would have to make the decision.”

I found Andrew to be highly engaged with the learning activity in the Prime Minister Dilemma Story. This is strongly indicated by the big difference in his responses to the attitude scale (“How I Felt”) in the pre and post questionnaire (Figure 7). For item 3 (I enjoyed the activity), Andrew rated it a 5 (almost always) in the post VLES questionnaire for The Prime Minister Dilemma Story activity, compared to a 3 (sometimes) for normal science lessons. When I asked if he had mentioned the dilemma activity to his family, he replied “Yes, I had a 10 minute discussion with my mom after we did the debate. My mom said that I should have picked AUSworld instead of Planet explorer..coz she feels sorry for them and wants to help them.”

It is unfortunate that Andrew’s poster shows little indication of his engagement. This is partly due to his poor literacy skills and I suspect his distraction during the poster making session. As mentioned before, Andrew was busy looking at the pictures his friends were looking at and also doing some ‘catching up’ with his mates due to his absence from school the day before. His intrigue with the space pictures on Patrick’s computer screen might be the reason why he chose Planet Xplorer over AUSworld although I did not have the chance to confirm my suspicion.

Halfway through the interview, Andrew made a comment that I had never thought would come from him. While studying Gordon’s poster, he kept looking at the picture of a malnourished African child, and he said “That sucks...look how skinny he is..he’s got big feet but he’s skinny as a twig..it sucks..” When I asked him if there was anything he could do about it, he replied “No”, and I initiated a brief discussion about not wasting food by not throwing it away, to which Andrew listen and agreed, nodding his head along the way. This is evidence of Andrew’s reflective thinking but unfortunately this could not be seen in Figure 8, as the post VLES questionnaire had already been administered before the interview was conducted. A limitation of the positivist methodology.

It is very unusual that I was able to have this rich discussion with Andrew outside of the science classroom as it has never happened before. We were talking about what constitutes a dilemma, problems faced by people in Africa and, most importantly, what he could do to help alleviate the problem. I felt very privileged to be able to have this mature conversation with him and, for once, I was not telling him off for not doing the right thing, which always happened in class.

Dominic and Patrick

Dominic is a normal average high school boy of Serbian ethnicity. He doesn't muck up too much in classes, can be a bit talkative but will stop and do the right thing when instructed. Sports being his favourite subject, Dominic has his goal set on entering a soccer specialised school in Year 11. His aspiration is to become a soccer player if opportunities arise or to study Engineering at university.

Patrick, on the other hand, is a dreamer. He loves to draw and it is not unusual that his science file is covered with his art. Patrick was born in Australia but both his parents are Romanian, and he is one of six children in his family. Due to his parents' influence, he strongly believes that hard work will help him get ahead. Patrick's aspiration is to study Astronomy and to become an astronomer.

Patrick is a typical boy who has the idea that science is about making things explode. He is forever asking when we will be doing experiments that blow things up. It is not surprising that when I asked him how hard he had to think to make up his decision between Planet Xplorer and AUSworld, he replied "Usually, I would find it hard, but because I knew the Earth is going to blow up, awesome crap..and we are just going to die, so I chose Planet Xplorer. If there was to be human survival, it will have to be on a different planet."

Both Dominic and Patrick expressed that Sports is their favourite subject at school with English being their least favourite subject. Figures 10 and 11 show the posters that they produced. Simple English was used in both posters and this is not surprising given that English is not their strongest subject.

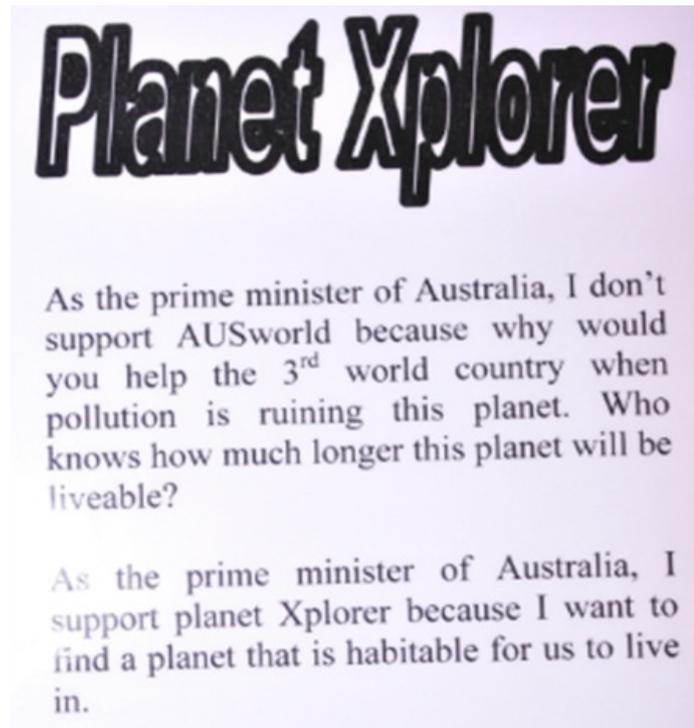


Figure 10: Dominic's poster.

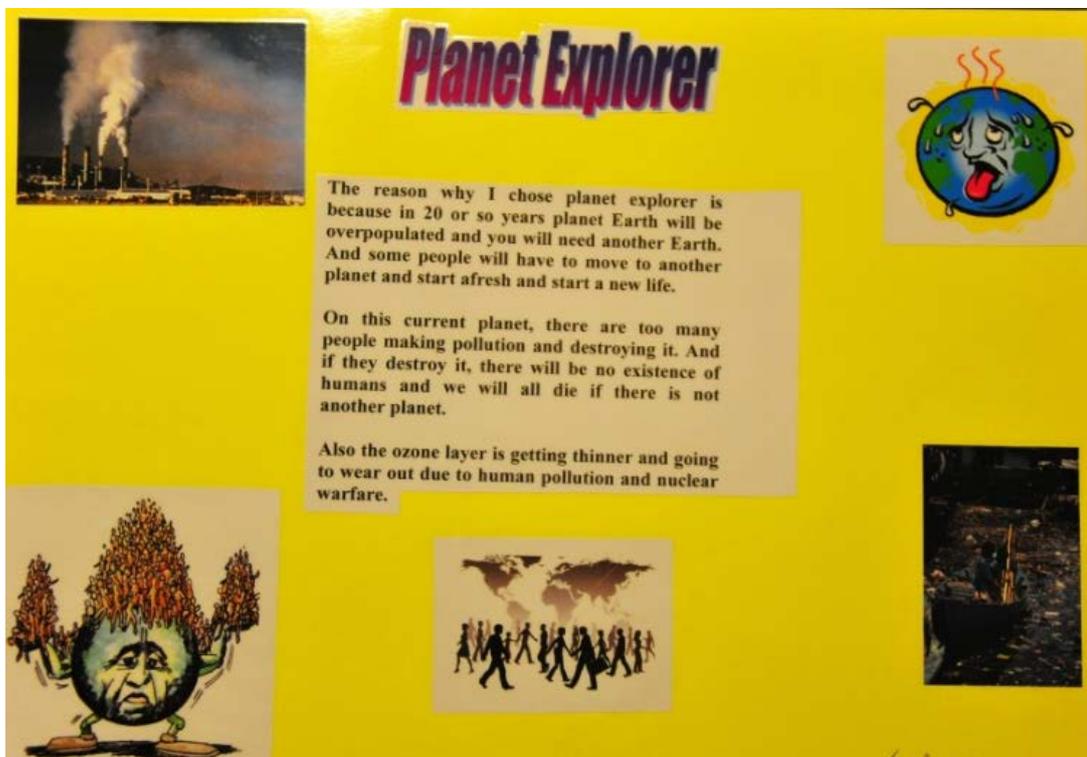


Figure 11: Patrick poster.

It is intriguing from Patrick's poster (see Figure 11) that it did not contain any space-related pictures that he was looking up on the computer earlier on. Instead he focused on the current state of the Earth, choosing pictures of pollution and overpopulation to get his point across. This suggests that he was thinking deeply whilst engaging in the dilemma story activity, otherwise he would have plastered space pictures over his poster like Andrew's.

During the interview with Patrick and Dominic, both indicated that they wouldn't mind doing more dilemma stories in science. When I asked Patrick the reason why he had shown a decrease in his level of engagement (see Figure 7), he replied "It's pressuring to choose, that's why it's called a dilemma...I just don't like to choose." This explains why Patrick's attitude scale dropped, while the reflective thinking scale stayed high (see Figures 7 and 8).

After almost a year since I introduced The Prime Minister Dilemma Story to Dominic he could still remember the gist of the story. We were having an informal conversation about his ranking of subjects and he ranked Sports first, followed by Mathematics and Science coming in third. When I asked Dominic if doing more dilemma stories would increase his ranking of science, he replied "Really depends on the types of dilemma stories we are doing....if they are the sports types...the ranking will go up..." When I asked if the past two dilemma stories were interesting for him, Dominic replied, "I like the Prime Minister one...that was interesting as it has got space stuff in it...I love Astronomy...The Akiki one (see Chapter 4) was alright, it wasn't the best, but I like it".

Dominic indicated a remarkable improvement on both the attitude and reflective thinking scales (see Figures 7 and 8). Deeper analysis of individual items (18 – 20) in the pre and post VLES questionnaire, revealed a huge jump from 'almost never to sometimes' in item 18 (questioning my own opinion) and an even bigger jump from 'almost never' to 'often' for items 19 and 20 (solving problems effecting life on Earth, thinking about anything but science). This indicates that The Prime Minister Dilemma Story had a demonstrable impact on Dominic's

life. It seemed to have made him question his opinions and think more deeply, however this was not evident on his poster, and that might be due to his English expressive ability.

Although both boys said that they didn't share the dilemma story with their family, it seems that the story had had an impact on their lives. During the interview, we had a deep discussion about the 'expiry date' of our Earth, and both boys told me the ways they are saving electricity at home by turning off their PlayStation, pulling out the plug, and setting the TV on a sleeper timer if they know that they are going to fall asleep while watching it.

Patrick, being the dreamer, asked whether it was possible to reverse extract air from water since Schweppes was able to put air into its drinks? He also mentioned an imaginative invention of a huge vacuum that could 'suck up' all the excess water into outer space in the case of a tsunami hitting Australia.

Both boys agreed that the Prime Minister story was relevant to their lives. Patrick's thoughts were that the Earth is going to blow up and everyone is going to die, just like in the movie '2012', so this dilemma story is relevant to his life. Dominic had a different view. He found the story to be relevant due to the following three issues – scientists looking for other planets, the existence of Third World countries and the possibility of adopting a kid from a Third World country.

Gordon

Gordon is a refugee from Afghanistan and came to Australia in 2001. Even though English is his second language, Gordon is the top student at Hopefield College. He is a highly motivated student who values education and getting good grades. His aspiration is to enter university, and although he is not sure at this stage what he is going to study he knows it will be something to do with Science.

When first presented with the dilemma story, he was not interested in it and he rated 'almost never' for items 1 and 2 in the attitude scale ("How I Felt") of the

post VLES questionnaire, namely, looking forward to the activity and finding it interesting. I suspected that it might be due to his initial inability to understand the dilemma. My suspicions were confirmed when I had an informal conversation with him about it.

The next day Gordon and Taza (Student F) approached me and asked if the poster was an assessable piece. Taza, a refugee from Afghanistan, and best friend of Gordon, shares similar values of achieving good marks at school. Knowing their motivation for getting high marks, I said “yes” and offered to help them since I had a free class period at that time. We had a wonderful discussion on Third World countries, such as how the rich countries are exploiting the poor nations. Using NIKE as an example, I told them about companies manufacturing shoes using cheap labour and in the process reaping huge profits from poor people. We ended the discussion by watching the ‘Water Bottle Pollution’, one of several short videos on sustainability available from <http://www.storyofstuff.com>.

I could see that the light switched on for Gordon when we had the conversation on Third World countries. Both of them appeared to be very engaged: they listened attentively and hung on every word I told them. They asked many questions and I could see Gordon deep in his thoughts when he was writing up the pros and cons of supporting AUSworld and the conclusion for his poster. Part way through his work, he asked me this question: “Can Africa build recycling plant so that all the wastes they have in the country, or the wastes that other countries dump into the country be recycled?” I was caught by surprise by his question and couldn’t believe that he came up with this idea on his own in the short span of time. This is evidence that he gained a lot from the discussion and from putting down his ideas into a poster (see Figure 12) which helped to make dilemma learning more meaningful to him.



Figure 12: Gordon's and Taza's poster.

Analysis of item 17 ('I thought carefully about my own ideas') in the pre and post VLES questionnaire indicated that Gordon indicated an improvement from 'sometimes' to 'often', and in item 19 ('I thought about how to solve problems effecting life on Earth') Gordon indicated an improvement from 'often' to 'almost always'. Even though Gordon only indicated a slight increase in the overall changes in the reflective thinking scale (Figure 8), close analysis of items 17 and 19 suggests that The Prime Minister Dilemma Story made an impact on his reflective thinking skills and made him think more.

Although Gordon and Taza did the poster together, Gordon did all of the thinking which he wrote on a piece of paper for Taza up. Taza's role was mainly to type out Gordon's notes and find relevant pictures for the poster. This was the reason why Taza was not one of my case study participants.

The combined effort of their poster clearly indicates the amount of work and thinking that went into it. Gordon had set out the poster exactly as I instructed, with a pros and cons section, followed by his conclusion. He was one of two students who had both the academic ability and interest in the dilemma activity to produce a poster, as shown in Figure 12. The other student (who is my case study for The Mining Dilemma Story in Chapter 4) produced an excellent speech, which can be found in Appendix E.

Looking closely at his conclusion, Gordon mentioned the existence of other organisations such as NASA that are already exploring life on other planets and thus there seems to be really no need for the Prime Minister to support Planet Xplorer. And he went on to give examples of how by supporting the Third World countries, problems such as pollution and climate change can be reduced, thus decreasing the likelihood of Earth being destroyed. This is strong evidence of deep thinking by Gordon at that point in time and also indicates his high level of engagement in The Prime Minister Dilemma Story.

During the interview with Gordon, when asked if he had mentioned the story to his family, he replied: “Oh yeah, I did tell my parents, especially about the Third World countries because I didn’t even know about it”. This further suggests that Gordon was deeply involved in the project, to the point that he felt he had learnt something important that he needed to share with his family. Similar to the other three students, Gordon found the dilemma story relevant to his life. In his words, he said it was because “of the future – children’s children”.

In Appendix E, there are three examples of posters produced by other Year 9 students in the class.

Opening a Window of Opportunity

I found that the dilemma stories opened a window of opportunity for the students and me to have conversations outside the science classroom. Very seldom do I find students coming up to me talking about science, but a few days after delivering the Prime Minister Dilemma Story, Taza, Gordon and Dominic came up to me when we were playing basketball and asked if I could take them for Science. My reply was “Science..are you serious??... Why do you want to do Science when you can be outside playing basketball?”

When another teacher came to relieve me of my duties, I asked them if they wanted to watch a science video clip about pollution, and they all said “Okay!!” without hesitation. While we were watching the video clip, all three students were very interested and asked relevant questions along the way. A comment from Dominic was “Miss, I can’t believe that trees took 400 billion years to grow! Wow...I didn’t know that!”

My Assessment Dilemma

One thing that bothered me was that Gordon and Taza kept asking me what grade they were going to get. “So this poster is worth an A, Miss”, “What marks are we

getting?” When I asked them what if this poster was not worth any marks, would they still do it? Not surprising the answer was “No!”

My usual assessment scheme is that I will tell the students outright when I first introduce a task I give them, a marking rubric attached to the task so that it will give them a clear outline of what is expected of them. I did neither of these when I introduced The Prime Minister Dilemma Story to the class. This then became my assessment dilemma. Should I tell Gordon and Taza that the dilemma activity and all their effort in making the poster will not be assessed, or should I lie to them instead so that they would put in their maximum effort? Not wanting to lie, I did neither of the above actions and instead avoided their question and distracted them with something else.

This was when I decided that for my next dilemma story – The Mining Dilemma Story (in Chapter 4) – I would make it into an assessable piece of work. Gordon was the trigger for the change in my teaching strategy for the next dilemma story.

Chapter Summary

In this chapter, I have discussed my learning journey in using The Prime Minister Dilemma Story with my Year 9 science classes, with special reference to four students – Andrew, Dominic, Gordon and Patrick. Statistical analysis of the post VLES indicated that all 18 students who completed the questionnaire found The Prime Minister Dilemma Story to be interesting and engaging (see Figure 5), and this engagement in the dilemma story has also translated into stimulating deep thinking about their personal values (see Figure 6).

Case study analysis of the four students further confirmed the positive impact of The Prime Minister Dilemma Story on their attitude and reflective thinking. After doing The Prime Minister Dilemma Story, both Andrew and Gordon went home to share their new learning with their respective families, and although Dominic and Patrick didn’t do that, the story had an impact on their lives as they indicated

in their interview that they are now more conscious about the way they are using electricity at home, such as turning off their PlayStations when not using it.

Important knowledge that I gained is that my discussions with the students played a big part in their level of engagement in the dilemma story activity. A fine example is Gordon who initially indicated on the post questionnaire that he did not enjoy the activity, but then changed his mind after having discussions with me. In the end, Gordon was deeply engaged in the whole dilemma and even made a brilliant suggestion about helping Third World countries. This indicates that in-depth supportive discussions with students can be important to the impact of the dilemma story on students' lives.

Triggered by Gordon and Taza, I have also struggled in terms of my own dilemma – should I tell the students that the dilemma activity is not being assessed? This in turn formed my new learning which shaped how I taught the next dilemma story, which is discussed in Chapter 4.

Even though I employed a survey research method to ascertain whole-class perception, as a teacher I was much more interested in the discussions I had with my students during the process of the poster-making sessions; and what the students said about their experiences in the interviews regarding their learning and engagement in the dilemma activity. This insight will be more evident in Chapter 4, where I explain my move from the positivist paradigm to the interpretive and critical paradigms.

Chapter Four – My Second Dilemma Story Journey

Introduction

The purpose of this chapter is to describe my follow-on journey into using ethical dilemma stories in my science teaching. My research objective is to investigate how students who were usually not engaged in science were affected when given an opportunity to voice their values on science issues. In the last chapter I discussed the use of The Prime Minister Dilemma Story in my science classes and its impact on my students. In this chapter, I reflect on my previous journey and reveal how that changed the way I delivered the second dilemma story – The Mining Dilemma Story. Throughout this chapter I consistently use direct quotes in order to give my new case study participants – Yody and Alice – a voice. In addition, vignettes and diagrams are used throughout the chapter to enhance thick description and thus the reader's ability to understand the context. All names used for students and teachers are pseudonyms in order to maintain privacy and anonymity.

The Second Stage of My Learning Journey

As a reflective person, I have always started the new school term with a reflective mind asking myself three basic questions – What did I do well last term? What went wrong? What changes am I going to make this term? Therefore it is not unusual that the second stage of my learning journey starts with my reflections on my last journey.

What went really well in The Prime Minister Dilemma Story was that most of the students were engaged in the poster making sessions. They seemed to enjoy looking up the pictures on the internet and articulating it onto a poster. Students I have interviewed also indicated that although they do not like standing in front of

the cohort presenting their poster, they felt good at the end of it. Most importantly, all of my case study participants indicated in their interview that they would like to do more dilemma stories next term, which is a strong indicator of their engagement in The Prime Minister Dilemma Story.

There were two things I found that did not go so well for me. Firstly, The Prime Minister Dilemma Story was broken up into too many parts and students were not as focused as I would like them to be during the delivery of the story. I started the story by introducing values, hoping that this would guide them in the decision making process later on. However I found that students were not able to make this connection and most were unable to justify their decisions based on their values.

Secondly, students were also unable to initially connect to being the Prime Minister and this made the delivery of the story difficult as I had to deal with behavioural issues at the same time. The majority of the students were unable to recall the full details of The Prime Minister Dilemma Story and were thus a bit confused when they had to do the poster. I had to repeat the story again and to shorten it to make it simpler for the students. It seemed to me that the confusion and behavioural issues were due to the students not being able to identify with the main character in the story.

In light of my reflections, I decided that in the next dilemma story, I would make sure that the story is not too complicated and not broken into too many parts. I would also have a main character that students can relate to by having the character at a similar age to my students. Finally, I will tell the story as if it is a true story, without using a script or technology (i.e. SMARTBoard) so as to make it more realistic for the students.

Sticking to the Rules ... or Not?

One thing about me is that I always like to ‘stick to the rules’. I guess this has very much to do with the product of my upbringing in Singapore, where it is very common for students to follow the instructions given by teachers. We have never

questioned or argued why we had to do something. We just did it because that was the norm, which was to do as you are told. Therefore when I was introduced to the way of teaching the dilemma story by my two supervisors, I followed their proposed way of how dilemma stories are taught, which was the classical model (see Figure 1) proposed by Gschweitl, Mattner-Begusch, Neumayr, and Schwetz (1998).

However, based on my past experiences in teaching The Prime Minister Dilemma Story and reflecting on the experiences I gained in my first learning journey, I decided to change things around and do some things differently in the second dilemma story – The Mining Dilemma Story. It is part of my belief system that teachers need to be flexible enough to adapt models to suit their different clientele for a successful learning experience for their students.

What has changed?

Taking into account my co-supervisor's comments when she sat in one of my classes when I was delivering The Prime Minister Dilemma Story, on the basis of the conversations we had after, and also my personal reflections as shared before, I decided on some changes for The Mining Dilemma Story. The reasons for these changes are discussed in the next section. The four specific changes were:

- Assessment of students' involvement in the dilemma story via a rubric
- Telling the dilemma story, not showing the dilemma story
- Slight modification to the Think-Pair-Share strategy
- Embedment of The Mining Dilemma Story into the science curriculum

The Mining Dilemma Story

In Chapter 2, I have discussed my reasons for writing The Mining Dilemma Story. Unlike The Prime Minister Dilemma Story, where I sat down and brainstormed about what would be considered a dilemma to me and writing it into a story, The Mining Dilemma Story struck me like lightning while I was on a plane back from Toowoomba. It was one of those moments where I could see clearly how the

story would flow and how it would fit nicely into the science curriculum for my Year 10 classes in Term 1.

It was on the plane that I decided that I would target the ‘Natural and Processed Materials’ and ‘Earth and Beyond’ outcomes in my Year 10 science classes in Term 1.

Embedding The Mining Dilemma Story into the Science Curriculum

Reflecting on the time when some students were away from school on the day The Prime Minister Dilemma Story was delivered, and thus making it hard for the poster making sessions to proceed, I decided to change tack. I delivered The Mining Dilemma Story as part of the science curriculum, which means that students’ participation in The Mining Dilemma Story was to be part of the assessment (see Figure 13). Students were also told at the beginning that they will be producing an informational report which would contribute to their grade. An informational report is a common piece of assessment used in schools. It is a report that presents information about a subject and it usually follows a very specific structure, such as having headings which tell the reader what topic is covered in the report. The role of the informational report was to give students an opportunity to demonstrate their learning of the science content.

The Mining Dilemma Story was incorporated into my Year 10 science curriculum through the ‘Natural and Processed Materials’ and ‘Earth and Beyond’ outcomes, which are part of the K-10 Syllabuses in Western Australia. I prepared the students for The Mining Dilemma Story by providing preliminary lessons on geology, chemistry and technology of mining for minerals. The K-10 Syllabuses are advisory materials designed to provide support for teachers with implementation of the Curriculum Framework. The outcomes for ‘Natural and Processed Materials’, as outlined in the K-10 Syllabuses, are that *‘Students understand that the structure of materials determines their properties, and that the processing of raw materials results in new materials with different properties and uses’* (Department of Education and Training, 2011a). The outcomes for

‘Earth and Beyond’, as outlined in the K-10 Syllabuses, are that ‘*Students understand how the physical environment on Earth and its position in the universe impact on the way we live*’ (Department of Education and Training, 2011a).

Both these outcomes integrate nicely into mining and, due to the reasons mentioned earlier, I decided to implement The Mining Dilemma Story as a formal activity that students will be assessed in. I started the term by teaching students about basic chemistry such as atoms, molecules, chemical formula, chemical bonding, physical and chemical reactions and the periodic table. This took about 5 weeks and after that I launched into the topic of mining, telling the students that mining has lots of chemistry involved. I made a PowerPoint on mining (see Appendix F), which I delivered over three lessons on a projector. It was a teacher-centred approach, where students listened while I explained the slides for students to digest. I taught about the history of mining and some statistics of mining in the first lesson; mining techniques and the extraction process in the second lesson; and the impacts, pros and cons of mining in Australia in the third lesson. The aim of the PowerPoint was for my students to realise how mining can contribute to the detriment of the local environment.

The reason for the teacher-centred approach was due to the large number of low ability students in Year 10. In my six years of teaching experience at Hopefield College teaching low ability students, I have found that the less structured the lesson is, the higher the chance of students’ misbehaving. Low ability often correlates with low literacy skills, and a key reason for misbehaviour is usually that students don’t know what to do or the task is too hard for them and thus they misbehave to mask their inability. Information presented on the PowerPoint when copied down by the students was to serve as useful notes when they started doing the information report. I was also hoping that through the PowerPoint, students would gain some background information, or prior learning, for when they had to make their decisions in the ethical dilemma story later on.

The dilemma describes the story of a young boy, Akiki, whose father has been chosen as the new project officer for a proposed mining site in the Kimberley. Students had to put themselves in Akiki's position and they are asked to decide whether to support his father in taking the position with the mining company or to support the local community who are against the mine site being built in their community.

The Mining Dilemma Story was told to the class in a single lesson as soon as I had finished the PowerPoint. Students' in-class learning activities that followed after the story include the decision making sheet (see Appendix G), an informational report and research into a mined element.

The dilemma story teaching approach had a strong influence on the in-class learning activities because it was the story that provided me with the idea of having the students produce an informational report. This is quite an unusual assessment piece for science as teachers usually get students to produce scientific or investigation reports. I decided on an informational report because of the high degree of overlap between Society & Environment (S&E) and Science in the topic of sustainability and environmental care (see later).

<u>Year 10 Mining Informational Report</u>						
Student Assessment Profile:					Total = / 40	
Learning Area Outcome	Specific Outcome	Not demonstrated (0 marks)	Beginning to Develop (1 mark)	Good (2 marks)	Very Good (3 marks)	Outstanding (4 marks)
Investigating Scientifically (Dilemma story)	Displays appropriate thinking and investigative skills	Did not attempt to work	Needed considerable help from teacher	Worked independently with some help from teacher	Worked independently with little help from teacher	Worked independently
Communicating Scientifically (Informational report)	Communicates using appropriate language	0	1	2	3	4
	Relevant pictures	0	1	2	3	4
	Well organised information	0	1	2	3	4
	Well summarised information	0	1	2	3	4
Natural and Processed Materials (Confidential information sheet)	Shows an understanding of concepts and principles	no history	date or place of discovery mentioned	date and place of discovery mentioned	some information given about discovery	details of discovery described
		no uses	uses only stated, not described	uses described	uses described and related to their properties	explains uses and advantages of the uses of the metal
		0-1 question answered correctly	2-4 questions answered correctly	5-6 questions answered correctly	7-8 questions answered correctly	all 12 questions answered correctly
		Did not attempt to work	Needed considerable help from teacher	Worked independently with some help from teacher	Worked independently with little help from teacher	Worked independently
		no resources or all resources incorrectly written	one research source written correctly or 2 sources but not correctly written	at least 2 research sources written correctly	at least 3 research sources not fully correctly written	at least 3 research sources written correctly

Figure 13: Students' assessment rubric of *The Mining Dilemma Story* and informational report.

Assessment of students' involvement in the dilemma story via a rubric

There were some differences between the delivery of The Prime Minister Dilemma Story and The Mining Dilemma Story. The Prime Minister Dilemma Story was delivered as a fun activity towards the end of the term to finish off the term and there was no plan to assess the outcomes of the activity, such as the students' posters and presentations.

However when several students, such as Gordon and Taza, questioned me about grades this made me think about assessing the second dilemma story. It wasn't just Gordon and Taza that provided stimulus for the change. I wanted my students to take the dilemma activity seriously, to really think about their decision and not just treat it as a fun activity to finish the term. Thinking back, there were a few students who didn't treat the previous dilemma activity seriously and only a handful of students produced a poster for The Prime Minister Dilemma Story.

Thus I decided that students would present an informational report as part of their assessment, instead of a poster, and their responses to The Mining Dilemma Story would be incorporated into the report. Thinking back, I have no idea why I approved of that decision, given that the earlier poster sessions and presentations had such a great outcome. It must have been the assessment aspect that got to the best of my judgement, resulting in me focussing on students getting a mark.

Figure 13 shows the assessment rubric handed out to my students at the start of the term so they were aware of what was required of them – my usual assessing technique. Students were told that they would be assessed on their participation in The Mining Dilemma Story, the completion of the informational report and research into a mined element. This was the assessment for the whole of Term 1.

Mining Dilemma story:

Name has been changed to protect the true identity of the subject and mining company. This is a true story about a boy named Akiki. Akiki is 15 years old, a Year 10 student living in the Kimberley. I knew him 2 years ago while I was tutoring him but then his family moved to the Kimberley late last year, but we have always kept in touch through emails. Over the last school holidays, he is troubled with some problems and we have been having lots of discussions. Anyways, I've told him that I'm currently teaching the Yr 10s about mining, so I would ask about your opinions and see what you think.

Some background information about Akiki. Akiki grew up in a family of 5. He is the eldest out of the 3 children and has 2 younger siblings – an 11 year old sister and a 10 year old brother. Akiki is currently living in a beautiful community in the Kimberley. This is the reason why they moved to the Kimberley. It is such a peaceful place that Akiki's mom fell in love with when they went there for a short holiday early last year.

His dad is currently employed as a site supervisor at a mining company in Kalgoorlie. He is the only bread winner in the family, and considering his level of education and the fact that his English is not very good, he is considered very lucky to have a job that pays well. Mom is not working and stays at home looking after the family. Akiki only gets to spend time with his dad when he flies back from the mines – a 1 week off, 2 weeks on shift. When his dad is away, he is the man of the house and has to take care of jobs around the house as he is the eldest. The mining company Akiki's dad is working for is currently thinking of investing in a location in the Kimberley. It is the perfect location because if his dad is chosen to work on this project, he will be able to stay closer to the family, and Akiki loves his dad very much and he looks up to him.

Thinking individually, what advantages will the proposed mine site bring to the Kimberley? What disadvantages will the mine bring? Now pair up and share your ideas.

As soon as the community of Kimberley hear about the proposed mine site, there is a huge reaction from them. This includes your family too! Both your younger siblings and your mother are totally against the mine's plan to make a hole on their ground. So much so that the people of Kimberley, including his mom have sign a petition against the proposed mine site. Their main concern is that the mining company is going to ruin the beautiful landscape of the Kimberley.

Naturally, the mining company is not very happy as this is delaying their timeline. They were hoping to start operation as soon as possible and this is a major setback for them. The boss of the mining company cannot understand what's the fuss is about. This new mining project will create jobs for the people of Kimberley and this is a win-win situation for both.

In pairs, do you think this is a win-win situation for both? Justify your reasons. Who do you think Akiki should support? His community or the mining company his dad is working for? The class will then share their ideas.

This is the dilemma. Akiki's dad was called into the CEO office last week. He was chosen to be the new project officer for this project. The company has looked through their databases and through recommendations from the other managers; they have decided to promote him to be the project manager of this new Kimberley project. This is a great opportunity for not only for your dad but for your family too. His salary will increase and his work condition will improve by a great deal too. And there is the added bonus of being able to stay closer to the family. No more fly in- fly out.

What should Akiki's dad do? Take up the offer or leave it?

Figure 14: Contents of The Mining Dilemma Story as told to the students.

Telling the dilemma story, not showing the dilemma story

Reflecting on the initial delivery of The Prime Minister Dilemma Story, I recalled that most students did not seem to be engaged when the story was delivered on the

SMARTBoard. Some were distracted by the pictures I put up, others were not paying attention as it probably felt like it was more like a standard lesson, rather than a story, as it was shown and not told. Therefore, I decided to modify the delivery of The Mining Dilemma Story. Instead of telling The Mining Dilemma Story using the SMARTBoard, I told the dilemma story to the whole class without the use of technology or a script, and I paused from time to time for individual student and small-group reflection.

I found that using this approach enabled students to identify more deeply with the main character in the story and to make decisions on behalf of the character. This was evident when students in all three classes asked clarifying questions about Akiki, the main character, in The Mining Dilemma Story.

Some clarifying questions asked by my students were:

- “How did you know Akiki again?”
- “So he really asked you to ask our opinion”
- “You are not lying Miss, this is really a true story?”
- “What subjects did you tutor Akiki in?”
- “Why did his family move to the Kimberley for?”
- “You still talk to Akiki now...hmm..what’s going on Miss?”
- “Is Akiki black or white?”

These clarifying questions were asked by students throughout the story, not just at the beginning of the story, indicating that they were intrigued by the main character, Akiki, and wanted to know more about him in order to connect to him. Yody, one of my case study participants, asked many questions to confirm that I was telling a true story and not one that was made up.

It might be confusing for a non-Buddhist to question a Buddhist’s precept of not telling lies, especially in this case when I, in my role as the teacher, kept telling my students that Akiki was a real character whom I knew for a period of time. The precept of abstaining from telling lies is about more than simply speaking

truthfully, it also means using speech to benefit and not to harm. There was an incident in the Buddha's time when he was seated under a tree. A rabbit ran past the Buddha going towards the east. Not long after, a man ran past the Buddha. Upon seeing the Buddha, he stopped and asked the Buddha if he happened to see a rabbit running past. The Buddha said "yes indeed", and pointed to the other opposite direction in which the rabbit had run.

Did the Buddha lie? Yes, there is no doubt that he lied, however he did it out of compassion for both the rabbit and the man. By telling the simple truth, the rabbit would have lost its life and the man would have accumulated bad karma for killing a living being.

Similarly in this case, although I told a 'white lie' in the Akiki story, it was done so as to keep the students engaged in the story. The storyline of the story is not far off the current situation happening in the Kimberley (Freeman, 2012).

Slight modification to the Think-Pair-Share strategy

Remembering the previous story where my students went straight into the pairing part with many off-task conversations, I made the decision to adapt Settelmaier's ideal model (see Figure 1) differently for The Mining Dilemma Story. To prevent off-task behaviour, I modified the Think-Pair-Share strategy so that it became a callout for the first part, with all students participating and having the same answers written down in the pros and cons table in the worksheet given to them (see Appendix H). In the second part, I took out the 'thinking to yourself' part and gave students the opportunity either to think by themselves or discuss it with their partner, thereby changing it into a Pair-Share or Think-Share cooperative strategy. I found that the modified Think-Pair-Share strategy worked much better with these lower academic ability students at Hopefield College. Students' off-task behaviours were reduced and class discussions were more lively compared to The Prime Minister Dilemma Story. This was witnessed by my co-supervisor when she came to observe the class in action.

Extending The Mining Dilemma Story into S&E

At Hopefield College, a team of teachers is in charge of the same cohort of students. In my team, there is Bob who teaches Society & Environment (S&E), Pauline who teaches Mathematics, Sam who teaches English and myself who teaches Science. Right from the beginning of the term, I could see the opportunity of The Mining Dilemma Story for cross-curricular themes in the learning areas of Science and S&E. Especially in S&E, under the strands ‘Resources’, where the outcomes as outlined in the K-10 Syllabuses are that *‘Students investigate the ways in which people meet their needs and wants by making optimum use of limited resources in enterprising ways’*. (Department of Education and Training, 2011b); and in ‘Place and Space’ where the outcomes as outlined in the K-10 Syllabuses are that *‘Students understand that the interaction people have with places in which they live is shaped by the location, patterns and processes associated with natural and built features’*. (Department of Education and Training, 2011b).

Conversation with Bob, the S&E teacher in the team, also confirmed the cross-curricular themes in the two strands pointed out to him. I had the initial idea of integrating The Mining Dilemma Story into both Science and S&E, with me introducing the ethical dilemma story (see Figure 14) to the students in Science, and then with Bob continuing in his S&E classes. I gave Bob a paragraph that he could read out to his class to conclude The Mining Dilemma Story, as follows.

Akiki’s dad decided to take up the job in the Kimberley. His job descriptions as the project manager involve liaising with the people of Kimberley, to be the spokesperson for the company and basically get the mining project up and running and oversee the whole project.

1) What steps should he take to ensure that the people of Kimberley will be comfortable with his mining company making a hole on their land / your land?

2) What steps can the mining company take to ensure minimal impact on the

environment and the people? Is there an urgent need to have the mine there?

3) What could both sides do to understand each other's viewpoints better and to work towards finding a workable compromise?

I was hoping that Bob could teach the students about the major environmental effect mining could have on the community and what steps the mining company should/could take to protect both the community and the environment from harm.

It was unfortunate that the partnership between Bob and I didn't turn out to work as well as I had planned. At the time when I had finished telling The Mining Dilemma Story and needed Bob to continue the next part of the story, he took a week off school for personal reasons. When I caught up with Bob when he came back, it became the start of an interesting yet frustrating week for me. My reflection on the 6th April 2011 summarized it all.

Reflection (6th April 2011)

Can't believe that it had been so long since my last reflection. I have been so busy and tired that I just can't seem to find the time to do my reflection and it has been swimming in my head so I don't forget it.

Anyway, the last I could remember was that Bob came back from his one week away and I ask him if he could do the third part of the dilemma story, which is basically what steps the mining company should take in order to protect the community and the environment. So that was my short conversation with him on Monday as I don't really spend much time down in that year group nowadays. So when I finally had the time to see him on Thursday to ask him how's he going, he says that this project got him reading up on the mining legislations and he has been losing sleep over it! I cannot believe it!! Losing sleep over it?? Hmm...what does this show? A relevant content can get people

thinking and wanting to find out more? And this applies to even adults?

And then we went into this interesting conversation. I asked Bob if he has discussed with the class the advantages and disadvantages mining brings to the community, and he told me that basically there are no disadvantages to the community, only advantages! He then gave me an example of how Port Headland has now developed into such a good city whereas before it was nothing. And then I went on to ask him what about the air and dust pollution? Anyways, this just shows how different people place different values on different things.

And then what's so frustrating with Bob was then after a few days, he told me that he's going to stop this project because he is running behind his S&E program! What the hell was that? This mining project that he's doing with the class is S&E related!!!! Gosh I was fuming inside at this point in time.

And I told him that, I said "Bob, come on, this is S&E content too you know, and you can also assess the kids on it." So after that he kinda go, okay, I will finish it and ask the kids to do a brainstorm on it. So on Monday (4th April), he did the brainstorm on the steps of mining with the kids using a free software on the internet. The kids managed to produce a pretty impressive brainstorm, which I was very impressed with. Good job Bob! Some teachers just need to be pushed and directed in the right direction.

As seen in my reflection, I was very surprised to learn that Bob became engaged in the topic of mining after having the conversation with me, and it got him researching articles and reading up on mining legislation. I didn't know that The Mining Dilemma Story could have such an effect on a fellow S&E educator.

Although Bob wanted to give up in the midst of it due to his perception of interference with his planned S&E curriculum, he ended up doing some very good work with some of the students. Bob taught the students about the major environmental effect mining had on the community and the steps the mining company should take to protect both the community and the environment from harm.

Students first wrote the information given to them in S&E on a structural overview and then later presented it as a form of a mindmap on the computer. The mindmaps students produced were all similar as they wrote the same notes given by Bob. Figures 15 and 16 are two of the mindmaps randomly selected from a student's file to illustrate the content of Bob's S&E lessons.

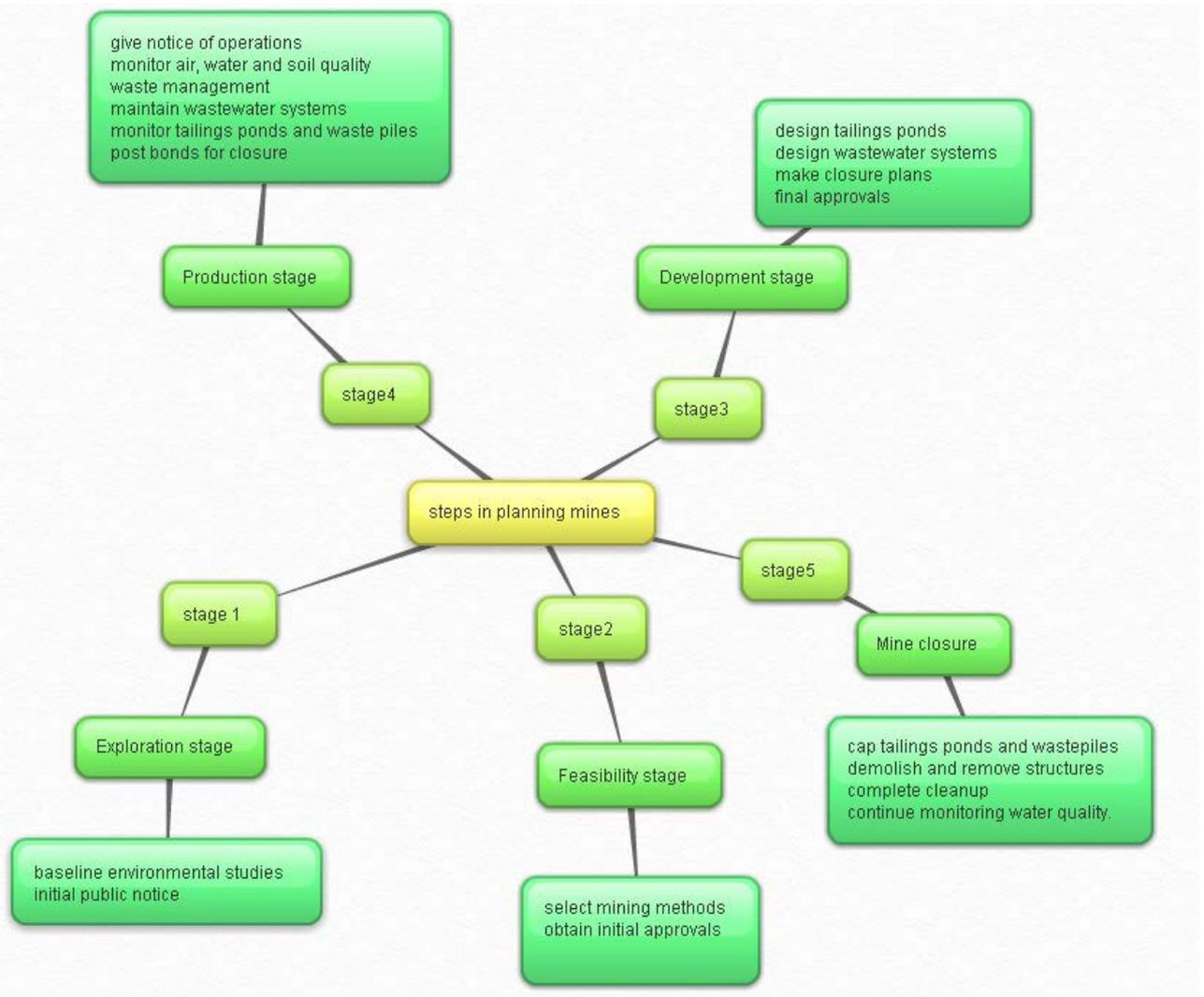


Figure 15: An example of a student's mindmap of steps taken by mining companies in planning mines.

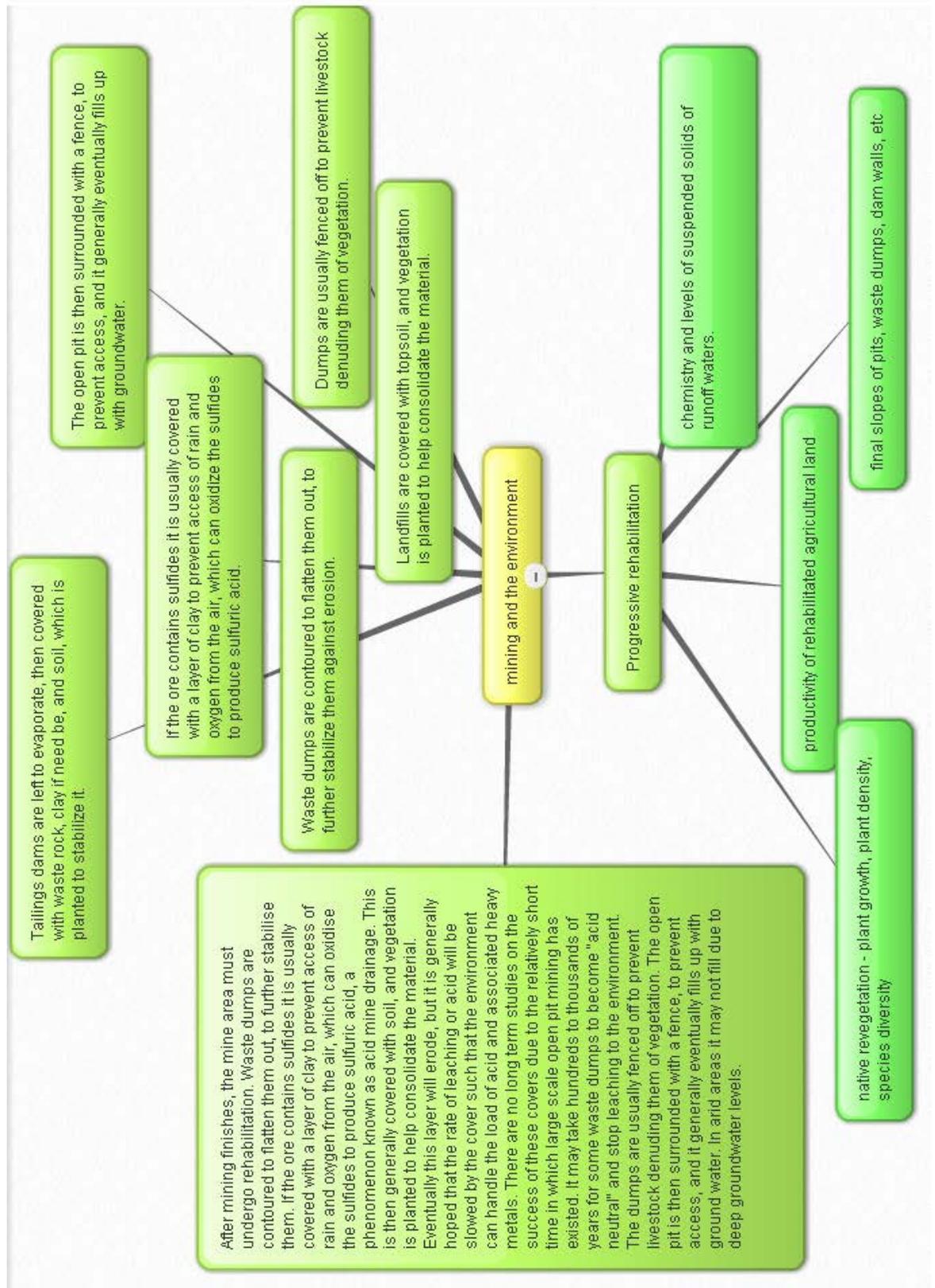


Figure 16: An example of a student’s mindmap of the major environmental effect mining had on the community and the steps taken by mining companies to ensure minimal impact on the environment and the people.

As seen in Figure 15, Bob went through the process of teaching the students the stages involved in setting up a mine site and the precautions the mining companies need to take to ensure minimal environmental impact. He went into more detail in the next mindmap as to how rehabilitation takes place after mining finishes (see Figure 16).

It took Bob two S&E lessons to do this with students but he only chose to do it with the mixed higher ability class, as he was behind his teaching schedule for the other two lower ability classes.

Aboriginal Students Engagement in the Dilemma Activity

Students seemed to be able to identify more deeply with Akiki, the main character in *The Mining Dilemma Story*. I felt that this was due to the way the dilemma story was delivered. The story was spoken to them instead of shown on a SMARTBoard. My students' intrigue with Akiki was an eye-opener for me, especially when it was the Aboriginal students who showed the most interest. These Aboriginal students were attempting to connect with Akiki and they asked many questions about him.

Hopefield College has a high proportion of Aboriginal students, and I had at least four Aboriginal students in each of my three Science classes. I will now describe their participation and engagement in the different classes which are streamed according to academic ability. There was an all-boys low ability group, a mixed low ability group and a mixed high ability group.

The majority of my Year 10 students seemed to be really engaged in *The Mining Dilemma Story*. When I asked them the questions “Do you think this is a win-win situation for both?” and “Who do you think Akiki should support? His community or the mining company his dad is working for?”, all three Science classes responded to my questions and the dilemma got them thinking.

Engagement of Aboriginal Students in the All-boys Low Ability Class

Ethan, an Aboriginal student, in the all-boys low ability group, who is usually distracted in class, was listening attentively to the story and when he asked his first question, “Was he Black?”, it seemed that he was trying to make a connection with Akiki. When I replied that Akiki migrated from another country, a different student said, “Oh, so he’s like Taza?”. Taza, whom I mentioned in Chapter 3, is refugee from Afghanistan.

Ethan paid the most attention, which was really surprising for me as I have never seen him like this in my Science classes. When the students were pairing up discussing with their partners, Ethan put up his hand and asked his second question, “Miss, the land they are mining on, is it on sacred land?” I was dumbfounded at that point because, firstly, I didn’t expect him to come up with that question and, secondly, due to my ignorance, I did not even know there are such things as sacred lands! Ethan proceeded to explain to me that there are sacred lands within Australia and he would surely oppose the idea of a mine site being on sacred lands.

Engagement of Aboriginal Students in the Mixed Low Ability Class

In the mixed low ability group, I received the same question from another Aboriginal student. He too asked if Akiki was Black. But something that struck me the most was an Aboriginal girl. This particular girl had a high absentee rate. The school had tried on numerous occasions to get her to attend school regularly but it had not worked. As a result of her irregular attendance at school, she was often disinterested in lessons, partly because there was no continuity in her school life. Thus I was not surprised that she did not participate well in the dilemma story when I was telling it to the whole class. She just sat in her seat, staring into space.

In the later part of the lesson when I had managed to settle the rest of the class in the computer lab, I approached her and retold The Mining Dilemma Story. With a one-on-one approach, she responded very well to the same questions asked to the class earlier on. I could see the ‘dilemma’ look on her face when she said “Yes,

his dad should take up the job because there will be more money, but then that will harm the environment...Right?”. There was a small pause, and she continued, “So...No...But then he will be closer to his family so...Yes”. And she said, “What should I do?...What would you do Miss Chow?”.

It is really priceless for me as a Science teacher when I see my students engaging in reflective thinking. This particular Aboriginal girl had missed five continuous weeks of school and it was her first day back to school the day I told the Akiki dilemma story to the class. Even though she was a bit out of touch with Science, she was able to connect to this dilemma story when I spent time with her and this gave me an excellent opportunity to tell her what she had been missing during the past five weeks.

Engagement of Aboriginal Students in the Mixed High Ability Class

It was in the third class, the mixed class with the highest academic ability, that the discussion of Akiki became a fun topic for the students in the class. I had two very articulate Aboriginal students – Jerry and Yody – in this class. Yody was one of my case study participants whom I introduce in more detail later in the chapter.

When I first introduced Akiki to the class, Jerry made a big deal by asking me questions such as, “How did you know him?”, “Is that his real name?”, “How long did you know him for?” and “I don’t believe this story...you are making this up, aren’t you?”. When I finally managed to get to the part where I told the class that I used to tutor Akiki, after all the questions students were firing at me, Jerry and Yody then asked me questions such as, “What was his house like?”, “What is his real name?”, “What about his last name?”, “Why does he need tuition?” and “Did he pay you?”.

Even after the lesson ended, I had students coming up to me telling me that they were going to check out Akiki on Facebook. Facebook is a social networking website launched in 2004 and is the most used social networking service by worldwide monthly active users. Facebook is very popular with my students and

one student told me that he was going to find out if Akiki was real! At that point in time, I could not believe how such a simple story could turn out to be so complicated.

Overall, it was a positive result for me that my Aboriginal students responded so well to The Mining Dilemma Story. When I planned The Mining Dilemma Story, I had at the back of my mind to make sure I catered for the Aboriginal students in my Science classes, knowing how important it is for them to be engaged in the story since I am incorporating it into my Science program. I had a strong suspicion that it might have been the topic on mining or the Kimberley that grabbed their attention, but unfortunately I haven't had the chance to confirm my suspicion.

Feedback from other students

While students were doing a test one day, I went around the class and, in my role as a researcher, had a short informal chat with some of the students. For these informal chats, I purposely chose four students whom I hadn't obtained parental permission for formal interviewing. I had four questions in mind, which I wrote on a piece of paper and then scribbled the students' responses underneath. In the table below, I have the four students' responses typed under the four questions asked.

1. How did you find the story?

Student 1: Awkward, because I found it hard to choose between mom and dad.

Student 2: It was alright, kinda like it when I had to write about it in the report.

Student 3: Easy. Easy to choose.

Student 4: Interesting, because I haven't heard such stories before.

2. Did you enjoy it?

Student 1: It's alright.

Student 2: Enjoyed it.

Student 3: Yes. I haven't done stories like this in my other school.

Student 4: Yeah because it was interesting that he had a huge decision to make but couldn't make his mind up. And I can relate to him because he's the same age as me.

3. Does the story have anything to do with Science?

Student 1: Not really..but yeah a bit...destroying the Earth, tailing and pollution.

Student 2: Yeah because of the mining bit.

Student 3: Sort of, the mining.

Student 4: Yes, it is about mine and stuff.

4. Does the story stimulate your thinking?

Student 1: Yeah, coz it's hard to choose between mom and dad.

Student 2: No, I found it easy to choose and that's why I enjoyed it.

Student 3: No. I cannot relate to Akiki. Would be better if he is a girl.

Student 4: What is stimulate? I've never done it at my old school and I don't mind doing more of these kinds of stories.

Two of the above students (students 3 and 4) had not come across dilemma stories at their previous school and this was their first encounter. However, all four students claimed to have enjoyed it and could see the relevance of the story in

Science. Student 3 gave a suggestion as to why she was unable to relate to Akiki, the main character, in the Mining Dilemma Story.

It was interesting to note that Student 2 enjoyed the dilemma story because he found it easy to choose and he liked writing it in his information report. A possible reason for this might be that Student 2 was not very bright academically and this task was quite achievable for him.

Choosing the Interview Samples

It was a very different process choosing the individual case study participants for The Mining Dilemma Story. In Chapter 3, the interview sample for The Prime Minister Dilemma Story was chosen based on the results of the VLES questionnaire. The initial idea was to interview the same sample of students so as to track their reaction to dilemma stories over time, making it a longitudinal study. However, I was unable to use this same method as I found that many students were not treating the questionnaires seriously. This was further confirmed when I asked the students directly and also in the interviews. Below is an excerpt from Patrick's interview.

Interviewer: Your response on the questionnaire indicated you could “take-it-or-leave-it”.

Patrick: Yeah.

Interviewer: But when I was talking to you just now about your report, and going over your findings, you actually seem to find it quite interesting. So, what do you reckon? Is this a true reflection of what you felt?

Patrick: Not really.

Interviewer: Can you explain it back to me? And for another question in the questionnaire, you were not as enthusiastic as you are now.

Patrick: I was bored.

Interviewer: Bored from the question?

Patrick: Yeah.

Patrick's response of "I was bored" mirrors other students in the class, who admitted to being bored when doing the same pre and post questionnaires. Because of the unreliability of students' responses in the questionnaires, I was unable to reliably collate data on the attitude and reflective thinking scales. It then became very important at this stage of my research that classroom observations and interviews with the case study participants became the crux of the research. Unlike Chapter 3, rich descriptions and interview scripts now become my main focus in this chapter.

A lengthy discussion with my supervisors led me to choose a different set of case study participants from The Prime Minister Dilemma Story. Going back to my first objective, which was to investigate how students' engagement in science is affected when given an opportunity to voice their values on science issues, I was interested in finding out (i) whether dilemma story teaching would induce a change in my students' thinking and deepen their understanding of the concept of sustainability and (ii) whether they were able to see the value of engaging in ethical dilemma stories in Science.

Based on this objective, I decided to turn my focus on students who had shown a positive engagement in The Mining Dilemma Story based on my classroom observations. The notion being that without statistical analysis of pre-post VLES results, and thus unable to justify the increase in engagement, it would be better selecting students whom I already knew were highly engaged in the dilemma story and thus able to ask them in the interviews how this experience was for

them. Yody and Alice were selected as they were the two that stood out for me as they had both seemed to have engaged deeply in The Mining Dilemma Story. Both of them were in the mixed high ability class.

Interviews of Yody

Yody is an Australian Aboriginal boy who engaged meaningfully in the dilemma learning. He has a relatively high literacy level and asked many clarifying questions during the delivery of The Mining Dilemma Story. Yody's aspiration is to study physics at university to become an engineer. He wants to have a high-paying job. Even though Yody is a highly capable boy, he is usually highly distractible in class. He is the clown of the class and will find any opportunities to fit in a joke or ask silly questions, just to disrupt the flow of the lesson, and his behaviour is similar in all his other subjects' classes.

Not surprising, Yody played the role of the seemingly disruptive student when I told The Mining Dilemma Story to the class. He kept interrupting me and asked questions such as "Are you sure this kid Akiki exists and you are not just making him up?", "How do you know him again?" and "Why are you still keeping in contact with him, that's illegal you know?" Gosh, his questions in turn stirred up responses from other students in the class and they in turn joined in. This was actually not a bad thing as it got other students who weren't paying attention to the story to be intrigued by the commotions created by Yody.

Unlike the other Aboriginal students, Yody was the only Aboriginal boy in the cohort that seemed to have a stable and supportive family. He was enrolled into the school half way through Year 9 and all the teachers immediately recognized that Yody was a highly capable student who was very articulate in class and had high literacy levels. Yody is the eldest child in his family, with two younger brothers. Both his parents work and he also did work around the house to get extra pocket money from his parents. This shows that Yody has to work for his money and that it was not just given to him, as is the case with most of the other Aboriginal students at Hopefield College.

When asked which dilemma stories he preferred, Yody chose The Prime Minister Dilemma Story because it was more relevant as, according to him, the world is dying, while the Mining Dilemma Story has more to do with S&E than Science. A very interesting point was that although Yody indicated in his informal conversation with me that he disliked S&E classes, giving his reason as “I don’t learn much in S&E”, he was still very engaged with the story, even when he could see the connection of The Mining Dilemma Story with S&E. This was also evident in the interview with him 2 months later where he drew upon his family values to personalise and resolve his dilemma thinking when asked how he would resolve the dilemma if he had been in Akiki’s situation. His responses are as follows.

Yody: I made the decision that his dad should stop working in the mines and stay with his family.

Interviewer: And why did you make that decision?

Yody: Because if he loves his family, then he’ll stay with his family and try and get another job in the Kimberley. There might be less pay, but at least you’ll be with your family.

Interviewer: Family is an important thing for you?

Yody: Yep.

Interviewer: Are you close with your family?

Yody: Yeah.

Being an Aboriginal student, Yody’s responses seem consistent with traditional Aboriginal culture. From my experiences working with Aboriginal students in the same school for the past six years, I have found that Aboriginal family ties are very tight and important in everyone’s lives. When a family member passed away, the entire family, including relatives, attended the funeral and sometimes the student was absent from school for a week as the funeral usually took place out of Perth with the requirement that all family members are present. In the following

excerpt, the link between Yody's responses and his cultural and social background becomes clearer.

Interviewer: What did you find interesting about the story?

Yody: That his father had a hard choice to pick. And we didn't really know which choice we had to pick so it was just really interesting for me to know which one he was going to pick.

Interviewer: Does any of your family work in the mines?

Yody: My dad used to, but we asked him to stop working there and he stopped and he started working somewhere else now.

Interviewer: He stayed with the family?

Yody: He used to work out in the mines, but now works for people who get into the mines. Like, helps people get jobs.

Interviewer: He doesn't fly-in, fly-out anymore?

Yody: Nope.

Interviewer: Do you like it that way? Or do you prefer seeing less of your dad?

Yody: Nah, it's better with my dad here.

When asked how he had liked the dilemma story approach, Yody said that he liked it, "...cause it kept me on task....like, other times I would rip out my iPod and start listening to it, but this had me thinking sometimes....most of the times I couldn't even sleep, just thinking about what would he do? Stay with his family or go up to the mines ...". When asked if the story affected him pretty deeply, Yody's response was "No. Not pretty deeply, just that it made me think for some reason". However there were some contradictions in his interview responses when Yody said that he would not like to do another dilemma story in Science (see excerpt

below) even when he mentioned earlier that the dilemma story kept him on task as he had to think.

Interviewer: Would you like to do another dilemma story this term?

Yody: No.

Interviewer: Because it was a hard decision, is that why?

Yody: Yeah...because it got me thinking.

Interviewer: And you don't like thinking?

Yody: In science, it doesn't really get me thinking because you just write it up on the board after, so it is easy questions.

Interviewer: Because science is mostly about facts, right?

Yody: Yeah.

Interviewer: Theory has been proven over thousands of years and then they put them into text books. So, you got used to that?

Yody: Yeah.

Interviewer: You don't like thinking?

Yody: Nah.

Interviewer: For you to enjoy science more, what do you think is the most important thing?

Yody: More chemistry....more stuff to do with explosions and that.

Although Yody mentioned in the interview that he did not wish to do any more dilemma stories, the reasons were that the dilemma got him thinking and he did not like that. Another reason was that his usual concept of science lessons was the

presentation of facts from textbooks, written up on the board to be copied and learned, which once again equates to very little thinking. Very similar to the other boys in the year group, Yody believed that Science is all about making things explode, and that to him and others is the most important thing in Science.

This seems to give rise to the dilemma of teaching dilemma stories! Ethical dilemma stories, which involve neither right nor wrong answers, presented a challenge to Yody. He might have said that he didn't like it but I perceived, based on classroom observations, that he enjoyed the story as he was constantly asking question about Akiki, the main character and, being an attention seeker, Yody also enjoyed the attention he was receiving in class while voicing his opinions.

Should I continue with the dilemma story approach knowing that my students will benefit from it as it elicits critical thinking skills? Or should I discontinue with the dilemma story approach because some students say so? Even if some students didn't like the ethical dilemma story approach, should I still present it because I know critical thinking skills are good for them? There are many dilemmas with dilemma story teaching. Settelmaier (2004) identified "six potentially problematic aspects of a dilemma teaching approach not addressed by existing literature: student engagement with the stories, the (in)authenticity of student portfolio-notes, teachers' good intention as potentially unethical imposition, the frequency of dilemma units, teacher skills, integration of ethics into existing learning areas, the effect of so-called problem students on the dilemma approach and vice versa, and time requirements".

I guess my dilemma of teaching dilemma stories best resonates with one of Settelmaier's potentially problematic aspects of a dilemma teaching approach which is the frequency of dilemma-units. It is important to keep a balance between keeping students "interested and engaged and avoiding dilemma-overload" (Settelmaier, 2004).

Overall, The Mining Dilemma Story seemed to have had a strong resonance with Yody's personal beliefs and values. It had engaged him deeply in dilemma thinking and had "*made me think*". This is strong evidence that dilemma stories can be a useful tool to engage students in science and, most importantly, to make them think, as evident in Yody's case.

Interviews of Alice

Alice, a 15 year old Spanish-French Australian girl, was my next case study participant. Similar to Yody, Alice has high literacy skills and she is very articulate in class, with English being her favourite subject. Alice aspires to go to university after Year 12 to study teaching and she hopes to become either a junior primary teacher or a music and drama teacher.

Science being her least favourite subject, she usually spends most of her time in science lessons 'texting' her phone under the table, writing notes to pass to her friends, thinking that it goes unnoticed. Alice would also try to get away from doing work by using techniques such as pairing up with the person sitting next to her when the assignment is due. Alice being an attention seeker, I remember we had a huge row over her not concentrating in class and for several weeks she was constantly giving me the 'evil' look.

When The Mining Dilemma Story was told to the class, Alice as usual was busy chatting away to her friend in the form of note passing. In order to focus her back to the lesson, I purposely asked her opinion on what she thinks Akiki should choose. This got her attention back and Alice was then voicing out her opinions to the whole class and at the same time asking clarifying question such as "So you mean Akiki is living in the Kimberley now?", as she wasn't paying attention when the story was told.

As the lesson went on, the conversation with the friend that she was busy chatting to before turned into a conversation about Akiki. They were debating as to what Akiki should do and Alice was writing down her responses on the worksheet

given to her (see Appendix G). I remember that I was feeling so happy that Alice was finally doing some work in class. The interview with Alice two months later confirmed that she was indeed engaged in The Mining Dilemma Story.

Interviewer: Do you remember the dilemma story?

Alice: Yep

Interviewer: Would you mind recapping what it was about?

Alice: A kid in the Kimberley. His dad moved up there with his family. And his dad had a job in the mines, and was working away a few weeks at a time. And they were given a choice, the mining company said they were going to start mining in the Kimberley and the town said they didn't want the mine. And he (Akiki) had to decide whether he wanted his dad to be home constantly and have the mining through the town he's just moved to, or keep the town as it is and have his dad still working away.

Interviewer: What was the dilemma of the story?

Alice: That he had to choose between seeing his dad. He was put into a bad position, he had to choose and it was a tough decision. We were asked what we would do if we were in that position and we had a bit of a debate about it

Interviewer: And what did you talk about?

Alice: How the Kimberley was such a nice place, and putting mines there is a stupid idea because there's families living there and it would pollute the area, and noise pollution and all that, eventually people would have to leave anyway. So, they're better off working there. Lots of parents have to work away, and it's just something you have to learn to deal with. And it's better

off that way, rather than a year or so and they have to move again

Interviewer: And what decision did you come up with?

Alice: I think it is better that his dad can choose working away and they don't mine in the Kimberley because it is not necessary. He's got a job where he is. And that's another thing; he would get a higher position, better pay. But umm...it is still ruining their home. Their family, he had a younger sibling I think, it would affect him and everything.

In the excerpt above from Alice's interview, it seemed that she was able to recall and articulate the dilemma that the main character (Akiki) was facing, even when it had been two months since she did The Mining Dilemma Story activity. The reason for this is the personalisation of story for Alice and her ability to identify with Akiki. She revealed in her interview that her step-dad works away, and "mining is something that needs to be done". In her exact words, "It brings good income, and everything. And it sucks that he goes away but it is part of life. And I've still got my mum as Akiki still had his mum". The most important impact of The Mining Dilemma Story was perhaps when Alice went home to discuss her learning with her mother, something that is priceless from an educationist's point of view.

Interviewer: And how did you feel about the dilemma story after you did it?

Alice: It made me think about it a lot. I went home and discussed about it with mum. It stayed on my mind a few days afterward, like thinking about the different things. And we were told it was about a real person, which I still don't know whether it is or not, and I was thinking about how he's dealing with it, like had we helped him and stuff like that.

Interviewer: What did you guys talk about at home?

Alice: I just told her that, I told you we're kind of in the same situation, and it opened my mind to the possibility of leaving. Like after I heard everyone's opinions and me and mum sat down and had a big talk about it.

Interviewer: So you really identified with Akiki?

Alice: Yeah

Interviewer: And you feel the dilemma that Akiki was feeling?

Alice: Yeah like it's a hard decision. Like if my step-dad had the decision to work here, like we're considering moving to Collie cause we'll be right on site and he'd come home every day. But then we'd have to move and stuff like Akiki, and we've come to the decision that we're going to stay here. And that's what I think Akiki should have done.

Another positive impact of The Mining Dilemma Story was the connection that Alice was able to make between the Science that she was learning in class and how that relates to life outside school. From the interview excerpt below, I was able to gain some valuable insights into how dilemma stories and debating can bring about a change of values in students' life, in this case Alice's life.

Interviewer: What did this dilemma story make you think about science? Do you like science in normally?

Alice: No.

Interviewer: But that changed with this story?

Alice: Umm yeah. Well, we were doing rocks and stuff at that time and then I was like, you know, a lot of mining goes into

science, like they have to know what they're mining for and stuff like that, and it does involve a lot of science.

Interviewer: So you learned about science through the story?

Alice: Not really through the story, but it made me think back to the stuff we learned in science and that this stuff actually does relate to real life. Like when I'm in science, I'm thinking when am I ever going to know about the inside of a brain? And I was thinking about the same thing about rocks, but after seeing this story it does affect everyday life in a big way.

Interviewer: Did you learn anything new through the dilemma story that you did not know already?

Alice: I think so. It was a while ago. I do remember getting into a conversation with one of the boys in my class, Yody-he believed it was a good idea, I think. And I was talking to him about it and he was like, "What about family and stuff, it could affect their house but, you know, the area's polluted, people smoking could affect their household and having a bunch of teenagers as neighbours could affect their household. Someone mining in the same city isn't going to affect it anymore than everyday people do". That kinda made me think to be more open to other people's ideas.

Alice indicated that she was more open to other people's ideas and that came about through conversing with Yody and listening to his point of view. She also came to realise the reasons that Science plays a role in people's lives and that through the story, it made her "think back to the stuff she learned in science and that this stuff actually does relate to real life". Regardless of the ways in which the students resolved the dilemma, the results confirm that The Mining Dilemma Story successfully engaged these socio-culturally and academically diverse Year 10 students in science-related learning.

Even though I did not explicitly mention about values in the second round of dilemma stories, I could clearly see the student's values coming into play when they wrote down their decision on the worksheet provided (see Appendix G). In struggling to resolve the family versus environment dilemma, my students arrived at different conclusions based in large part on their different family values. Although many of the students indicated that they were in favour of protecting the natural environment, ultimately Akiki's father's job prospects took precedence over the environmental impact. In the case of Alice, she said, "I think a steady income is more important than staying home and being on welfare". She meant that Akiki's dad should stay with mining so that there would be a continuous source of income for the family. This resolution is not unexpected given that most of my students live in a low socio-economic area and their families face the daily spectre of unemployment and poverty.

Ethical Dilemma Stories as an Assessment Tool

The dilemma story added value to my students' thinking skills but, for the majority, it did not get transferred into their work ethic. They dawdled in getting their work done and had to be constantly pushed in the computer lab when typing up their informational report. Thus engagement on the dilemma story did not necessarily have a considerable impact on their overall Year 10 Science learning outcomes. For example, in the case of Alice, she was very engaged in the dilemma story, however when it was time for her to work on the informational report, she was very slow to get started and, at the end, she was unable to finish her report. In terms of her assessment, I gave her a high score on displaying appropriate thinking and investigative skills (see Figure 13) as she was able to articulate her ideas, however overall she did not get a high score due to her inability to complete all parts of the informational report. Yody, on the other hand, not only received a high score for displaying appropriate thinking and investigative skills (see Figure 13), but also received a high score on the other areas as he managed to complete all parts of the informational report.

Usefulness of Using Ethical Dilemma Stories in Teaching Sustainability

I think the most valuable thing about implementing ethical dilemma stories into my science curriculum is that it drives the engine for inquiry learning to take place. In ethical dilemma story teaching, students are given opportunities to listen to others' views and to come up with answers of their own which are neither right nor wrong. There is no shame of failure as long as students can support their answers with evidence or reasons.

Using my Year 10 students as an example, I have strong evidence to show that ethical dilemma story teaching had a positive influence and impact on students in digesting materials relating to sustainability. The Mining Dilemma Story delivered at the beginning of the year had a clear focus on sustainability and I found that my students were able to accept the sustainability content without much difficulty.

However, when I specifically focussed on the topic of sustainability in Term 3 during the same year and asked for feedback at the end of the term, almost all the students reported in their feedback form that, although it was important to learn about sustainability, they found it to be boring. This seems to be reasonably strong evidence that students are more likely to be more actively involved in the science concepts being taught when there is a context or point of relevance by which students can make sense of the ideas to be learnt. In the case of ethical dilemma stories, these stories set the scene by which students can explore the ideas through the follow-on activities. Using this exploration as a basis, science concepts and terms can then be introduced in a way that has meaning to students; and students are more readily able to see the application of the science concepts previously learnt to situations relevant to them.

Using the ethical dilemma story approach, I was able to engage students who normally would not contribute positively to the classroom discourse. In this case, both Alice and Yody, who are normally the distractions of the class, participated in the discussions and it seemed to open up an avenue for other disengaged

students to participate in science in a positive manner. For Alice, this positive manner was also demonstrated in Term 3 when I taught the topic on sustainability. It wasn't just Alice. The entire class of the higher ability group was generally more open to environmental discussion. It seemed that I could have an open discussion about environmental issues without the students being too much against the issues.

A particular incident left a deep impression on me when I was talking to the class about the use of biological control versus chemical control. Alice's best friend asked a question as to why scientists do not use only one single sex species in biological control to stop the introduced species from reproducing itself thus stopping it from going out of control. Alice contributed to the discussion by proposing the use of trackers to see where the introduced species has gone when biological control has been used. I personally really enjoy having these types of conversations with my students. It means that students are really absorbing and thinking about the science issues presented to them and sharing their opinions with the class.

When Alice and her best friend were asking questions, the other students in the class were paying close attention as to how I was going to respond to the questions. I felt like I was put on the spot at that point, which was an unusual situation for me as normally my students don't ask me questions that are not written on the worksheet given to them. Alice had a good science lesson that day as she felt important and valued when the others in class were listening to what she was saying.

Chapter Summary

Overall I am very happy that through the use of ethical dilemma stories I was able to manifest my Buddhist sustainability ethics in my teaching and use it to influence my students. In this chapter, I have discussed my learning journey in

using The Mining Dilemma Story with my Year 10 science classes, with special reference to three students – Ethan, Yody and Alice.

I am elated that the majority of my students were engaged in the story, especially in the all-boys low ability group. This boys group which usually had the most disengaged students were delightful to teach in the ethical dilemma story-telling session. Boys were asking questions, discussing with their partners and writing answers on their worksheet, which is a very rare scene. Ethan's enthusiasm, for example, was a rarity. I had never seen him so switched-on in class. He has a hearing problem and most of the time had problems following the content, partly due to his hearing problem and partly due to his inattentiveness during the lessons.

My classroom observations and in-depth interviews with Yody and Alice strongly indicated that students found The Mining Dilemma Story to be engaging due to the connections they were able to form with Akiki. It was pretty amazing to find out from the interviews with Yody and Alice that they both had experiences with their family members working in the mines. For example, both their dads had worked in the mines at some stage of their lives and this had affected them in some ways. This may be one of the reasons why they connected with the main character, Akiki, in the story and why they were both interested as to which decision Akiki's dad is going to make. This engagement in the dilemma story also translated into stimulating deep thinking about their personal values and their home experiences. In Alice's case, although the engagement in the dilemma story did not make an impact on her work ethic as she failed to complete her informational report, she did however show a more positive attitude towards sharing her views on sustainability in the later part of the year.

I have also reflected on my own practice as a science teacher with regards to implementing ethical dilemma stories, and I believe that the modifications I employed in the second dilemma story had its successes and its downfalls. I was successful in getting my students to be more involved in the story and identifying with the main character, however the downfall was when I failed to get my

students to present their views on a poster. In the next chapter, I discuss the implications of my learning to the betterment of future dilemma story teaching and the usefulness of embedding dilemma stories in the school curriculum.

Chapter Five – Discussion and Conclusion

Introduction

It was a hot summer day in 2011. Three science teachers sat in the conference room for a special meeting to adjust their current science curriculum to suit the new Australian Curriculum for 2012. In front of them were piles of paper titled ‘The Science Australia Curriculum’. Discussions were rich and lively as they racked their brains trying to think of contents to fit into the new science curriculum that will soon roll out next year. One teacher, Belinda, was highlighting and jotting down ideas while the other two gave suggestions. “Hmm...how are we going to fulfil this Year 8 outcome under ‘*Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations*’ asked Linda, a S&E teacher who had been allocated to teach science for the very first time this year. “This is hard!” continued Linda, and Belinda agreed with her. This was when the third teacher got really excited. “I know!! I’ve been trialling out dilemma stories with my Year 10s this year and I know of this fantastic website that has other examples of dilemma stories dealing with ethical issues and decision making that will be applicable to our students!!”

Not surprising, the third teacher was me. Having gone through the process of writing out my own stories and implementing them in my science classes with low achieving students, I have confidence that it will work in other science lessons. Ethical dilemma stories give students opportunities to engage in science and at the same time consider ethical issues. Ethical dilemma stories actually fit very well into the new Australian Curriculum.

This chapter discusses my findings in terms of the two research objectives formulated in Chapter 1 and answers the four questions I had set out to investigate in this action research. This chapter also discusses the after effects of dilemma story learning on my students' views, values and perceptions of environmental issues as well as the implications for my future teaching practice.

Dilemma Stories in the New Australian Curriculum

The Australian Science Curriculum to be fully implemented in every school across Australia in 2015 has split up Science into three broad strands. The Australian Science Curriculum will be organised around three interrelated strands: science understanding, science inquiry skills and science as a human endeavour. The aim of the Australian Science Curriculum is to provide students with a solid foundation in science knowledge, understanding, skills and values on which further learning and adult life can be built. In particular for them to learn that Science is a human endeavour that they should learn to appreciate and apply to daily life (National Curriculum Board, 2009).

Science understanding forms the foundation of science in the areas of physics, chemistry, biology and human biology. Students are expected to learn about facts, concepts, principles, laws, theories and models that have been established by scientists over time and that represent the building blocks of science understanding (National Curriculum Board, 2009).

Science inquiry skills are similar to science investigation, which is concerned with evaluating claims, investigating and making valid conclusions by involving students in posing questions, planning, conducting and critiquing investigations, collecting, analysing and interpreting evidence and communicating findings (National Curriculum Board, 2009).

Science as a human endeavour highlights the need for informed, evidence-based decision making about current and future applications of science and it

acknowledges that, in making decisions about science and its practices, moral, ethical and social implications must be taken into account, as science influences society through posing and responding to social and ethical issues and science research is influenced by societal challenges or social priorities (National Curriculum Board, 2009).

In adapting the current Science curriculum in response to the Australian Science Curriculum, it is clear that teachers need to report on student achievement in the five science stands, which reflect achievement in the areas of science understanding and science inquiry skills. Students are not currently assessed in the area of critical thinking skills, which is the main component in science as a human endeavour strand. In the Australian Science Curriculum, students from Year 8 to Year 10 (typically 13-15 years of age) are expected to apply scientific understandings to make responsible, ethical and informed decisions about issues in the science as a human endeavour strand (National Curriculum Board, 2009).

It is also stated in the Australian Science Curriculum that sustainability is one of the concepts that should be incorporated into the Year 7 to Year 10 science curriculum. In particular, it is written that *“The idea of sustainability is central to the nature of dynamic systems. A system has inputs, outputs and a variety of internal functions. The interaction of these inputs, functions and outputs determines the degree to which any system can sustain itself. The inputs include resources that may be renewable or non-renewable.”* (National Curriculum Board, 2009).

Sustainability as the Next Big Thing in Science Curriculum

Personally I think the topic of sustainability is going to be the next ‘big thing’ in Science as it is closely related to climate change, a challenge that is faced by most governments around the world. This is the reason why I decided to write up the two dilemma stories relating to the topic of sustainability.

Humans around the world are faced with the challenges of climate change on a daily basis – hotter summers, colder winters, increase in greenhouse gases, etc. Ever since the release of the documentary, ‘An Inconvenient Truth’ by Al-Gore, people are more aware of their unsustainable actions and what is happening to the environment that they are living in. The issue of climate change will almost certainly affect them and it is important that students are able to have the knowledge and capacity to take action in addressing this pressing issue.

The importance of sustainability and climate change is highlighted by the science exhibition section dedicated to teaching the public about climate change at the Scitech Discovery Centre. Scitech is an educational and engaging science centre located in Perth. It is a very popular destination for school visits and its feature exhibitions relate to explaining science concepts in a fun and interactive way. In 2011 Scitech launched a new Science program, Climate Change Careers Workshop, aimed at Year 10 students. This is an interactive workshop specially designed to encourage scientific thinking and critical analysis skills, where students investigate greenhouse gas emissions from household appliances, make bio-diesel and discover the potential of using hydrogen gas as a fuel. The high ability Year 10 science class at Hopefield College was very fortunate to be able to participate in the Climate Change Careers Workshop.

Considering the importance being placed on critical thinking skills and sustainability in the new Australian Science Curriculum, ethical dilemma stories are a powerful tool to use in the science classroom. This will be more evident when I discuss the findings of my research in the next section.

Research Objective 1: Student Engagement

My first objective had two questions that drove this research. Firstly, does dilemma story teaching induce a change in my students’ thinking and deepen their understanding of the concept of sustainability? Secondly, can my students see the value of engaging in ethical dilemma stories in science?

Students' Engagement

It is evident in Chapters 3 and 4 that students were engaged in both the dilemma stories presented to them in Year 9 and Year 10. Results from the post VLES questionnaire indicate that students found The Prime Minister Dilemma Story had stimulated deep thinking about their personal values (see Figure 6). The four students who were interviewed further confirmed the positive impact of The Prime Minister Dilemma Story on their attitude and reflective thinking. Gordon, in particular, seemed to have gained the most from participating in the story as he developed his own understanding of the concept of sustainability and put forward his idea of promoting sustainability in Third World countries.

In Chapter 4, Yody and Alice both indicated that The Mining Dilemma Story had engaged them and led them to make decisions based on their family values and prior experiences with mining. When Alice was asked what she thought about environmental protection in The Mining Dilemma Story, she responded with “I think the environment is important, but they are going to mine regardless....there's no laws against it and companies pay lots of money for the mining they do, it's not like they're going to stop it...I haven't really thought that much about it but they're going to mine anyway, and global warming's going to kill the earth anyway...there's not really much you can do to stop it.”

Similarly in The Prime Minister Dilemma Story, when Patrick was asked if he found it hard to make his decision between choosing Planet Xplorer and AUSworld, he responded with “Usually, I would find it hard, but because I knew the Earth is going to blow up and we are just going to die, so I chose Planet Xplorer. If there was to be human survival, it will have to be on a different planet”. These comments by Alice and Patrick highlight the way they were feeling about their current situation. It is interesting to note that their comments highlight aspects of the widespread feeling of helplessness amongst adolescents. One can see that there is a huge potential to tap into students' deeper learning into sustainability through the feeling of helplessness. It was a pity that I had failed to make full use of this opportunity to elaborate it further in class. In future I will

definitely be bringing out comments made by students to generate further discussions in class.

Differences in Students' Engagement

My students engaged differently in the two dilemma activities. In the Prime Minister Dilemma Story, I had issues in classroom management when I was presenting the story on the SMARTBOARD. Students were a little lost and they were not able to relate to the main character. My students were more concerned with why they were doing it rather than with the details of the story. However I found that my students seemed to enjoy the poster making sessions more than the Prime Minister Dilemma Story itself. They loved looking up space pictures on the internet to stick on their posters. And while they were doing that, it gave me a chance to talk to individuals and groups about their arguments for and against the decisions they were making as the Prime Minister. When they had to select pictures to represent the conditions faced in the Third World countries this, once again, gave me a chance to talk to the students. The poster making session was magnificent as it gave me the freedom to wander between the groups, talking and listening to students' ideas, sometimes clarifying the story if there was a misunderstanding. For example, there was a group in The Prime Minister Dilemma Story who came up with a solution to benefit both parties in the story, and upon questioning them I found that they were making their decision not knowing they were meant to be the Prime Minister. They changed their initial decision after our discussions.

In The Mining Dilemma Story, students were very engaged in the story. Classroom management was almost 'zilch' as students seemed to be very interested in Akiki and they asked many clarifying questions about Akiki throughout the story. I felt that because students could relate to and identify with Akiki, they were more engaged in the story, and this was evident in the interviews with Yody and Alice. However, most students were not excited about producing an informational report on mining as part of their assessment and they found it

boring and were not deeply engaged. This was when I had issues with classroom management as mention in Chapter 4.

Pointers for Future Implementation of Dilemma Stories

I would suggest the following five pointers for future implementation of dilemma stories. Firstly, the main character of the story needs to have a creative name that students can identify with. It can be a name that sounds weird or even a name of a current pop-singer if your students are into music, basically a name that stands out.

Secondly, based on my experiences with the two dilemma stories, I found that it is crucial that the story be told and not presented. For example, when the storylines of The Prime Minister Dilemma Story were presented on the SMARTBoard, students weren't paying much attention to the story, leading to confusion in the poster-making sessions. Whereas when The Mining Dilemma Story was told as a story without a script I found that students could remember the dilemma story months after it was first told, mainly because they had asked clarifying questions and this probably seeped deeper into their consciousness. Settelmaier (2009, p. 349) reported similar findings and, after observing the implementation of ethical dilemma stories in different classrooms in Austria, she recommended introducing dilemma stories via storytelling instead of story-reading. Settelmaier (2009 p. 349) observed that some students pointed out that storytelling conveyed much more than reading because of issues related to body language, intonation and voice. Reflecting back to both times when I presented the two dilemma stories, I can now see that there was a marked difference to how I presented The Mining Dilemma Story. There was a lot more energy involved when I changed my voice tone and used more body language when I walked around the room as I told the story since I was not restricted to pressing the buttons on the computer for the next slide on the SMARTBoard.

Thirdly, the contents of the story need to be relevant to the students' lives. It must be something that the students can identify with. For example, most of my

students were unable to put themselves into the shoes of the Prime Minister as they couldn't see themselves being one. But, on the other hand, they were able to identify with Akiki as some of their dads or relatives were involved in mining, which is a job they could picture themselves in. Most students could still remember the contents of The Mining Dilemma Story six months after it had been delivered. Sometimes students would ask me how Akiki is doing when they saw me in the yard on recess duty! Likewise Settelmaier (2009) also found the importance of ensuring the relevance of the story's content before implementation of ethical dilemma stories.

Fourthly, do not overlook the value of the poster making sessions. This activity can be very important to the success of the dilemma stories. The freedom of time given to the teacher allows for checking and clarification of misconceptions or misunderstandings students might have about the story. Looking up pictures on the internet can stimulate discussions among students, and can provide an opportunity for the teacher to have informal teaching sessions with students.

Lastly, do not place undue pressure on yourself by wanting to assess formally the dilemma activity. As I found with the Akiki dilemma story, I had put myself under unnecessary pressure when I tried to assess students' informational reports. I was frustrated that students were taking so long to type up information and most of the time I was in no mood for conversation, as most of my energy was used up making sure students were on-task with their informational report. Students reported that they disliked this computer session as it required them to type up information they found boring. I felt that if I had directed them to produce a poster the outcome would have been much different.

Upon reflection, if I was to conduct the Akiki dilemma activity again, I would scrap the idea of assessing students' informational reports. Instead I would direct them to produce posters and to present them to the entire cohort during assembly. Students might not like the idea of public speaking but, as I found in the Prime Minister Dilemma Story, presenting their posters placed the accountability back

on the student which would be an excellent piece of assessment for the learning area outcome: Communicating Scientifically.

The Value of Ethical Dilemma Stories in Science

Looking at the outcomes of both The Prime Minister Dilemma Story and The Mining Dilemma Story, it was evident from my classroom observations and interviews with my students that the dilemma stories seemed to have deeply touched many of them. Students identified with the main character and further discussed the dilemmas with their parents, bringing the class discussions home. Most importantly, all students who were interviewed said that they enjoyed the experience of doing dilemma stories in Science and, with some exceptions (discussed later), wouldn't mind doing more of them as long as they are 'fun and not boring'.

During the interviews, when students were asked if they could see the science in the dilemma stories presented to them, all of them said that they were able to identify the science content through engaging in the dilemma stories. The science content identified by the students matches up with what I initially set out to teach in my science program, indicating the relevance of dilemma stories in the science curriculum.

Research Objective 2: Development of Dilemma Stories

My second objective had two questions that drove my personal growth as a teacher in this research. Firstly, will my stories be engaging enough to tap into my students' current way of thinking? Secondly, is there a 'best way' of engaging students in ethical dilemma stories?

In response to the first question, observations from my students participating in both dilemma stories and from the interviews indicated to me that the two stories were engaging to them. In The Prime Minister Dilemma Story, although students found it hard to put themselves into the shoes of the Prime Minister, they were

fascinated by the concepts of finding a substitute for Earth and conditions in Third World Countries, and investigating these concepts was engaging for them.

In the Mining Dilemma Story, almost all students could identify with the main character, Akiki, and immerse themselves in his world and the dilemma Akiki was facing. The identification with Akiki subsequently led to many students being engaged in the story and asking questions along the way. It was really interesting that fifteen weeks after I had delivered The Mining Dilemma Story, students gave me this response when I told the class that they are about to learn about environmental sustainability, at the start of Term 3. “Why are we learning this again?” “We did it in Year 8...this is so boring...we already know all of these things...”

However, the really interesting thing that I observed during the term was that when I held discussions about science issues such as feral animals, recycled drinking water and natural resource depletion, I was able to hold my students’ attention for that little bit longer. They didn’t switch off immediately or kick up a huge fuss as I would have expect based on the comments they made at the start of the term. And I was so surprised that most of them remembered about mining tailings when I raised the environmental issue about mining. Yody, as usual with his cheekiness, brought up Akiki and asked me again what subjects I tutored him in. It was good to know that the ethical dilemma stories I had written specifically for my students had an effect on them in the long term.

I remember showing these students a documentary film, ‘Food Inc’, in which an American family was interviewed about the food they were eating. Although they knew that cheeseburgers from the fast food chains were unhealthy and contained saturated fats, they were faced with the high cost of buying fresh vegetables from the supermarket. It worked out that it was cheaper to buy cheeseburgers and soft drinks than fresh vegetables, and due to their low family income, they were facing the dilemma of either spending the money on fresh vegetables or on the diabetic medication that their dad, the sole income generator, is currently taking. Patrick

was sitting next to me and I leaned over to ask him what he would do if he was part of that family. His responses were “Yeah it’s hard, isn’t it? If they spend the money on fresh food, their dad won’t be able to have the money to buy the medication and if he dies, the family would be in trouble...I don’t know...It’s a dilemma isn’t it?”

Patrick was one of the case study participants in Chapter 3, the boy who had shown a decrease in his level of engagement in the post VLES questionnaire while his reflective thinking scale stayed high. The drop in Patrick’s attitude scale was due to him finding the task of deciding between the two choices to be pressuring, and thus not to his liking. This was the same with Yody in Chapter 4, who indicated in his interview that he would not like to do another dilemma story in Science, although the story kept him thinking and staying focused in class. More about this issue later.



Figure 17: Which way is he looking? A picture showing two perceptions.

This is a dilemma in teaching dilemma stories! Like the picture in Figure 17 given to me by my co-supervisor in one of our debriefing sessions, on the one hand, the subject seems to be looking straight at you, but on the other hand, he seems to be looking to the left. Staring at the picture is parallel to listening to the contradictory comments these students were making about ethical dilemma stories.

In response to the second question of whether there is a ‘best way’ of engaging students in ethical dilemma stories, I have shared some of my pointers for future implementation of dilemma stories earlier in this chapter. Those pointers might be the ‘best way’ for my particular type of students in my school, but that does not mean that it is necessarily the ‘best way’ for all students.

Nevertheless, I believe that successful implementation of ethical dilemma stories may have some shared mutual characteristics regardless of the type of students. These shared mutual characteristics are, firstly, that the stories need to be meaningful to the students. Students need to be able to relate to the characters and their role in the story. For example, in the Prime Minister Dilemma Story, the story was a bit complicated for my students to comprehend and, due to low self-esteem issues, most found it hard to place themselves in the role of the Prime Minister. Hence, in the second dilemma story, I made the story simpler and told it without reading off the script. I also made sure the main character, Akiki, was the same age as my students so they could relate to him better.

Secondly, the story and associated learning activities need to cater for the students’ academic ability. It needs to be at a level that students can understand. Students at my school are not very academic, and thus I chose to write my own dilemma stories at a level that they could readily understand. Similarly in Hill’s (2009) honours thesis, where she observed and interviewed teachers who had trialled dilemma stories in their science classrooms, teachers who perceived success in implementing dilemma stories were those who had introduced the main character via storytelling, thus enabling their students to relate to the character and thus engage in the dilemma at hand. Settelmaier (2009) also found in her research

that storytelling provided a “context for identification and reflection and promoted attention and engagement”.

For the students to be able to relate to the main character, the scene and characters in the story need to be ‘told’ to the students via storytelling. As in Ada’s case (a teacher in Hill’s thesis), who drew on her drama background and regularly incorporated storytelling as part of her classroom practice, although “ethical dilemma stories were ‘ideally suited’ to her high ability class, she commented that it is possible to use ethical dilemma stories in both high and low ability classes” (Hill, 2008 p. 47) This is in contrast to Jean (another teacher interviewed in Julia Hill’s thesis), who implemented the ethical dilemma stories by delivering information rather than telling stories. Ada’s positivity about ethical dilemma stories was largely due to her ability to engage her students via acting out the scene and storytelling. This contrasts with Jean who read the dilemma story off a script and later commented that ethical dilemma stories would not go well for the lower ability classes. Ada’s approach exemplifies what I mean by enhancing the meaningfulness of the stories.

By contrast, Jean, who perceived “lower ability classes, especially students with difficulties in writing, not to be compatible with ethical dilemma stories as a teaching strategy” (Hill, 2008, p. 63), explained that:

most lower school classes at this school would struggle with this strategy due to its teacher centeredness...most classes in lower school here to run well, stand up there and dominate the whole lesson would be asking for failure because kids just get bored listening, and you constantly, as you do anyway have to stop and get their attention and pull them together ‘cause there’s so many stops and starts throughout the process and that’s a challenge if kids aren’t obliging and aren’t keen. So yeah it’d be very tricky to do with the less academic students. (Hill, 2008, p. 62-63)

The issue of engaging low academic achieving students is the main reason why I chose to write my own dilemma stories. Jean most probably did not have a chance to write his own dilemma stories and this might be a reason why he felt that the dilemma story would only work with high ability students. Similar to Jean's case, most of my students had difficulty in writing. With the low ability classes, I also experienced frustration when my students were not putting themselves into the shoes of the Prime Minister, but were instead distracted with the technology of the SMARTBoard! This experience underpins my assertion that it is essential to ensure the suitability of the contents of the dilemma stories in relation to the academic ability of the students in the class.

Thirdly, there needs to be an activity after the dilemma story. It might be a computer research activity where students find pictures or type down their responses. The purpose of this activity is to give the teacher the time and opportunity to interact with individuals or groups of students for further discussion about the dilemma story. This is the best opportunity for the teacher to find out what the students got out of the story and to make sure that they understood the dilemma presented to them. Similarly, Settelmaier (2009) found that the poster presentation in the science classes resulted in "discourse between the presentations, the audience and the teacher. The discussion was passionate and students appeared to be involved".. I made the mistake of not getting my students to do a poster in the second dilemma and the result was that I was not able to spend a lot of time talking to individual students regarding Akiki and the dilemma he faced. Because I was so focused on the formal assessment part, I did not spend much time discussing the dilemma story with my students and instead I was preoccupied helping them with their informational report writing.

Thus I suggest that the three shared mutual characteristics for successful delivery and outcomes of dilemma stories in Science are: the meaningfulness of the story, the appropriateness of the content to the academic ability of the students, and a poster activity to conclude the dilemma story.

Emergent Research Questions

Reflection occurs at every stage of action research. The notion of reflexivity is central to action research, because the researchers are also the participants and practitioners in the action research – they are part of the social world that they are studying (Hammersley & Atkinson, 1983, p. 239).

Hall, as cited in Cohen, Manion and Morrison (2000, p. 239), suggested that reflexivity is an integral element and an epistemological basis of emancipatory action research because it takes as its premise the view of the construction of knowledge in which: (a) data are authentic and reflect the experiences of all participants, and (b) democratic relations exist between all participants in the research; the researcher's view (which may be theory-laden) does not hold precedence over the views of participants.

Zuber-skerritt, as cited in Cohen, Manion and Morrison (2000, p. 240), proposed that one of the practical problems that action research might face is how action research techniques can be sufficiently specific that they enable a small-scale investigation by a practitioner to lead to genuinely new insights, and avoid being accused of either being too minimal to be valid or too elaborate to be feasible? Zuber-skerritt suggested also that the issue of the audience of action research is problematic. According to her, there are three important audiences. The first audience comprises colleagues with whom we have collaborated in carrying out the research reported. The second audience are those interested colleagues in other institutions for whom the underlying structure of the work presented may be similar to situations in which they work, and the third audience is ourselves.

I agree with Zuber-skerritt that because the process of writing involves clarifying and exploring ideas and interpretations, the third audience is perhaps the most important. Being a reflective teacher and keeping a reflective journal while I was implementing the two dilemma stories, I found that four questions emerged during my journey which I reflect on next.

The emergent questions discussed in order are:

- How strong is the credibility of my case study participants?
- Did I provide the best interview conditions for my case study participants?
- Has there been a shift in my teaching style and pedagogy since delivering ethical dilemma stories?
- What is the future of ethical dilemma teaching in my teaching career?

The Credibility of my Case Study Participants

The shift in my research paradigm from the positivist to the interpretive and critical paradigms meant that I shifted my focus from analysing the VLES questionnaires to interviewing selected students that formed my case studies. I found my case study research to incorporate what Yin (1984) identified as exploratory, descriptive and explanatory aspects. For example, my case studies of Andrew, Dominic, Gordon and Patrick in Chapter 3 are both exploratory and descriptive, while my case studies of Yody and Alice in Chapter 4 are both descriptive and explanatory.

The Prime Minister Dilemma Story was, in effect, a pilot study. I implemented the story as a fun thing to finish the year off and interviewed the students to ‘test the water’ before I implemented a second story when the same students were in Year 10. Thus when the Mining Dilemma Story was implemented in Year 10 and students were interviewed, the case studies became explanatory as they were used to test the theories that I formulated the year before. All of my case studies are descriptive as I have provided narrative accounts for each of them.

So how creditable are my case study participants? Did I purposely choose students whom I knew would give me a good response? Of course life would be so much easier if one could handpick the perfect student that gave the perfect answers and thus write a perfect thesis. But from my perspective and role as a teacher researcher, and in accordance with my Buddhist values, there would have been absolutely no gain in me doing that. Educators play a very important role in society. As the person who imparts knowledge and wants only the best for their

students, we like to share our experiences with other educators, especially activities and resources that seem to have had a positive impact on our students in our classrooms. From a Buddhist point of view, I follow five moral precepts: not killing, no false speech, no drinking alcohol, no sexual misconduct and no stealing. The precept of no false speech includes telling the truth and this applies to what is written in this thesis.

Moreover, based on Guba and Lincoln's (1989) criterion of trustworthiness, negative case analysis is a measure of credibility. In Yody's and Patrick's case studies, although both boys seemed to show a drop in their interest in doing more dilemma stories, both indicated that the stories made them think more. Strangely, they seemed to be contradicting themselves. This reported contradiction in speech is a feature of negative case analysis and strengthens the credibility of my case study participants.

As discussed by Stake (1988, p. 256), a case study doesn't tell the whole story but it does deal with the unity of the case, the unity of the experience, in ways other research methods do not. The validity of my case studies was optimised by 'triangulation' – direct classroom observations, formal and informal interviews with my students, and my reflective teacher's log which I kept from the beginning of the research. Altogether, these methods contributed to optimising the credibility of my case study participants.

The Interview Technique

I was reflecting on the time when I took selected students out of class to interview them about their experiences with the dilemma stories and also the time I spent with the research assistant while she was interviewing the students. And then this scenario pops into my head. It happened during Term 4 in the school's science lab.

*“What do you think of when you see the word sustainability?”
the Scitech presenter asked enthusiastically. Glancing around*

the room, no one put up their hands. “It can be really simple”, he continued, still with a positive upbeat in his voice. Someone in the audience responded in a not so confident voice “Food?”. “Yeah..that’s good” and the presenter wrote it up on the board. “Anything else?”, he pressed on. And there was this complete silence in the room. This is so awkward for me as their teacher. A bunch of Year 10 students, supposedly the top group in the school struggling to give an answer. And then the spotlight turned to me. “Let’s ask your teacher and see what she thinks”. Oh my god! I could feel adrenaline pumping straight up to my brain, giving me a temporary state of blankness and my face suddenly burning hot.

My second emergent question is whether I provided the best interview conditions for my case study participants. It might be our teacherly nature that when we ask questions of students, we have in our minds exactly what we want them to say. It’s like we have the desired answers scripted in our heads and when we don’t get what we want to hear, we press on and on, guiding them along the pathway until we are at least close to the desired answer. This might happen in interviews too. But have we ever thought what is going through the mind of the person being interviewed. Have we given them enough preparation time and thinking time? Have we accounted for the state of blankness (that even I experienced as a teacher) that may occur when we put students in the spotlight?

Going through the interview scripts, the best experience I had with the students was when we had informal chats about their experiences. I recall my first interview with Andrew after The Prime Minister Dilemma Story. It was so stiff and formal. Me asking him questions that I had scripted on a piece of paper that I held in front of me, while he sat across from me with a table between us. The room was so quiet that I could hear the clock ticking loudly above me. Needless to say, the interview I had with Andrew was a formal one and there was no laughter

or conversational talk happening between us. It was plainly a situation where I asked him questions and he gave me answers.

I decided to make some changes after this unsatisfactory experience. My second interview involved a group of students sitting around a table. The atmosphere was quite different. It was noisy as students dragged their chairs to fit around the table. They were smiling and talking as we entered the classroom. I felt the tension easing when we got to the third question. Students were listening to each other's responses and bouncing off each other, contributing to a very lively conversation. It no longer felt like a formal interview and it became more like a friendly conversation that you find most people have in a café. It was amazing that a lot more discussion was generated when I conducted the small-group interview.

Sociologists James Holstein and Jaber Gubrium claimed that “all interviews are active interviews, where an interviewer constructs knowledge with the interviewee, making interviews collaborative accomplishments” (Holstein & Gubrium, 2004). According to them, “highly refined interview technologies streamline, systematize and sanitize the process and technical attempts to strip interviews of their interactional constituents will be futile” (Holstein & Gubrium, 2004). The interviewer's objective is not to “dictate interpretation through a predetermined agenda but to provide a conducive environment for the production of meanings that address relevant issues” (Ritchie, 1997).

Unfortunately, I didn't have the opportunity to interview the second round of students after the Akiki dilemma story. Feedback from my co-supervisor, Peter, and the research assistant were that it was hard to get answers from some of the kids. Quote from Peter: “For some of the kids, it is like trying to squeeze blood out of a stone”. Reflecting back on how their interview was set up in the library, it was most probably like the one I had with Andrew at the beginning. The students no longer had their teacher discussing with them. They were being interviewed by complete strangers, with whom they had had little or no previous contact. Just like what happened in the story with the Scitech presenter, these kids likely

experienced a ‘brain-freeze’ moment in the interviews, and hence this explains the constrained types of responses given.

I would suggest the following two pointers for future interviews. Firstly, it is best done by the teacher, with whom the students already have a relationship. Secondly, having a few students in a small group will create a more relaxed feel to the interview process. Students are more likely to open up after a while, with the conversation going into a higher level. Not only that, as soon as the barrier between the interviewer and the interviewee becomes ‘fuzzy’, students are likely to no longer treat the process as a formality, as it becomes more like a normal conversation to them.

Shift in Teaching Style and Pedagogy

My teaching philosophy has always been to provide enriching education experiences that will develop each child into a happy and unique individual who feels confident in the directions he/she wants to take after graduating from the school. Activities that I am more inclined towards are those that help develop life-long skills, such as communication skills, analytical skills and social skills, which each child will find useful in the world beyond school. My goal, from the beginning of my teaching career, is to develop a set of good teaching strategies that I can use to develop intrinsic motivation in students towards learning more about the world they live in.

In the first three years of my teaching career, I was very much focused on improving my classroom management skills due to the type of clientele at Hopefield College, where the majority of problems come from students mucking around in class. During those three years, I learned that a more teacher-centred approach is required when I am dealing with a class that is disengaged from learning. The lessons need to be very structured and occasionally cooperative learning strategies such as Think–Pair–Share can be added into the lessons. Content taught needs to be simplified to gain the confidence of low ability students and I have extra work prepared in advance to cater for students who have

already finished the ‘easy’ work, especially if it is a class of mixed ability. Building rapport and having a good relationship with the students is the key to surviving at Hopefield College. I have seen many prac teachers, relief teachers and even newly appointed teachers tearing their hair out when they were unable to connect with the students. Students would purposely give them a hard time, not necessarily because the activities were boring but because they didn’t like the teacher and were unable to connect with him/her.

Thus in my time at Hopefield College, I was able to polish my classroom management skills, and as the years went on I began teaching the younger siblings of students that I had taught in previous years. This made a huge difference as there is an immediate connection that ‘I have taught your older brother/sister’, which works very well at a small school such as ours.

In my fourth year at the school, I was more open to experimenting with more student-centred activities, but I was still adapting them so they were structured and easy for my students to follow. I was also beginning to impart some of my Buddhist values to my students. For example, in class discussions in Advisory, which is similar to a form class, I would justify some of my comments based on my Buddhist values and explain them to the students.

The VLES questionnaire contained six key factors of the classroom learning environment that are conducive to ethical dilemma learning. However, I only focussed on two factors – ‘How I Feel About This Class’ (or deep engagement) and ‘Learning to Think’ (or critical self-reflection) in my analysis in Chapter 3. The reason was that these two factors resonated best with my teaching philosophy. It is imperative that students enjoy what they are learning and doing in my science class, and lately because I have observed the ease with which science facts are obtained due to advancements in information communication technology, the most important skill for students to gain is not being able to memorise science facts but to be able to think critically about scientific issues.

I agree that the other four VLES factors – ‘The Teacher’ (teacher support), ‘Learning to Work Together’ (collaborative decision-making), ‘Learning to Listen’ (empathic communication) and ‘Learning about Science’ (critical social thinking) – are also important elements, however because I felt that I could tease those out from my students either during the interviews or through my classroom observations, I decided to leave them out. For the purpose of my research, I preferred to go deeply into two factors rather than broadly across all six factors.

It was funny that when I was first introduced to ethical dilemma story teaching by my supervisors, I only saw its potential in terms of the capacity to expose my students to the ideas of sustainability. However, after implementing two stories to my students in Science, I became more aware of the other benefits of telling ethical dilemma stories. Firstly, my students who come from low socioeconomic areas and who tend to lack in family love and attention, love listening to stories. From a psychological point of view, it seems that they love being read to as they were deprived of it in their childhood.

Also I became aware that Aboriginal students were more switched on and asked a lot more questions when The Mining Dilemma Story was narrated to them. This made me recall a professional development session I attended on Aboriginal two-way literacy. The lady gave us a rundown on how Aboriginal students learn in their usual home environment. I remember her saying that story telling is the method where older generations pass down their knowledge to the younger generations and that this is the way that Aborigines learn. This seems to make sense about why my Aboriginal students were more engaged in the delivery of The Mining Dilemma Story compared to normal science lessons. McCarthy (2010, p. 135) in her doctoral thesis described her teaching days in a remote Aboriginal community in the Northern Territory. Her descriptions of her dealings with adults and kids in the Aboriginal community mirrors what I experienced at Hopefield College. McCarthy made mention of an eight-week Silkscreen Workshop she organised which turned out to be extremely popular with the older men who took the opportunity to screen-up their totemic stories. In her words –

“When they calmly cut out their designs, they yarned giving them the opportunity to tell the younger ones sitting and watching them work their traditional stories.” The word ‘yarned’ used in this context is an Aboriginal word for telling stories. McCarthy’s doctoral thesis seems to support storytelling as a feature of Aboriginal learning styles.

I felt that through engaging myself and my students in ethical dilemma stories I have changed some aspects of my teaching pedagogy. For example, I am now more inclined to give out assessments that trigger students’ thinking and I ask for their opinions on issues. I find that a right or wrong answer restricts students’ creativity and critical thinking ability. Some students are so driven by getting the right answers that they don’t even trust themselves. For example, in the dilemma stories, some would ask continuously “Is this the right answer, Miss?”, even when I had told them there’s no right or wrong answer. This is the sort of culture we need to change in the classroom. We want to educate students, to give them the skills to be able to make the right decision when they leave school and enter society. We do not need to create robots that store data and correct answers when we already have the internet and encyclopaedias for this purpose.

I have also learnt not to be too obsessed in getting students to finish off work so I can assess them. An important lesson learnt was when I missed an opportunity to further engage them in critical thinking because I was so driven in getting the students to produce an informational report in *The Mining Dilemma Story* so it could form part of their formal assessment. Reflecting on this now, it was really meaningless for my students and me that they produced an informational report in Science. Now that they have graduated from Hopefield College (at the end of Year 10), the production or non-production of an informational report doesn’t really have a huge impact on their life compared to the new knowledge and skills gained from thinking critically about sustainability.

Secondly, I feel that teaching dilemma stories across different curricula, such as Science and English or Society & Environment, feels more natural to me.

Especially in the topic of sustainability, the links between Science and Society & Environment are inseparable. Not only do cross-curricular activities expose students to different teachers' viewpoints, but students can also see the interconnectedness of what they are learning in school.

Overall, writing and teaching ethical dilemma stories to my students for the past two years has had a strong influence on shaping the way I teach Science. Without doubt I could see the benefits ethical dilemma stories brought to my students and, in view of the introduction of the new Australian Science Curriculum, I see no reason why ethical dilemma stories shouldn't be embedded into the curriculum across the different learning areas.

The Future of Ethical Dilemma Teaching in my Teaching Career

Basically this issue equates to 'Would I do it again?', and the answer is a definite YES because I can see the positive impact of my students engaging in ethical dilemma stories, especially the influence of story-telling on my Aboriginal students. Ethical dilemma stories not only build up students' critical thinking skills, as they need to be able to justify their decisions, but they also are a less demanding learning task as there are no right or wrong answers, which means less pressure on lower ability students. Given the right amount of guidance through discussion with individuals or groups of students, regardless of the level of ability, I find that the solutions students give can be quite original and creative.

Science is not all about learning facts from the textbook, but is also about being able to utilise facts to make new hypotheses and then testing the hypotheses. Science is also, as stated in the new Australian Curriculum, the ability to make informed, evidence-based decisions about the current and future applications of science. If science teachers do not steer their students towards building up critical thinking skills, the world is going to end up with people who are 'answers rich but questions poor'. This will not only lead to a decline in science innovation, as there will be no one out there making and testing hypotheses, but also to a greater

misuse/abuse of science as people are not thinking critically about the possible impacts of new technologies.

Luckily scientists and science lecturers and professors are recognising the increasing trend towards ‘answers rich but questions poor’ students due to computer technology, where the answers to most questions can just be ‘Googled’ on the internet. They are changing the future direction of Science by promoting critical thinking. This year (2012) Australian Chief Scientist, Professor Ian Chubb, together with some of the most influential scientific minds in Australia, is on a panel to judge a ‘Critical Thinking Competition’, an initiative of the Australian Government’s Department of Industry, Innovation Science, Research and Tertiary Education (Critical Thinking Competition, 2012).

Students are encouraged to make a 3-5 minute video arguing for or against four topics. It is interesting to note that all four topics relate directly to or indirectly to sustainability, which indicates the importance of sustainability in the current world. The four topics are:

- In order to reduce our carbon emissions, should Australia replace our coal-fired power stations with nuclear power generation?
- Considering the stated benefits and risks, should farmers be allowed to grow Genetically Modified crops?
- Should we use geoengineering to stop or limit climate change?
- Should the inclusion of nanoparticles in products be stopped until the safety of nanoparticles is assured?

Teachers can easily modify any of these topics and create an ethical dilemma teaching story.

An Insight into Critical Thinking – My Perspective

Transformative learning...hmm...its funny how just looking at these 2 words is simple but when you really think about it, it sorta opens up a can of worms!! Thinking really makes my head hurt sometimes, especially when I'm thinking about a concept that opens up a can of worms. Thought I have finished writing up my thesis...you know finally being able to submit it and move on to other things. But then my co-supervisor decided that I should expand on what I meant by critical thinking and critical reflection since I have used it many times in this thesis. Aren't they the same thing? It has never cross my mind to differentiate between the two because how can one critically think about something without reflecting on it, and vice versus, how can one critically reflect on something without going through some serious thinking?

Looking back at previous chapters, I have to admit that my supervisor is right when he said that I should expand on what I meant by critical thinking. I have mentioned these words on many occasions and thus it is paramount that I explain what I meant by critical thinking. In my point of view, critical thinking and critical reflection are the same thing and this is explained further on. Before attempting to 'Google' the definition of critical thinking (the norm nowadays for searching information), I define critical thinking as a person engaging in deep thinking. It means that the entire thinking process takes time and some reflection has been gone through before reaching a conclusion. The conclusion that is reached is in the best interest of the wider community and not just for oneself. This is where my Buddhist's values step in – to think about others and not just yourself, as we are all family. To hurt others is to hurt yourself. This is the reason why I am passionate about the area of sustainability. To hurt the environment we are living in will eventually hurt us. Hence I am committed to expose my students

to environmental studies and sustainability in the Science curriculum that I deliver.

In this current research, I have used ethical dilemma stories to induce a change in my students' thinking, to think and reflect critically about the issue of sustainability, especially how our current actions can lead to destruction of the environment in the future. The use of dilemma stories can be traced back to psychologist, Lawrence Kohlberg, who expanded upon Jean Piaget's work and formed a theory that explained the development of moral reasoning (Kohlberg, 1984). Kohlberg presented a series of moral dilemmas to groups of young children and interviewed them to determine the reasoning behind their judgments of each scenario. Based on his findings, Kohlberg proposed that moral development is a continual process that occurs throughout one's lifespan. According to Kohlberg's theory, "the suitability of dilemmas is grounded in the concept of values clarification, whereby students explore their own values (i.e., critical reflection) and compare and discuss those values with their peers, leading to a cognitive disequilibrium which leads to moral learning" (Settelmaier, 2004). In the literature on moral education, dilemma stories are often suggested as 'the' tool to achieve ethical discourse in a classroom and critical reflection in the students since Kohlberg trialled dilemmas over thirty years ago (Settelmaier, 2004). In my research, I am interested in using ethical dilemma stories as a tool not just for developing or testing the level of moral development of my students, but to engage my students by getting them to explore their personal values and to think critically in the area of sustainability.

However, I am now interested in finding out if my perspective on critical thinking is correct. Searching on the internet, I came across a website, 'The Critically Thinking Community'. According to this website, critical thinking is a rich concept that has been developing for the past 2500 years. The website offered a range of definitions of critical thinking by Edward Glaser, Linda Elder, William Graham Sumner, Michael Scriven and Richard Paul. Thus, it is clear that different people are entitled to have their own perspective on the definition of critical

thinking. It is important to note that there is no fixed concept of critical thinking, rather an array of overlapping definitions exists, which forms a substantive, trans-disciplinary conception of critical thinking (Defining Critical Thinking, 2011).

I resonate best with the perspective of Michael Scriven and Richard Paul, who defined critical thinking as “entailing the examination of those structures or elements of thought implicit in all reasoning: purpose, problem, or question-at-issue; assumptions; concepts; empirical grounding; reasoning leading to conclusions; implications and consequences; objections from alternative viewpoints; and frame of reference” (Defining Critical Thinking, 2011). I especially like the way Michael Scriven and Richard Paul put the notion that “critical thinking is responsive to variable subject matter, issues, and purposes, and thus is incorporated in a family of interwoven modes of thinking, among them: scientific thinking, mathematical thinking, historical thinking, anthropological thinking, economic thinking, moral thinking, and philosophical thinking” (Defining Critical Thinking, 2011). Michael Scriven has over 400 publications in the areas of critical thinking, technology studies, computer studies, and evaluation.

I was drawn to the words ‘moral thinking’ and started researching it on the internet. The beauty of the internet – no wonder my students found it unnecessary to learn about contents in class when most information is literally at their fingertips! Recalling a conversation with Dominic (one of my case study participants in Chapter 3), I have to agree with him when he told me that school is useless. In his words “everything I need to know is on the internet...YouTube is so cool... If I need to know how to do something, I’ll just ‘youtube’ it, why do we still need to come to school?”. YouTube is a video-sharing website where users can upload, view and share videos. Cloud (2006) wrote in an article in Time magazine that YouTube is to video browsing what a Wal-Mart Supercenter is to shopping – everything is there, and all you have to do is walk in the door. This is the reason why I think implementation of ethical dilemma stories activities in school is so crucial for these Y-Generation kids. As an educator, we need to teach

these ‘information-overloaded’ kids to be able to think and reflect critically, so as not to be misled when exposed to a wide range of information on the internet.

Searching on the internet on moral thinking, I came across an article, ‘Thinking Ethically: A Framework for Moral Decision Making’, developed by Manuel Velasquez, Claire Andre, Thomas Shanks, S.J., and Michael J. Meyer. These authors developed a framework for moral decision making by using the five different approaches to values developed by philosophers to deal with moral issues – The Utilitarian Approach, The Rights Approach, The Fairness or Justice Approach, The Common-Good Approach and The Virtue Approach (Velasquez, Andre, Shanks, & Meyer, 1996). I found the five different approaches to be inseparable from each other and thus it was hard to settle on only one approach. In the end, after looking at different people’s perspectives of critical thinking and moral thinking, I came to the conclusion that when I say I want my students to think critically, what I really mean in my heart is for them to think ethically and to be able to justify their reasoning behind their actions.

Limitations of the Research

As with all types of research, there is no such thing as a picture-perfect research. Our natural tendency to strive for the best means that there are always things that could be improved on, and this applies to my research. While typing up my thesis, I find myself coming up with extra questions that I could have asked of my students. However, one of the limitations of my research is that my students graduate and leave school at the end of Year 10. Some may go to a different high school, others may enter into an apprenticeship and some will enter into the workforce. The disappearance of my case study participants means that I won’t be able to interview them with my ‘extra questions’ and, for some cases, I wasn’t able to collect the assessment sheets (see Figure 13) that I had given out at the end of the term (2011). Most importantly, I wasn’t able to observe the benefits, impacts and after-effects of ethical dilemma story teaching further down the track. Implementing my first dilemma story at the end of Year 9 and the second story at

the start of Year 10, meant that I was only able to document the impact of ethical dilemma stories on my students for three school terms. It would have been better if I had the same students for a few more years, enabling me to conduct a longitudinal study development.

Another limitation is the link between dilemma learning and science content learning. Many science educators would question the benefit of implementing dilemma stories in their classrooms because of their inability to link it to progression in science content learning. However, in this research with the particular type of clientele at Hopefield College, getting the students to engage in Science is the first and most important step, followed by content learning. Thus, I am interested first and foremost in the engagement of my students in Science via the use of dilemma stories teaching, rather than being preoccupied with the link between dilemma learning and science content learning. As mentioned before, the limitation of this research lies primarily in the students leaving the school at the end of Year 10. The link between dilemma learning and science content learning could, however, be documented and observed if the students continued onto Year 12 at the same school, adopting the school plan of having the same teacher from Year 8 through to Year 12; or the teacher could start teaching dilemma stories early in Year 8 and observe the impact on the same students through to Year 10.

Coda

In this chapter I have explored my own perception as a science teacher with regards to implementing ethical dilemma stories, the role of ethical dilemma stories in science classrooms, especially in the context of the Australian Science Curriculum. To conclude my research, I would like to refer to Mezirow's (1991) Theory of Transformative Learning. This theory was developed by Jack Mezirow and represents a combination of constructivist thought with the Critical Theory of Jurgen Habermas (Mezirow, 1991). Similar to Settelmaier (2004), I agree that ethical education at all ages has a transformative intent. If implemented successfully, this type of education can result in transformative learning whereby

a learner critically assesses their own assumptions (beliefs, values, etc.) leading to a perspective transformation, and in the case of ethics education, (hopefully) to moral learning (Settelmaier, 2004).

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Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendices

Appendix A – Student Information Sheet and Consent Form



Curtin University of Science and Mathematics Education Centre

Dear Parent/Carer,

My name is Meiling Chow, currently the Science teacher of Year 10. I am currently completing a piece of research for my Master's degree in Science Education at Curtin University.

Purpose of Research

The aim of my research is to find out whether giving students an exciting opportunity to explore their personal values in a given science topic helps them to find science more interesting and relevant to the world around them.

Dilemmas associated with science and technology (e.g., pollution, climate change) will be taught as part of the normal Science program in selected topics. A survey will be given to help ascertain your child's level of engagement, participation and interest. In addition, I will interview selected students about their learning. The interview will take approximately 30 minutes and will be conducted outside of normal class time.

Consent to Participate

Your child's involvement in the research (survey, interview) is entirely voluntary. You have the right to withdraw at any stage. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your child's data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number SMEC-82-10). If you would like further information about the study, please feel free to contact me on 9251 8333 or by email mei.ling.chow@det.wa.edu.au. Alternatively, you can contact my supervisor, A/Prof Peter Taylor on 9266-7501 or p.taylor@curtin.edu.au.

**Thank you very much for your involvement in this exciting research that is helping to make learning science more interesting and relevant to your child.
Your participation is greatly appreciated.**



CONSENT FORM

- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name and address will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Parent's/Carer's Name: _____

Parent's/Carer's Signature: _____

Child's Name: _____

Child's Signature: _____

Date: _____

Appendix B – Student Pre Questionnaire

My details

a. my name:	b. my school:
c. my grade / year level:	d. male or female? (circle one)

1. How I felt

		Almost Always	Often	Sometimes	Seldom	Almost Never
1	I looked forward to the activity.	5	4	3	2	1
2	I found it really interesting.	5	4	3	2	1
3	I enjoyed the activity.	5	4	3	2	1
4	I felt confused during the activity.	5	4	3	2	1

2. This teacher

		Almost Always	Often	Sometimes	Seldom	Almost Never
5	The teacher really made us think.	5	4	3	2	1
6	The teacher encouraged us to get involved.	5	4	3	2	1
7	The teacher made sure we respected everyone's ideas.	5	4	3	2	1
8	The teacher wanted us to work silently.	5	4	3	2	1

3. Learning to work together

		Almost Always	Often	Sometimes	Seldom	Almost Never
9	I explained my ideas to other students.	5	4	3	2	1
10	I asked other students to explain their ideas to me.	5	4	3	2	1
11	I worked closely with other students.	5	4	3	2	1
12	I just got on with my own work.	5	4	3	2	1

4. Learning to listen

		Almost Always	Often	Sometimes	Seldom	Almost Never
13	I paid attention to other students' ideas.	5	4	3	2	1
14	I listened carefully to other students' opinions.	5	4	3	2	1
15	I learned a lot by listening to class discussion.	5	4	3	2	1
<u>16</u>	I really didn't care about what other students were thinking.	5	4	3	2	1

5. Learning to think

		Almost Always	Often	Sometimes	Seldom	Almost Never
17	I thought carefully about my own ideas.	5	4	3	2	1
18	I questioned my own opinions.	5	4	3	2	1
19	I thought about how to solve problems effecting life on Earth.	5	4	3	2	1
<u>20</u>	I thought about anything <u>but</u> science.	5	4	3	2	1

6. Learning about science

		Almost Always	Often	Sometimes	Seldom	Almost Never
21	We learned that careless use of science can harm life.	5	4	3	2	1
22	We learned about the dangers of misusing science.	5	4	3	2	1
23	We learned how science has been harmful in the past.	5	4	3	2	1
24	We learned that science has no bad effects at all.	5	4	3	2	1

Appendix C – Student Post Questionnaire

My details

a. my name:	b. my school:
c. my grade / year level:	d. male or female? (circle one)

1. How I felt

Being the Prime Minister...		Almost Always	Often	Sometimes	Seldom	Almost Never
1	I looked forward to the activity.	5	4	3	2	1
2	I found it really interesting.	5	4	3	2	1
3	I enjoyed the activity.	5	4	3	2	1
4	I felt confused during the activity.	5	4	3	2	1

2. This teacher

In the Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
5	The teacher really made us think.	5	4	3	2	1
6	The teacher encouraged us to get involved.	5	4	3	2	1
7	The teacher made sure we respected everyone's ideas.	5	4	3	2	1
8	The teacher wanted us to work silently.	5	4	3	2	1

3. Learning to work together

In the Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
9	I explained my ideas to other students.	5	4	3	2	1
10	I asked other students to explain their ideas to me.	5	4	3	2	1
11	I worked closely with other students.	5	4	3	2	1
12	I just got on with my own work.	5	4	3	2	1

4. Learning to listen

In the Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
13	I paid attention to other students' ideas.	5	4	3	2	1
14	I listened carefully to other students' opinions.	5	4	3	2	1
15	I learned a lot by listening to class discussion.	5	4	3	2	1
<u>16</u>	I really didn't care about what other students were thinking.	5	4	3	2	1

5. Learning to think

In the Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
17	I thought carefully about my own ideas.	5	4	3	2	1
18	I questioned my own opinions.	5	4	3	2	1
19	I thought about how to solve problems effecting life on Earth.	5	4	3	2	1
<u>20</u>	I thought about anything <u>but</u> science.	5	4	3	2	1

6. Learning about science

In the Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
21	We learned that careless use of science can harm life.	5	4	3	2	1
22	We learned about the dangers of misusing science.	5	4	3	2	1
23	We learned how science has been harmful in the past.	5	4	3	2	1
<u>24</u>	We learned that science has <u>no</u> bad effects at all.	5	4	3	2	1

7. The Story

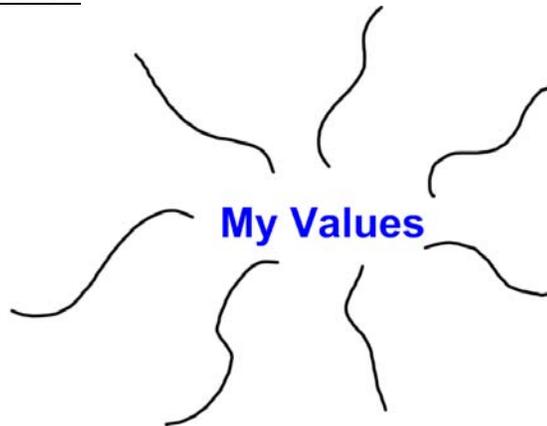
The Prime Minister story...		Almost Always	Often	Sometimes	Seldom	Almost Never
25	I found the story relevant to my life.	5	4	3	2	1
26	I felt curious about the story.	5	4	3	2	1
27	I made good sense of the problems in the story.	5	4	3	2	1
<u>28</u>	I was <u>not</u> keen to solve the problems in the story.	5	4	3	2	1

Appendix D – Worksheet Given to Students in the Prime Minister Dilemma Story

Prime Minister's Dilemma

Today, you will be asked to put yourself in the shoes of the PM and be required to make some of the most decision of your life as you face your biggest dilemma! Are you ready?

Think – Pair - Share



Think – Pair - Share



Think – 3's – Share

PM's original vote: _____

Group members votes: _____

PM's final vote : _____

PM's reasons: _____
(based on your values)Think – 4's – Share

PM's decision: _____

Reasons: _____

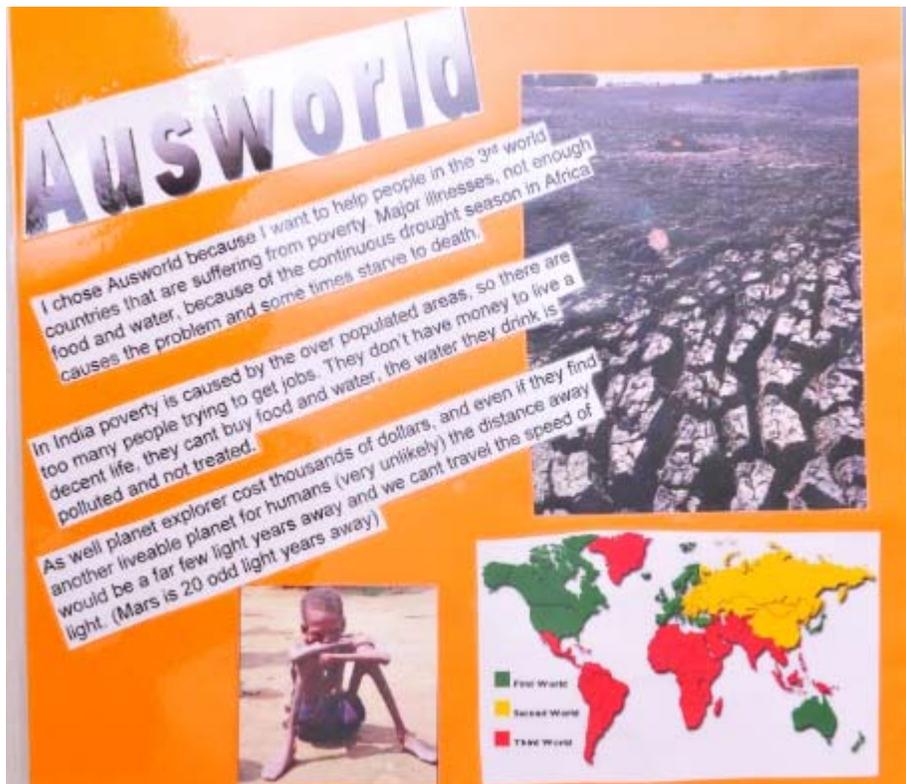
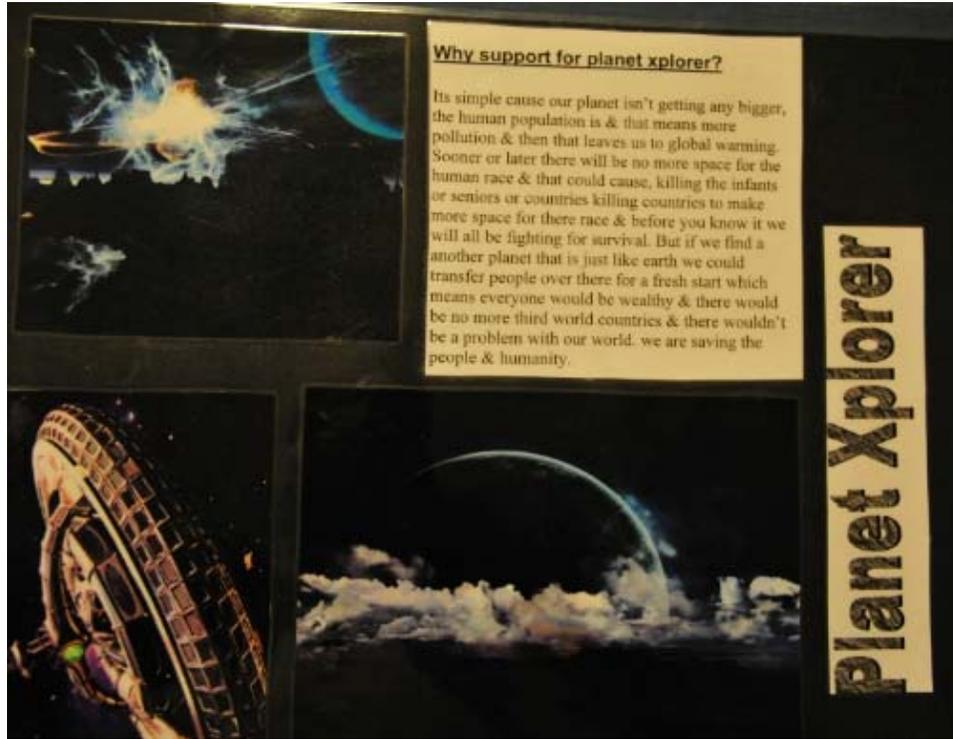
Group's Pros & Cons table:

Pros (advantages)	Cons (disadvantages)

PM's final decision: _____

Reasons:

Appendix E – Students’ Posters for the Prime Minister Dilemma Story



Aus World Debate

In science we were asked to choose between two world causes, Aus World, or Planet Explorer. Today we are here to voice our reasons on why we think Aus World is the more important cause.

Although they are both extremely important causes we believe that Aus World is more important as it supports third world countries. Yes we are being more and more populated each day and it is important to find more liveable resources, but people in third world countries are here today, they need our attention now! These people are still humans, it isn't there fault they were born into poverty so why should they have to suffer.

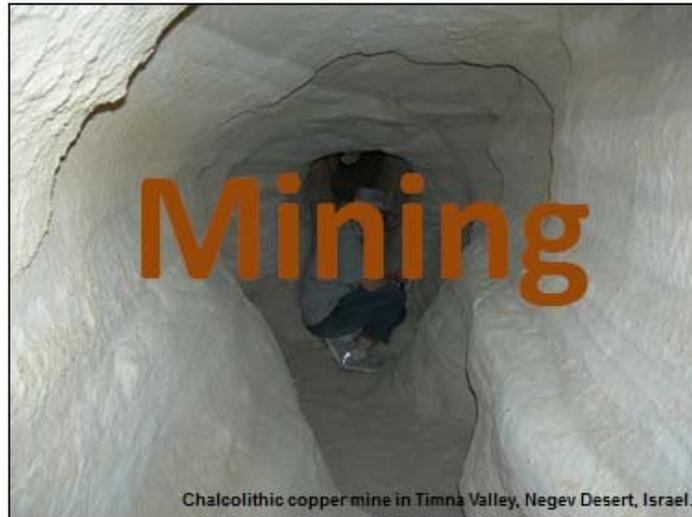
While we are sitting at home in the comfort of our house, enjoying our meals, using clean water to bathe, sleeping in our beds, there are people, children, families fighting to survive.

These people don't have the opportunities we do, they don't have schooling and education. They don't have access to hospitals like we do.

Think about that then ask yourselves again what is more important? Saving the lives of starving children and families? Or exploring the solar system for a possible living environment? You decide.

Three examples of posters produced by other Year 9 students.

Appendix F – Original PowerPoint Slides Used in the Delivery of Mining Contents in Term 1



Slide 1

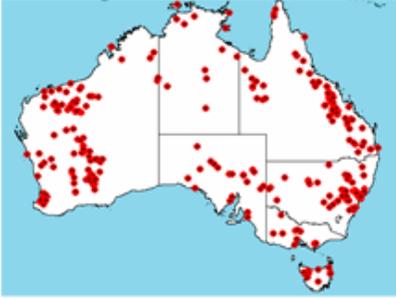
Mining

- The extraction of valuable minerals or other geological materials from the earth. It also includes the removal of soil.
- Mining in a wider sense comprises **extraction of any non-renewable resource** (e.g., petroleum, natural gas, or even water).
- Any material that cannot be grown is usually mined.

Q: Why do people mined ??

Slide 2

Mines in Australia



Australia has rich deposits of many minerals. We are self-sufficient with regard to many of the metals that we use. The mining and export of these minerals is big business for Australia. Some of these minerals are processed into metals here. We import some of our minerals back into the country after they have been processed into metals overseas and converted into consumer goods.

Slide 3

STATISTICS

- Western Australia hosts some 531 commercial mineral projects, covering **1032 operating mine sites** which produce over **50 different minerals**. There are also more than **60 operating oil and gas fields**.
- Over the past decade, royalties received by the Australian government from mineral and petroleum producers in Western Australia has increased 280 percent from \$777 million in 2000, to **\$3.2 billion** in the 2009 financial year.
- Mining employment averaged approximately **71,329 people**.

Slide 4

Top 5 Commodities in Order of Value

- **Iron ore** recorded an impressive **\$33.6 billion** in total value of sales for 2008-09.
- **Crude Oil** recoded **\$7.7 billion** in total value of sales for 2008-09.
- **LNG** recoded **\$8.5 billion** in total value of sales for 2008-09.
- **Gold** had a record value of **\$5.2 billion** in total sales for 2008-09.
- **Alumina** recorded **\$4.6 billion** in total value of sales for 2008-09.

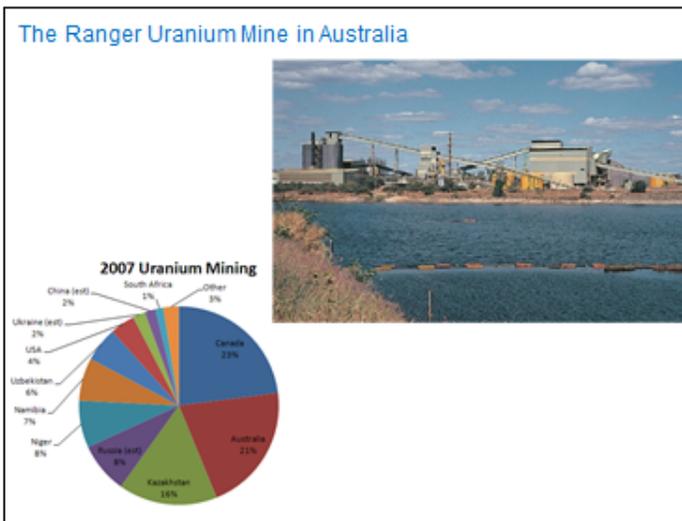
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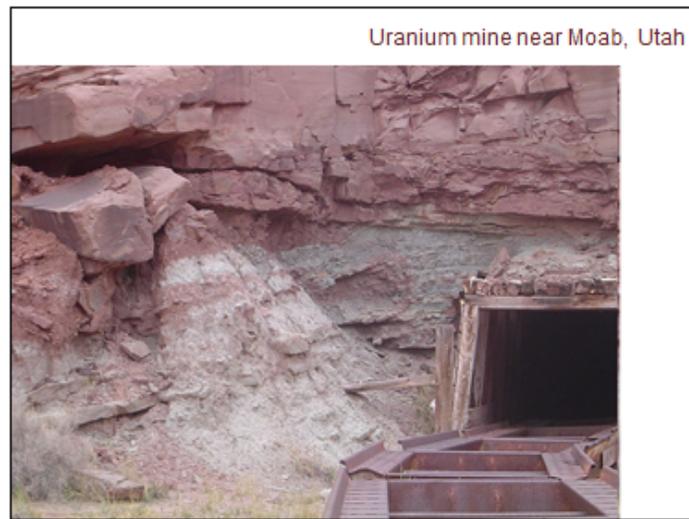
Slide 6



Slide 7



Slide 8



Slide 9

Prehistoric mining

- Since the beginning of civilization, people have used stone, ceramics and, later, metals found on or close to the Earth's surface. These were used to manufacture early tools and weapons, such as high quality flint tools found in northern France and southern England.



Slide 10

Ancient Greece and Rome

- Mining in Europe helped support the Greek city state of Athens.
- The Romans developed large scale mining methods, especially the use of large volumes of water brought to the mine by numerous aqueducts.
- The water was used for a variety of purposes, including using it to remove overburden and rock debris, called hydraulic mining, as well as washing crushed ores and driving simple machinery.



Slide 11



Slide 12

Mining techniques

- Mining techniques can be divided into two common excavation types: **surface mining** and **sub-surface (underground) mining**.
- Surface mining is much more common.

See information sheet

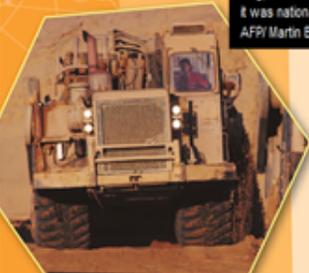
Slide 13

ore body: Contains the wanted mineral in large enough and rich enough deposits for mining.
ore: Contains wanted minerals and other rocks. This is what is recovered after mining.
ore mineral: Contains the elements that are wanted. Often these elements are present as compounds, for example, iron combined with oxygen. Fe_2O_3 , SiO_2 and Cu_2S are examples of minerals that are compounds.
element: This has been recovered from its mineral. The process can involve removing oxygen or sulfur (smelting). Iron, silicon and copper are examples of elements.

figure min.2 From ore body to ore to mineral to element.

The minerals we use to make everyday products are usually bound into solid mixtures called rocks. Often these rocks are deeply buried and difficult to get at. Therefore, minerals are only mined if there is enough demand for them to be worth the effort and money. Even if the mineral is useful, there has to be enough of it concentrated in one place to make mining worthwhile. The minerals of economic value that we dig out of the ground are called ore minerals. The minerals we find so useful are not very common in the Earth's crust, but fortunately for us they tend to be concentrated in certain types of rocks in localised areas. These large deposits of rock rich in ore minerals are called ore bodies.

Slide 14



A worker negotiates his way amid the melting pots of copper at the foundry of the Chuquicamata copper mine, in the desert town of Calama, 1,000 kms north of Santiago, Chile. Chuquicamata, the world biggest open cast mine, is 4.3 kilometers long, 3 kms wide and 825 meters deep. As all the other mining enterprises in Chile, it was nationalized in 1971 by late Chilean President Salvador Allende. Picture: AFP/ Martin Bennett



Figure 10.1 Trucks removing ore containing rutile and ilmenite from a mine in Encabba in Western Australia. Rutile and ilmenite are important sources of titanium and zircon. Titanium is used in making non-toxic white pigments for paints, plastics, toothpaste and cosmetics. Zircon is used in ceramics and tiles.

Slide 15



Slide 16

To separate most metals from their ore it is necessary to remove the unwanted elements from the metal. This usually means combining the ore with another element that will react with the oxygen or sulfur, leaving the metal uncombined. This is called smelting and the chemical reaction used is one of reduction. Reduction is the removal of the elements that combined with the metal during oxidation.

$$\text{metal oxide} + \text{carbon} \begin{array}{c} \xrightarrow{\text{reduction}} \\ \xleftarrow{\text{oxidation}} \end{array} \text{metal} + \text{carbon dioxide}$$

Slide 17

Impact of mining

- The nature of mining processes creates a potential negative impact on the environment both during the mining operations and for years after the mine is closed.
- This impact has led to most of the world's nations adopting regulations to moderate the negative effects of mining operations.

Slide 18

Tailings

- **Tailings** are the materials left over after the process of separating the valuable metals from the ore.
- Tailings present a long term cost to the mining industry. If the company leaves or goes bankrupt, the local government can find itself with responsibility for the maintenance and monitoring of tailings dumps essentially forever - this, and other costs of cleanup were estimated at up to 12 billion dollars in the US alone in 2005.

Slide 19

- In order to prevent the uncontrolled release of tailings material into the environment, mines usually have disposal facilities which takes the form of a dam or pond.
- These facilities often require the clearing of more land and failure of the dam wall can result in a massive release of tailings into the environment.
- Several major environmental disasters caused by tailings dam failures are the Ok Tedi environmental disaster, the Buffalo Creek Flood, the 2000 Baia Mare cyanide spill and the Ajka alumina plant accident.

Slide 20

Common minerals and elements found in tailings

- **Arsenic** - Found in association with gold ores
- **Barite**
- **Calcite**
- **Fluorite**
- **Radioactive materials** - Naturally present in many ores
- **Mercury**
- **Sulfur** - Forms many sulfide compounds / pyrites
- **Cadmium**
- **Hydrocarbons** - Introduced by mining and processing equipment (oils & greases)

Slide 21

Environmental effects

- Erosion
- Formation of sinkholes
- Loss of biodiversity
- Contamination of soil, groundwater and surface water by chemicals from mining processes
- Additional forest logging is done in the vicinity of mines to increase the available room for the storage of the created debris and soil
- Contamination resulting from leakage of chemicals can also affect the health of the local population if not properly controlled.

Slide 22

Iron hydroxide precipitate stains a stream receiving acid drainage from surface coal mining.



Slide 23

October 06, 2010

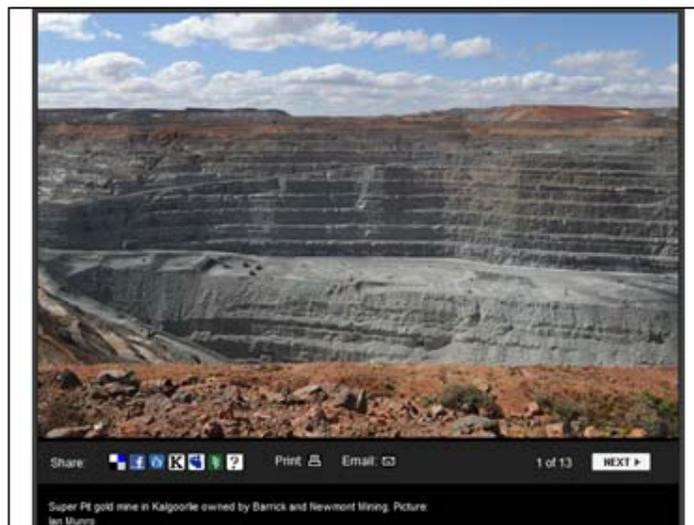
Environmental destruction undercuts global economy to the tune of \$6.6 trillion

- The cost of environmental damage to the global economy hit 6.6 trillion US dollars in 2008. If business continues as usual, environmental damage is predicted to cost 28 trillion dollars by 2050. According to the report, one third of the environmental destruction (costing 2.2 trillion US dollars) was carried out by the world's top 3,000 public companies. The most destructive industries included utilities, oil and gas, and mining.

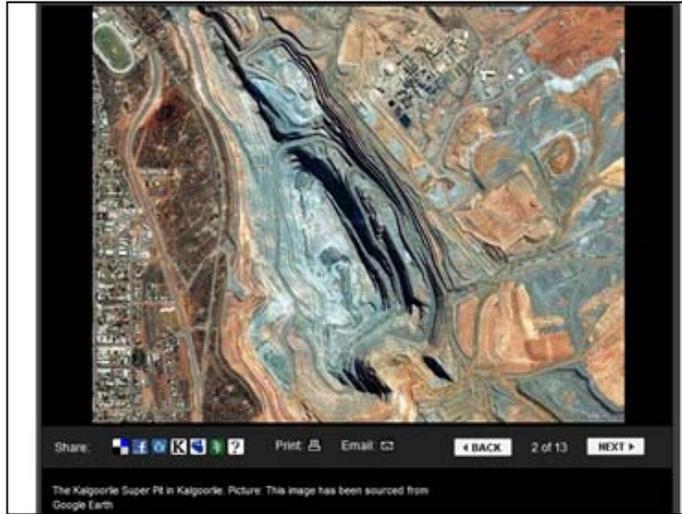
Slide 24

Scars of the Earth

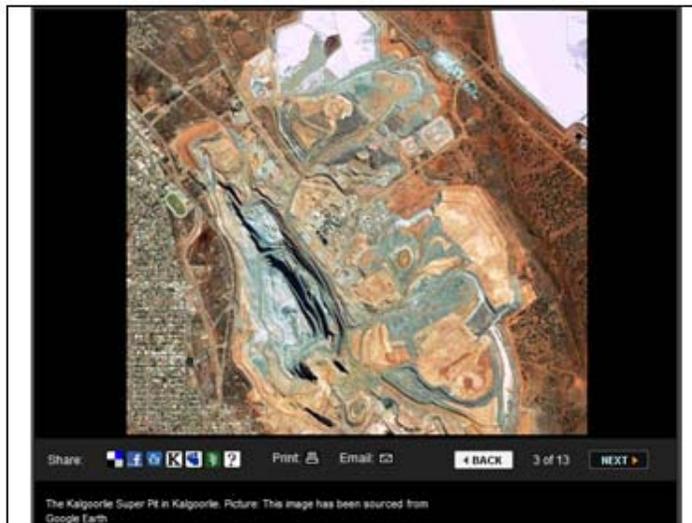
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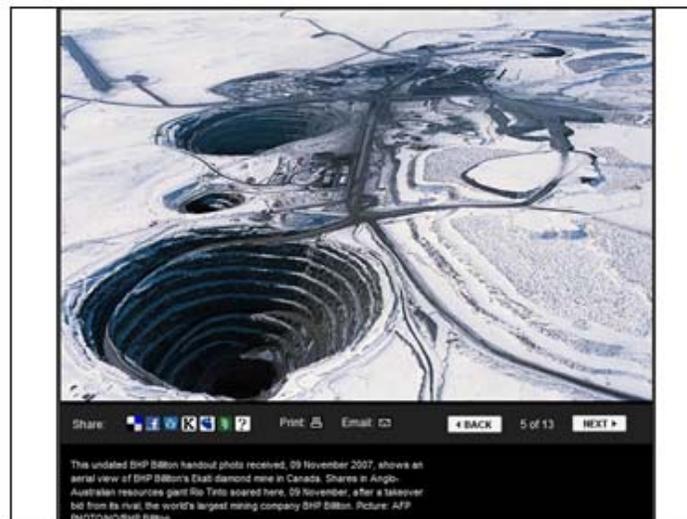
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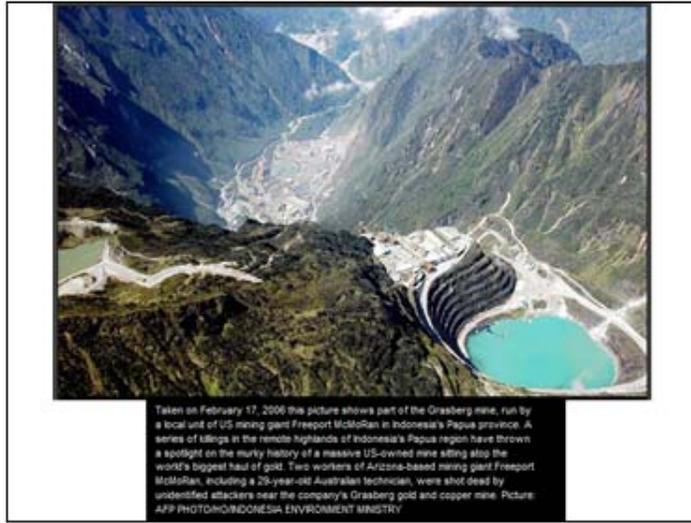
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Slide 28



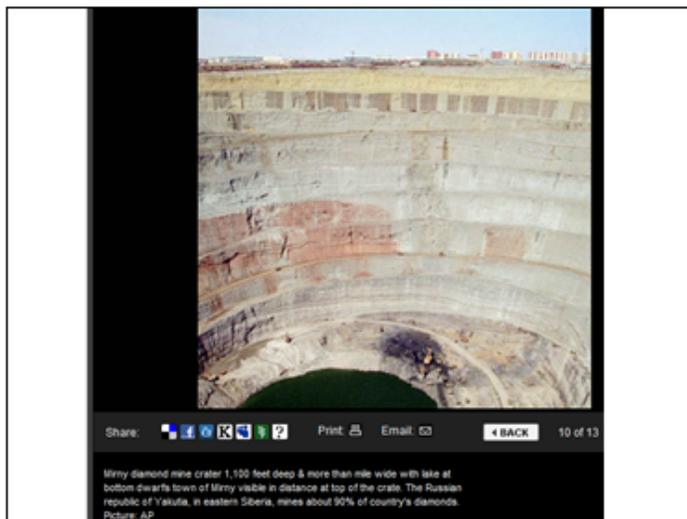
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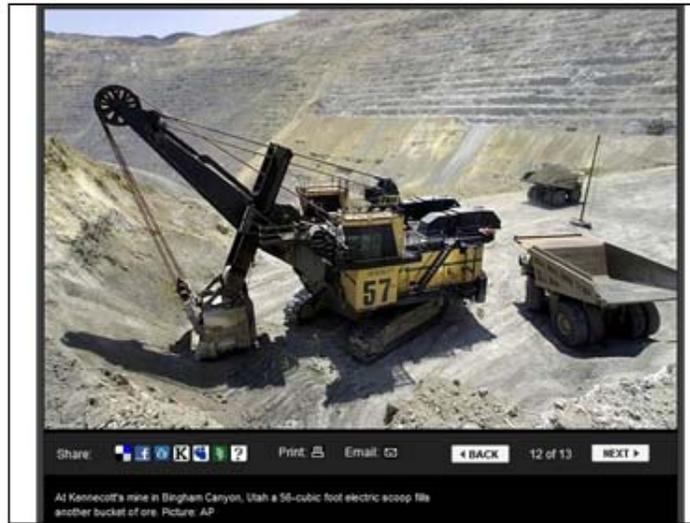
Slide 30



Slide 31



Slide 32



Slide 33



Slide 34



Slide 35



A bulldozer traverses a landfill in Brooksville, Florida. Landfills are the most common organized waste disposal system in the world. They can pollute local environments immensely, contaminating groundwater, releasing environmentally disastrous methane gas.

Slide 36



The waters of Dhaka, Bangladesh are heavily polluted. The city is experiencing a large amount of air and water pollution from traffic congestion and industrial waste.

Slide 37

Appendix G –The Mining Dilemma Story Students’ Worksheet

Akiki’s Dilemma

Question 1

Advantages of the mining company:

Disadvantages of the mining company:

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Question 2

Do you think this is a win-win situation for both? _____

Why?

Who should Akiki support? His community or the mining company his dad is working for?

Reasons:

Question 3

What should Akiki’s dad do? Take up the offer or leave it? _____

Reasons:
