



**MONASH** University

**SPECULATING ON SCIENCE AND ETHICS  
IN AUSTRALIAN SECONDARY SCHOOL EDUCATION:  
A POSTHUMANIST APPROACH**



Blue Jaryn Mahy

Bachelor of Arts (First Class Honours)

---

A thesis submitted for the degree of the Doctor of Philosophy at

Monash University in 2017

Faculty of Education

---

*For Lois Jean Smith*

## COPYRIGHT NOTICES

© Blue Jaryn Mahy, 2017.

I certify that I have made all reasonable efforts to secure copyright permissions for third-party content included in this thesis and have not knowingly added copyright content to my work without the owner's permission.

## ABSTRACT

Science provokes ongoing complicated ethical questions about the world and humanity. Much research suggests, however, that science in Australian secondary school education may not effectively address this ethical complexity. In contrast, the emerging frameworks of posthumanism and feminist materialisms do critically interrogate the connections between science and ethics. Despite this, research on science and school education, especially within Australia, has tended to overlook these emerging frameworks. Furthermore, little attention has been paid to 'speculative' fiction and its potential contribution to creative ways of researching the 'science-ethics nexus'. This study therefore brings science education into conversation with posthumanist and feminist materialist thinking, and with speculative fiction as method.

The main question addressed is: how does posthumanism/feminist materialism, combined with speculative fiction as a creative research practice, help to renew thinking about the science-ethics nexus in Australian secondary school education? Ideas are drawn from three main theorists, including two scientists/theorists, Karen Barad and Donna Haraway, as well as posthumanist philosopher, Rosi Braidotti. Their ideas, along with my original speculative fiction short story, allow me to conduct a 'diffractive' analysis of major research reports about Australian science education, the Australian Year 7-10 curriculum, Years 7-10 science textbooks, and interviews with beginning secondary school teachers. These teachers are a mix of those intending to teach humanities and science subjects. Humanities teachers were chosen to reflect the nature of the science-ethics nexus in school education to be more than the specific science curriculum.

This study contributes to knowledge about secondary school science and ethics through the realisation of four main propositions. The first concerns the use of speculative fiction as a research method. I contend that this allows usually unrelated areas and ideas to be brought together and, thus, to renew thinking. Secondly, I employ posthumanist and feminist materialist

concepts to facilitate alternative ways of thinking about the current constitution of the science-ethics nexus in secondary school education. In so doing, I illustrate why ethics should be a major concern in secondary school education. Following this, I examine the idea of 'world-science-education' relationality, to emphasise the inconsistencies and limitations of a humanist, masculinist, and Euro-Western-centric definition of ethics.

Thirdly, this study proposes a renewed way of understanding teachers' views of science and ethics. My approach views teachers' agency as an 'intra-active' process involving assemblages of matter-discourse-bodies-environments-emotions-experiences-identities. Additionally, I present the implications of their 'becomings', due to such assemblages, as relevant to their views of science and ethics. The fourth proposition outlines the potential benefits of critically interrogating cultural and disciplinary boundaries by addressing the posthumanist and feminist materialist concept of 'relationality'. Ethics, here redefined through a posthumanist lens, re-situates the human as 'of the world' rather than at its centre. Overall, this approach acknowledges ethics are 'messy' and relational, and insists on the inseparability of ethics and 'knowing-being'.

*Keywords:* ethics, feminist materialism, posthumanism, science education, speculative fiction

## DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:



Print Name: Blue Jaryn Mahy

Date: 14.08.2017

## ACKNOWLEDGEMENTS

This study has unequivocally been a great personal and professional challenge, which would not have been possible without the many people who have directly, and indirectly, supported me. My supervisors, Jane Kenway and Mary Lou Rasmussen, have inspired and guided me, and therefore this project, with a very valuable combination of talents. I thank you both for playing a significant role in advancing both this study and my development as an academic; I am very fortunate to have been your student. Thanks also to Iris Duhn for providing valuable feedback in the middle of my study.

I extend gratitude to my ten interview participants, without whom this study would not nearly have been as interesting. Thank you all for your time and your contribution.

I thank Deana Leahy, Dorothy Smith, Graham Parr, Miriam Faine, and Scott Bulfin for participating in my milestone panel reviews and offering words of great insight and encouragement. I offer my appreciation to the professional staff in the Faculty of Education at Monash University for providing me with administrative support. Thank you also to Melissa Wolfe, Genine Hook, and the many other past and present postgraduate students I have encountered along the way, with whom I have had many valued conversations.

To my family and friends, especially Petra, Jenni, Ash, Ghill, and Jess, thank you for your ongoing encouragement and interest in my work.

Of special importance, I thank Leo. I cannot name all the many large and small ways in which you have given me your support and made it possible for me to complete this study and dissertation. I'm forever grateful for your unreserved belief in me.

## CONTENTS

COPYRIGHT NOTICES.....	3
ABSTRACT .....	4
DECLARATION.....	6
ACKNOWLEDGEMENTS.....	7
CONTENTS .....	8
LIST OF TABLES .....	10
LIST OF FIGURES.....	10
LIST OF APPENDICES .....	11
INTRODUCTION .....	12
<i>The Beforetimer</i> .....	16
<i>Situating this research</i> .....	32
<i>Entanglements of self</i> .....	38
<i>Subsequent structure</i> .....	43
CHAPTER 1: STORIES OF SCHOOL EDUCATION, SCIENCE, AND ETHICS .....	46
<i>Shaking the foundations of science</i> .....	51
Recent education literature .....	56
<i>Entanglements of phenomena</i> .....	59
Gender-Sex .....	59
Recent education literature .....	63
Euro-Western humanism .....	67
Recent education literature .....	70
<i>Ethical concerns</i> .....	75
Recent education literature .....	76
<i>Speculatively moving beyond ‘science’</i> .....	77
Speculative fiction .....	78
Recent education literature .....	81
<i>Concluding thoughts</i> .....	82
CHAPTER 2: POSTHUMANIST PROVOCATIONS.....	84
<i>The ‘material/ontological/posthumanist turn’</i> .....	86
<i>Defining posthumanism</i> .....	89
<i>Connecting theory with research</i> .....	99
Creative research practice.....	103
Modes of analysis.....	107
<i>Concluding thoughts</i> .....	111
CHAPTER 3: PLUGGING IN/TO DATA .....	113
<i>Research ethics</i> .....	115
<i>Data generation</i> .....	118
<i>Fiction research practice</i> .....	118
<i>Education materials</i> .....	120
Reports.....	120
Australian Curriculum .....	120
Secondary textbooks .....	124
Materials analysis .....	126
<i>Interviews</i> .....	128
Human participants .....	133
Session 1.....	134

Session 2 .....	136
Interview analysis .....	141
<i>Concluding thoughts</i> .....	145
CHAPTER 4: THE SCIENCE-ETHICS NEXUS IN AUSTRALIAN SECONDARY SCHOOLS .....	147
<i>Speculatively reevaluating science in Australian school education</i> .....	151
<i>Ethical ambivalence in the Australian curriculum</i> .....	166
<i>Anthropocentrism in science textbooks</i> .....	177
<i>Concluding thoughts</i> .....	188
CHAPTER 5: TEACHERS' SCIENCE-ETHICS VIEWS AS ONTO-EPISTEMOLOGICAL ASSEMBLAGES .....	191
<i>Entangling with objectivity</i> .....	194
Entity 1 .....	197
Entity 6 .....	207
Entity 7 .....	215
<i>Storying diffractions i</i> .....	221
<i>Entangling with ethics</i> .....	224
Entity 10 .....	226
Entity 4 .....	233
Entity 9 .....	241
<i>Storying diffractions ii</i> .....	248
<i>Concluding thoughts</i> .....	250
CHAPTER 6: TOWARDS A POSTHUMANIST SCIENCE-ETHICS NEXUS .....	252
<i>Relational world-science-education</i> .....	255
<i>Posthumanist ethics</i> .....	261
<i>Speculative fiction diffractions in school</i> .....	269
<i>Diverse ways-of-knowing-being</i> .....	277
<i>Concluding thoughts</i> .....	286
CONCLUSION .....	289
<i>Questions addressed</i> .....	290
<i>Contributions to knowledge</i> .....	295
Proposition 1.....	295
Proposition 2 .....	298
Proposition 3.....	301
Proposition 4.....	303
<i>Future provocations</i> .....	306
REFERENCES.....	310
APPENDICES.....	343
<i>Appendix 1: Recruitment materials</i> .....	343
<i>Appendix 2: Interview materials</i> .....	348
Survey 1 .....	348
Survey 2 .....	349
Question guide/Prompts .....	350
Session One .....	350
Session Two.....	353
<i>Appendix 3: Analysis examples</i> .....	355
Reports.....	355
Textbooks.....	358
Interviews.....	368

## LIST OF TABLES

Table 1: Summary of the Australian secondary school curriculum learning areas

Table 2: Human participants

## LIST OF FIGURES

Figure 1: General capabilities graphic from the Australian secondary curriculum

Figure 2: Entity 10's influence diagram

Figure 3: Assemblage map

Figure 4: Entity 10's lesson plan exercise

Figure 5: Entity 10's interview map

Figure 6: Entity 10's analysis map

Figure 7: Entity 4's views-assemblage map

Figure 8: Entity 1's influence diagram

Figure 9: Entity 1's views-assemblage map

Figure 10: Entity 6's influence diagram

Figure 11: Entity 6's views-assemblage map

Figure 12: Entity 7's influence diagram

Figure 13: Entity 7's views-assemblage map

Figure 14: Entity 10's influence diagram

Figure 15: Entity 10's views-assemblage map

Figure 16: Entity 4's influence diagram

Figure 17: Entity 4's views-assemblage map

Figure 18: Entity 9's influence diagram

Figure 19: Entity 9's views-assemblage map

## LIST OF APPENDICES

Appendix 1: Recruitment materials

Appendix 2: Interview materials

Appendix 3: Analysis examples

## INTRODUCTION

---

Posthumanism doesn't presume the separateness of any—"thing," let alone the alleged spatial, ontological, and epistemological distinction that sets humans apart.

—(Barad, 2007, p. 136)

---

Stories matter; they illuminate, provoke, challenge, console and involve a multitude of becomings. Various types of stories contend with what the world is and what it might become in its continual unfolding. In this dissertation, various stories are presented. I analyse and question the entwined stories of science, ethics, and school education, through which various interpretations are 'diffracted', including that of posthumanism and speculative fiction. As the above quote by scientist and theorist Karen Barad suggests, posthumanism challenges humanist exceptionalism, including how this is implicated in science. I draw on her theory in this study, as well as the work by scientist and theorist Donna Haraway and philosopher Rosi Braidotti, which has informed the framework I call 'relational posthumanism'.

The stories of science are increasingly enmeshed in the becoming of the world, and provoke ongoing complex ethical questions about the world and humanity. Global issues, such as climate change, also require intense ethical considerations as well as scientific and technological innovations to understand and manage. The contentiousness and difficulties of such global, complex issues suggest we may need to develop alternative, and more diverse, terms of engagement. Meanwhile, the so-called 'material/ontological/posthumanist turn' in emerging theory has led to renewed interrogations of the foundations of knowledge and science, including the crucial connection with ethics and how ethics is defined.

A question that has not yet been engaged with in research is: what might this mean for how science and ethics is constituted in school education, and specifically in the Australian context? Including a critical perspective on disciplinary boundaries in this question also means

understanding a ‘science-ethics nexus’ in school education as more than the science curriculum. Instead, I conceptualise this nexus as a fluctuating ‘assemblage’ that acknowledges the complex relationality of various relevant phenomena, such as teachers, students, curricula, other curricula subjects, as well as the various materialities involved in schooling.

I examine secondary school education specifically because this context offers understanding of the midpoint of the science-ethics nexus in school education, when students are expected to have formed basic skills already and to be moving into more complex engagements. Questions here include: how do secondary students and teachers understand ethics? What is ‘the world’ in an Australian English or science classroom of secondary students discussing issues such as renewable energy, genetic modification, or climate change? What relationship between science, technology, and ethics is enacted and why?

The material/ontological/posthumanist turn in theory has also involved renewed thinking about speculative approaches to doing research, including creative methods, and ‘transdisciplinary’ connections. I use the latter term to refer to research that brings together different fields while also in some way interrogating disciplinary boundaries. My engagement with these developments, as well as the subjects of this study and my background in creative writing, resulted in my writing speculative fiction as a creative practice for this study and dissertation. I also utilise the word ‘speculative’ not just to refer to speculative fiction but also to frame my research *as* speculative.

The strong link between speculative fiction and this ‘turn’ in theory is demonstrated elsewhere. For instance, Haraway combines many ideas and sensibilities into ‘SF’, that is ‘science fiction, speculative fabulation, string figures, speculative feminism, science fact’ (Haraway, 2016, p. 2). Others argue ‘The very word speculation stands ripe with multiple associations’ (Åsberg, Thiele & van der Tuin, 2015, p. 151). Additionally, Alex Wilkie, Martin Savransky, and Marsha

Rosengarten argue that they draw on ‘speculation’ for research in close relationship with speculative fiction because ‘creating (im)possibles, making possibles [sic] perceptible and experimenting with them, is a collective, transdisciplinary task’ (Wilkie et al., 2017, p. 8). Understanding my research as ‘speculative’ is not just to traverse novel methods of assessing the past and present, but also to envision possible futures, and futures that break the boundaries of what is currently considered likely or possible.

Consequently, in bringing all this together, the main research question I address in this study is: *How does relational posthumanism, combined with speculative fiction as a creative research practice, help to renew thinking about the science-ethics nexus in Australian secondary school education?*

The subsidiary questions are:

- *How is the science-ethics nexus currently constituted in Australian secondary school education?*
- *How does relational posthumanism, and speculative fiction, offer an alternative way of understanding how teachers’ come to their views about science and ethics?*
- *What might relational posthumanist and speculative fiction provocations offer to an alternative vision of the science-ethics nexus in Australian secondary school education?*

My original speculative fiction short story, ‘The Beforetimer’, is integrated in full in this introduction, in the following section. The intention of including my short story here is to help set the stage of issues this study has inquired into, but it is also ‘diffracted’ throughout this dissertation. The concept of ‘diffraction’ comes from Haraway and Barad, who describe it as a contrast to ‘representation’ and ‘reflection’. It concerns ‘how different differences get made,

what gets excluded, and how those exclusions matter' (Barad, 2007, p. 30). I expand on this in Chapter 2.

I wrote 'The Beforetimer' during my 'data generating' processes by employing Alecia Youngblood Jackson and Lisa Mazzei's concept of 'plugging in' theory (Jackson & Mazzei, 2012), or what might be called 'thinking/doing' with theory. This does not mean that my short story is to be understood as a depiction of my framework; rather, it should be understood as a process of my engagement with this framework and the issues of this study. Following my short story, there is a more detailed explanation of the development of this study, an account of how I as a researcher am entangled in this project, and lastly a section outlining the subsequent structure of this dissertation.

---

## THE BEFORETIMER

The faded red number on the door was the only thing to distinguish it from the dozens of others just like it along the corridor. Cubicle 109. Yet, even in a post-testing haze, Pax enduringly found xirself<sup>1</sup> in front of it. Swiping the entry card, Pax dragged xir feet through and slid the door shut. The cubicles were all the same on the inside too; metal walls, a bench bed, a combined shower and pull-out toilet compartment, a tiny kitchenette with sink, induction pan and kettle. Opposite the bed was an e-screen, which lit up as Pax entered, displaying a looping movie of a waterfall, surrounded by flowing luminescent green ferns.

*The green things are dead and the world is dark.*

Collapsing onto the bed, Pax sighed and rubbed xir eyes before staring blankly at the virtual waterfall. Maxin and Jeorg had been even more harried today than usual, arguing endlessly over which test they should do. Jeorg had even wanted to try two serums in a row on Pax, but Maxin had objected. Not out of concern for Pax but because the results would be muddled, impossible to understand.

‘We’re running out of time!’ Jeorg had exploded at one point, in xir wheezy voice. Pax had almost laughed. They were always running out of time, so much so that time was a slinky thing that barely existed in xir mind. It slipped away like

---

<sup>1</sup> In this story and other parts of my dissertation I use the gender-neutral pronouns ‘xe/xir/xirself’ as a way to maintain critical attention to the gender-sex binary. A more detailed explanation of this is included in Chapter 3.

wet soap. Had it been a year or years since the last factory closed? When had they started to starve?

Pax slumped onto xir back. A small, tightly wound nugget of ferocity wanted to burst out of xir chest and shoot up, up and up, through concrete, rocks and dirt. To where? *This is purgatory, and we are neither alive nor dead. We cannot repent, we cannot return.* Pax knew little about the old religions. But Che, the oldest resident of Subhouse 451, and Pax's only friend, had told xir once some of the stories; the stories about dying.



'This is the one,' Maxin said. Xir light-coloured eyes shone with Pax knew not what. Confidence or madness? Jeorg was the one who brought the needle over while Maxin kept an eye on the two dusty monitors Pax was hooked up to. Jeorg's eyes caught Pax's for a moment, something unfathomable flashing in them before Jeorg injected the needle into the permanent catheter in Pax's arm.

Pax closed xir eyes, shivering as always as the icy serum flooded xir veins. Would this really be the miracle serum that would take them to the longsleep? After a moment, Pax opened xir eyes again, looking up at the grimy yellow spotlight above xir head, struggling to focus. Xir heart was slowing down. Pax's eyes tracked towards Maxin, whose own red-rimmed eyes were riveted on the monitors.

They were starving now, all of them, even the testers. Pax could see it in the tightness of the skin around Maxin's cheekbones. When Pax had been around

nine, or ten, xe had eaten one of the last apples, stolen from a cold store room. Xe still vividly remembered its sourness, the crunch and burst of juice that dripped down xir chin. Today, apples seemed like a serene dream; Pax now salivated in response to the manufactured and mostly tasteless sludge they ate every day.

‘Do you really think there’s any hope?’ Pax had asked Che once. ‘Will there be anything left to wake up to, after the longsleep?’

Che had frowned, scratching at the scraggly beard on xir chin. ‘My father told me once, that some of us stayed behind, on the surface,’ xe said. ‘Can it have been so bad, if some chose to stay? If they found a way... they might have survived,’ Che said and met Pax’s eyes. ‘They had methods, you see. They were trying to change, to morph, from the inside out. Manipulating the smallest parts of us. They called them genes, I think. Tiny info bits inside of us. My father said they succeeded, they made blends of humans and other animals.’ Che paused and shrugged, ‘I don’t know, my father never quite explained. And I was never sure I could believe those stories. My father was just a child, after all, when the subhouses opened, when here became home.’

*Home. What was home?*

‘There!’ Maxin yelled, jolting Pax from xir thoughts. ‘Look, there it is! Tell me I’m not dreaming!’ Maxin laughed and grabbed Jeorg’s arm. ‘I told you, didn’t I? I *told* you!’

Preparations moved swiftly after Maxin's serum was confirmed. The longsleeper capsules were dusted off and inspected one by one. The fission-thermal generators were scrutinised and then scrutinised again. It was funny in a way; their never-ending supply of power in contrast to their dwindling supplies of food and water. An echo of their past and all the things out of balance. *We're grasping for a future that slid out of slack fingers. All the green things are dead and the world is dark.*

Pax was surprised to find xirself numb in the face of all the excitement. After all, shouldn't xe, as one of the few surviving test subjects, be at least relieved? Other people were smiling again, hugging and crying. It felt like a dream. *This is the dream before the endless dream, from which we might not awake. Or, worse yet, to wake and for nothing to have changed. Purgatory.* It wasn't just that nothing ever changed, it was the hint of change only for it turn out to be a lie, a fantasy. Were they all delusional? Did it matter? *Not a bang, but a whimper in the night.*

So, they would sleep.



Che, who had been elusive since the preparations began, came to visit Pax three days before the longsleeper was due to begin. Strangely twitchy, Che insisted on a walk, so they strolled down to one of the old factories, each lost in their own thoughts. Long ago, Pax knew, Che had worked as a mechanical engineer. Xir work had been genius, though Che always downplayed xir work. 'I was just a tinkerer, only playing around with others' machines,' Che insisted. Just like the

serum testers; they only understood the bare minimum of what they did, from the patched together fragmented knowledge of long ago.

‘So here we are,’ Che said, when they stopped walking, and Pax knew it was not the factory Che was referring to as the *here*. ‘Now we take one last gasp of air, hold it and hope for more at the end of a very long tunnel,’ Che said and laughed suddenly, eyes crinkling. Xe turned away from the graveyard of rusting machines and met Pax’s eyes searchingly. ‘There’s something no one knows about the longsleep capsules,’ xe said. ‘Everyone forgot... everyone but me.’ Che took Pax’s hand and squeezed it. ‘I want you to do something that I cannot do myself.’ Che paused for some time before speaking again and Pax heard and yet did not really understand.

When Che had finished speaking, Pax could only blink and ask, ‘Why me?’

‘You’re the only one I trust to make the decision,’ Che said. Some minutes passed in silence before Che spoke again, almost to xirself. ‘You will wake alone and, when you do, you must seek out the light.’



Entity was abruptly pulled away from a perpetual dream of nothingness, into a hazy state of bewilderment; xe did not know life, xe did not know xirself, xe did not know this world. Existence was cold and blinding and wet. Entity thrashed and slowly apprehended the body that xe was, a body that trembled and slid inside the confined slick space xe found xirself within. The body knew without language

to think; confinement was unwanted. Yet, striking out only resulted in a hot spike of pain and Entity stilled, blinking repetitively as disused lenses began to adjust.

The fog gradually lifted and Entity looked through a hard, transparent surface into a dark room. Before there was time to take in more, there was a sudden noise, a *breep breep breep*, and the door of the capsule Entity was inside opened, spilling xir onto the floor. Gasping in a shuddering breath of air, Entity coughed violently until a liquid was expelled from xir mouth onto the floor. Scrambling up onto hands and knees, and then straightening to sit, Entity took in xir body, a tan-coloured, thin and slick-skinned thing. Xe was naked except for a thread that hung around xir neck, with a small symbol attached. The symbol was incomprehensible to xir but nonetheless Entity touched it as if it was some comfort.



Entity stumbled from one cold, dark room to another and up staircase after staircase. Faint blue lights on the walls saved xir from being entirely blind, but they did not help xir find a way out. Getting out was no clear goal but an instinct that drove Entity ever forward on weak, shaky legs. In one of the endless rooms, Entity had found some clothing, saving xir from the worst of the biting, cold air, although xe had failed to put it on correctly. This dark, sterile place made no sense to Entity but at the same time hinted at familiarity; weak connections teased beyond the next light, behind the next corner.

An age or more passed when Entity came to a door different from all the others. This one was larger, circular, and white. It also did not have a handle.

Entity shoved and pressed on it, and got more and more frustrated, but the door did not give. In the half light, it took a while before Entity noticed the small screen and pad of buttons to one side of the door. Eyeing it carefully, Entity touched the screen and then, when this did nothing, stabbed at the buttons. As xe did, the symbol that hung around xir neck swung in front of an embedded sensor below the buttons.

Abruptly, the screen lit up, blinding Entity. Xe made a startled, garbled noise and fell over backwards. The light blinked out and a heavy *callunk* sound came from the door. It lasted for a long moment before the door swung outwards, revealing a large room, lit with a grey light.

Entity got up carefully and stepped through the doorway. Despite being large, the room was mostly empty except for a dusty desk and chair at one end. There were two other circular doors but it was the wall of windows, letting in the grey light through a grimy film, which drew Entity forward. Trailing xir fingers over the glass, Entity came to an outline of another door, nearly invisible to the eye. Once again, there was no handle and now no buttons either. Entity pushed at the glass as hard as xe had strength for, but it didn't move. A growing, burning urgency made Entity hit the door with the pads of xir fists, over and over again, heedless of the pain.

*You will wake alone and, when you do, you must seek out the light.*

Startled, Entity spun around but there was no one there. The voice had come from nowhere. Xir eyes fell on the only other things in the room; the desk and the chair. With instinctual purpose, Entity strode over and picked up the chair, taking it back to the glass door. Using all the strength xe could gather,

Entity swung the chair at the door. The first time it rebounded out of xir hands but this did not stop xir for more than a moment.

Entity slammed the chair into the door over and over again, lips moving soundlessly at first before a primal noise erupted from xir throat. Only after xir hands were starting to go numb and bruise, and after one of the chair legs snapped, did the glass finally crack, and with one, two more strikes the glass shattered and the chair went sailing out of Entity's hands. As the glass showered over xir head, Entity curled into a protective ball. After the last piece smashed and splintered on the floor, Entity's head lifted warily and xe looked outside, into a brilliant world of green.



A violent wind suddenly swept around the mountaintower Cedar was climbing, forcing xir to close xir eyes and hold on more tightly to the vines. Cedar's dense, black fur fluttered wildly while the mountaintower groaned and swayed. The wind passed quickly though, as such winds did. *What do you do when the storms come?* Cedar's teacher's voice echoed into the sudden silence. *We run, we hide, we run.* When the oldest generation of *Homo adaptos* were young, the storms had been worse and more frequent. They had swept up sand and loose dirt, blocking out the sun for days.

Cedar continued climbing, reaching long, powerful arms up for the next vine and then the next. At the very top of the mountaintower, Cedar swung in through a broken window, into the room that had been home for the last moon turn. Inside, Cedar had created a bed out of vines and old padded seats. There was

a small container in the corner, which collected the rain water that dripped down from the ceiling. Next to Cedar's bed was a collection of food; fruit, roots and berries. It was simple living but Cedar had what he needed and couldn't afford to be hampered by luggage. It had made Cedar laugh when his sibling, Apanie, had expected him to take a solar pack, cooking pans, water purifier and all manner of other equipment. Things that would have made fast travel impossible.

On the other side of Cedar's bed was the *beforetimer* collection. There were a handful of flat computers and various other small devices, some of which Cedar had determined the purpose of and others that were still mysterious.

Sitting on the bed, Cedar upended his woven grass bag, letting its contents fall onto the bed. It had been a good haul this last trip; Cedar had found two devices he had never come across before, including one that was solar powered and still worked on its own. For some reason, however, it was a small, soft, brown animal-shaped thing that Cedar was most interested in. At first sighting, Cedar had mistaken it for a real animal. He had found it underneath a mountaintower, inside a rusting wheelercarriage, where it had been protected from the weather.

It was unlike any real animal Cedar had seen, stubby-shaped with small, black eyes and a snout. Cedar turned it over and over in his hands. Apanie's voice came to him. *What can we learn from such beings? What do you hope to find out there?* Answers, Cedar thought. But answers to what questions?



Cedar first smelled the strangeness, at first faintly and then more strongly, after a blast of wind whipped down from the trees. The large nostril slits of Cedar's nose flared as xe turned in a slow circle, trying to determine the scent's direction. It came most strongly from an area around the mountaintowers that Cedar had already explored. Xe headed that way, slowly and cautiously. There were no large predators in this area but xe had not survived so long alone by being reckless.

Keeping close to cover, Cedar soon came to an area where the scent was strongest, near a half-crumbled mountaintower. Grabbing a vine, Cedar hauled xirself quickly up the mountaintower to the highest, safest point xe could reach and surveyed the area. Nothing seemed out of the ordinary. The only beings moving were a few speckled white beakwings, who were pecking at the ground nearby.

Cedar was about to climb down again when the beakwings suddenly *squaaarked* an alarm and took to the sky. Cedar looked down to see, moments later, something emerge from inside the mountaintower. Shock almost made Cedar lose xir grip on the vine but xe managed to recover just in time, xir heart pounding. It could not be and yet there it was, a ghost, a ghost as real as Cedar. A *beforetimer*.

The beforetimer being was carrying a bag and xe walked slowly, head turning in every direction. When the being was some distance away, Cedar, to some degree recovered from the shock, swung down to the ground and followed. It quickly became apparent that the being was exploring, just as Cedar did, collecting items and storing them in xir bag. Perhaps it was this commonality that made Cedar forget xirself, forget to be cautious and keep xir distance.

Instead, Cedar got so close that, when the beforetimer slipped suddenly on a rock and twisted to catch xirself, xe looked right at where Cedar was standing, exposed after moving out from behind a disintegrated wheelcarriage. Their eyes met and the past and present clashed together silently.



Entity sniffed the root before testing it with xir teeth. Cedar had pressed the dug-up root into Entity's hand and mimed eating but it took a moment for Entity to comprehend. Eyes watchful, Entity crammed the root into xir mouth and chewed eagerly. Cedar smiled. They had been together a day now and a brittle trust had developed. Entity could not comprehend this strange other being; xe knew this being did not look like xir. And yet Cedar was not hostile and knew how to find food and water, which meant a lot in this strange, quiet world Entity found xirself in.

Every now and then, while they ate, as Cedar had been doing all day, xe pointed at xirself and made a specific sound. Entity, at times, felt something like language forming inside xir muddled mind and finally it registered. The sound was the other entity-beings name.

*Cedar.*

As the realisation sunk in, Entity's mind was flooded with a jumble of moving images and sounds. This wasn't the first time it had occurred, since Entity smashed through the glass doors and made it *outside*, but it was more intense. In xir mind, a being that looked like xir, or at least more like xir than Cedar did, was

saying something, insistently. For all that Entity strained to understand, however, the sounds, the words, meant nothing.

That night, Cedar helped make Entity a nest bed of fern fronds under a massive, ancient tree but then went up into the tree to sleep alone in its branches. The voice in Entity's mind spoke once more, just before xe fell fitfully asleep.

*You're the only one I trust to make the decision.*

Entity did not understand the words but did vaguely apprehend something was expected of xir, something important.



There was a saying amongst Cedar's kind. *If a tree cannot bend in the wind, it will break.* In fact, it was more than a saying, but a relationship of the world that they all upheld. They also said *if it has no harmony, it cannot exist.* It was uncommon for Cedar's kind to want to travel far from home but there had always been some unnameable yearning within Cedar, a yearning to know the wider world. That feeling had made it inevitable that when Cedar was old enough, xe had volunteered to be a seeker. And unlike the other seekers, Cedar had transgressed the rules and travelled far beyond the mountains of the valley, to places yet unexplored. But not untouched.

Cedar tried not to stare at the beforetimer, but it was difficult. How could a beforetimer be here, alive? Were there more of them and, if so, where were they? Most curious of all, this beforetimer did not seem to know who, or even what, xe was. Xe made sounds but had no language. Xe was half a child, half a wounded

prey-creature. Cedar had no idea how the others would react but he knew the only course of action was to take the beforetimer back to the valley.

They travelled slowly but steadily and every day Cedar noticed a slow change in the beforetimer, a knowingness awakening in once blank eyes. And at night the being cried out in his sleep, writhing and twisting, perhaps going through some intense transformation.

On the third day, it began to rain heavily and they took shelter under a large, ancient tree with branches as thick as many other trees' trunks. The beforetimer stared at the rain for some time before turning his eyes to Cedar. They were sitting close together, shoulders almost touching. For a moment, the beforetimer's lips moved soundlessly and then he made a noise. 'Eedar.'

Startled, Cedar blinked a few times but remained quiet as the beforetimer tried again.

'Ceedaar.'

Cedar laughed. 'Yes, Cedar, that is my name!'

The beforetimer nodded slowly and then spoke again, softly and hesitantly.  
'I...I am Pax?'



*All the green things are dead and the world is dark.*

Yet, they weren't and it was not. Perhaps had never truly been, as Pax was slowly coming to understand. Indeed, the valley Cedar took xir to was beautiful, flush with life, so green that it almost hurt. After Pax's memory began to return, Cedar had endless questions, most of which Pax could not answer. Yet, there was one question Pax could answer but chose not to, at least for now.

'Are there more of you, more beforetimers?'

*Beforetimer.* A strange term. Pax remembered time now, endless time. A time of waiting, a time of nothingness. It was impossible to know how much time had passed, how long xe had been in the longsleep. Standing where Cedar had left xir, Pax could only just make out the tree homes down below. It was not just the distance that made them hard to spot but the seamlessness between the homes and the trees, a stark contrast to the ruined concrete and glass buildings they had left behind.

*You're the only one I trust to make the decision.*

But what kind of decision was possible? Not a right decision. It was surely a trick of the mind that made Pax hear hundreds of beating hearts beneath xir feet.

When Cedar returned, it was with many smiles and reassurances. The others were excited to meet xir, though many had doubted Cedar's claim, xe relayed. 'They think I have been alone too long,' Cedar said with a laugh. As always, there were some words of Cedar's that Pax didn't understand but xe nevertheless understood the main meaning and xe smiled in response.

Pax followed Cedar deeper down into the valley readily enough but xir heart began to pound the more they descended. At first there was no one to see, just the tree homes, which were even more remarkable up close. They were not obscured by the trees but made of the trees themselves, Pax realised, the branches wound tightly together to form walls and roofs. How such a thing could be possible, Pax could not fathom. Stranger still was that, despite Cedar's offhand descriptions of xir kinds' technology, Pax saw no sign of it except for a faint glow that came from within some of the tree houses.

Cedar led xir to a small clearing amongst the trees, where a group of others like Cedar stood in a half circle. A baby clung on one of the being's backs, staring at Pax with large, curious eyes.

'You can't doubt me now,' Cedar said, when they stopped walking.  
'Everyone, meet Pax.'

There was a long silence as the others gazed at Pax, looking xir up and down. Eventually, one of the smaller ones, stepped forward and smiled. 'Hello, Pax. My name is Apanie,' xe said, in a soft voice.



Pax stood over the river, watching the rushing water bubble over the rocks, while grasping the pendant tightly around xir neck. It wasn't really a pendant, of course, but since Cedar and the others saw it as such, Pax had almost begun to as well. Just a harmless, meaningless bit of decoration. It was easier to believe because digital keys had no meaning for Cedar's kind, and even if they did know

what it was, they could not know what it opened. What it *could* open. Pax looked down at the key, brushing xir thumb over the engraved infinity symbol.

After a long time, Pax pulled the thread off from around xir neck and let it swing, back and forward, over the water. A thousand questions clamoured but, so far, an answer did not come.

*All the green things thrive and the world is light.*

---

## SITUATING THIS RESEARCH

Pax's key is left swinging over the river at the end of 'The Beforetimer' as an open question about ethical becomings. Great potential is held in that key; the power for Pax to bring back the other last surviving humans into a world that has moved on from them. Significantly, this is a world that is also no longer recognisable as a place considered to exist exclusively for humans. The key can also not be used and thus signal the end of humanity in this possible future. My short story purposefully asks more questions than it answers, just as this dissertation does. Indeed, the main purpose is to provide speculations and provocations, to shift the perspective and terms of engagement, and consequently to provoke rethinking.

In the 21<sup>st</sup> century, the world's 'becoming' is increasingly influenced by the advancement of science and technology. Some developments are likely to have immense impact in the near future, such as nanotechnology, genetic engineering, quantum computing, and artificial intelligence. There are also global issues that require specific scientific and technological attention and applications, such as climate change, the growing human population, and the threat of new or evolved diseases. The effects of climate change, both currently occurring through to highly likely to occur, are overwhelming.

The Intergovernmental Panel on Climate Change (IPCC), has concluded in their most recent reports that they are 'now 95 percent certain that humans are the main cause of current global warming' and that:

the more human activities disrupt the climate, the greater the risks of severe, pervasive and irreversible impacts for people and ecosystems, and long-lasting changes in all components of the climate system  
(Core Writing Team, Pachauri & Meyer, 2015, p. v).

The IPCC note that drastic changes are required to stabilise temperature increases, and that the longer these changes do not occur, the costlier it will be to do so and the more likely that the challenges faced will multiply (Core Writing Team et al., 2015, p. v).

The material/ontological/posthumanist turn in theory has provoked numerous renewed questions about the becoming of humanity and the world, wherein the meaning of ‘human’ as a unitary category is questioned. Here, ‘the world’ is perhaps precariously understood as the planet Earth and the matter and life associated with this planet. Barad, and others, also use the term ‘worlding’, which might be thought of as a floating concept, referring to something highly dynamic, that is always continuing and generative and cannot be reduced to matter or discourse. For instance, Barad uses the term to refer to the ways in which life and matter intra-act, or ‘the very condition of possibility of spacetime-mattering’ (Barad, 2011, p. 150).

There are various incarnations of this ‘turn’ in theory but, overall, they might be understood as challenging humanist exceptionalism and the separations involved in ‘Cartesian’ dualisms, principally nature/culture, matter/discourse, mind/body, knowing/being, and reason/emotions. The term ‘Cartesian’ refers to the French philosopher René Descartes, who argued that the mind or soul is nonmaterial and thus enacted a split between the mind and the (material) body (Colebrook, 2010, p. 79). Humanism, meanwhile, is contingently understood as ‘a doctrine that combines the bio-logical, discursive and moral expansion of human capabilities into an idea of teleologically ordained, rational progress’ (Braidotti, 2013, p. 13) in which humans are considered special and separate from other living things (Barad, 2007, p. 136). This is a contingent definition primarily because the term ‘humanism’ covers such a broad set of characteristics and concerns, its meaning will inevitably exceed any attempt of its definition. This is true also for ‘posthumanism’.

The main theorists who inform the framework I call ‘relational posthumanism’, Donna Haraway, Karen Barad, and Rosi Braidotti, are often associated with this ‘turn’ in theory, but more specifically the theoretical frameworks of feminist epistemology, feminist materialisms, and posthumanism. Working with Haraway, Barad, and Braidotti in the research area of science, ethics, and school education is a significant relationship, as they separately and together bring about renewed thinking about science and ethics. Haraway, along with Barad, who draws a lot on Haraway’s work, have revitalised questions about how science and ethics are defined, as well as their ‘entangled’ relationship. Braidotti, meanwhile, has put forward a persuasive challenge to ‘anthropocentrism’ in her account of a posthumanist philosophy.

By naming my framework ‘relational posthumanism’ my intention is to combine the emphasis on understanding the world *as inherently relational* with the challenge to the centring of humanity. This will be further explained in Chapter 2 but to summarise this approach, it involves acknowledging the inseparability of ethics, knowing, and being, or what Barad calls ‘ethico-onto-epistemology’ (Barad in Juelskjær & Schwennesen, 2012, p. 15)<sup>2</sup>. It also conceptualises the inseparability of the material and the discursive, which has become the ‘material-discursive’ (Barad, 2007, p. 141).

Relational posthumanism includes Haraway and Barad’s concept of ‘diffraction’, which I also combine with Braidotti’s reworking of ‘difference’; that is, unfolding, unbound difference rather than “different from” [meaning] “less than” (Braidotti, 2011, p. 75). In challenging humanist exceptionalism, this framework interrogates the distance between ‘human’ and the ‘nonhuman’, or the ‘other/more-than-human’. This is part of what Braidotti and others call the

---

<sup>2</sup> This reference is an interview of Karen Barad by Malou Juelskjær and Nete Schwennesen.

challenge put to the ‘Anthropocene’; ‘the historical moment when the Human has become a geological force capable of affecting all life on this planet’ (Braidotti, 2013, p. 5).

Furthermore, renewed thinking about doing research, including understanding data, researchers, methods, participants, and analytical techniques as a material-discursive ‘entanglement’, has been an evolution of this ‘turn’ in theory. Researchers in this area have drawn inspiration from French philosophers Gilles Deleuze and Felix Guattari’s conceptual developments of assemblage, becoming, and affect, especially for analysing data. Consequently, this working and reworking of Deleuze and Guattari’s ideas has also informed my analysis. Most importantly, perhaps, is the attempt to de-centre the human in doing research, placing emphasis instead on relationality within ‘assemblages’. Consequently, throughout this dissertation, I refer to my human participants as ‘entities-as-multiplicities’, or just ‘entities’, which is intended not only to de-centre the human but also to acknowledge that humans are not necessarily coherent ‘individuals’.

Additionally, I have been inspired by renewed thinking concerning creative practice in research, understood from a relational posthumanist perspective. In this sense, creative work is conceptualised as an active force, a ‘thinking-doing’ practice that is more than ‘representative’. Thus, I examine the possibilities of this approach by diffracting ‘The Beforetimer’ throughout this dissertation. In terms of including the connection with the speculative, I also include analytical diffractions of others’ speculative fiction, including Margaret Atwood’s *MaddAddam* (Atwood, 2014), and the films *Ex Machina* (Garland, 2015) and *Snowpiercer* (Bong, 2013).

Speculative fiction, like all fiction genres, is difficult to wholly define and this difficulty is further detailed in Chapter 1. However, it might be understood as a genre that takes the world as it is, or may well be, to speculate on the world’s becoming in specific relation to science and technology. Thus, speculative fiction essentially stays true to what is conceivable in the current

world. This view follows definitions from theorists, and authors, such as Margaret Atwood. Atwood, for instance, argues that:

for me, “speculative fiction” means plots that descend from Jules Verne’s books about submarines and balloon travel and such—things that really could happen but just hadn’t completely happened when the authors wrote the books (Atwood, 2011, p. 6).

In ‘The Beforetimer’, I examine the possibilities of thinking with, or diffracting, posthumanism while writing speculative fiction. Within this story, ethical science issues are depicted in various ways. The most obvious one is that a climate-related cataclysm has occurred, resulting in widespread devastation. This compels the few human survivors to live underground but inevitably this becomes a struggle as food supplies begin to run out and the humans search for another way to survive. Consequently, they enter a ‘longsleep’ in the hope that when they wake the planet’s surface will be habitable once more.

The human survivor, Pax/Entity, who wakes up alone after the longsleep, meets the *Homo adaptos*<sup>3</sup>. They are genetically modified beings, the result of blends between ‘human’ and ‘other animal’ DNA, who have managed to survive on the planet’s surface. This story is also an attempt to examine the foundational considerations behind issues like climate change and genetic engineering; it implicitly asks, what is ‘the human’? What is our responsibility to the world’s becoming and other species?

Despite the crossovers of concern, there is yet little research that combines the material/ontological/posthumanist turn with considerations of science in school education, and

---

<sup>3</sup> ‘Homo’ in Latin means ‘human’ while ‘adapto’ can translate to ‘adapt’; thus ‘adapted’ or ‘modified/altered/improved’ humans.

certainly even a smaller amount in the Australian context. Various problems of science and school education in Australia are noted widely in the literature; specifically, the difficulties with reform, the connections with ‘real world’ science, declining student interest, and claimed stagnant improvements in students’ performance. Since 2014, Australia has a new national curriculum that must be transitioned to by all schools and teachers, posing yet more questions.

I utilise two major reports about science and Australian school education that encapsulate the broad issues in this area. The first is ‘Reimagining Science Education’ by Russell Tytler (Tytler, 2007), who is a well-known Australian researcher in this area. The second is ‘STEM: Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) Education’ by the Australian Council of Learned Academies (ACOLA)<sup>4</sup> and authored by Simon Marginson, Russell Tytler, Brigid Freeman, and Kelly Roberts (Marginson et al., 2013).

Tytler’s report outlines a ‘crisis’ in Australian science education, and both reports cover why science education is important, possible reasons for the issues, and suggest several solutions. While both reports are very comprehensive, my research seeks to look at these issues through an alternative lens and with a focus particularly on the science-ethics nexus. This contrasts with the more common substantiations of these issues in terms of labour markets, as well as the partnership between national economic and scientific/technological development.

This differing posthumanist perspective is an attempt to ask renewed questions about science and ethics in Australian school education, to open yet unexplored connections, and to

---

<sup>4</sup> ACOLA is an independent and not-for-profit organisation, made up of four academies, for the humanities, sciences, social science, and technology and engineering. It conducts research and provides policy advice to the Australian state and federal governments on a wide array of issues. It is directed towards solving ‘complex societal issues for the benefit of Australia’s social, cultural, economic and environmental wellbeing’ (Australian Council of Learned Academies, 2017).

push our collective imagination of this area even further. However, I do not propose that a relational posthumanist framework constitutes any final resolution for the issues concerning the science-ethics nexus in school education. My speculative research study is rather a set of provocations, through which I contribute to a conversation about what this framework might invoke.

---

## ENTANGLEMENTS OF SELF

Who is the ‘self’ that does research? From a relational posthumanist viewpoint, this ‘self’ is not a singular, coherent being that precedes research. Instead, this self is always already a part of the becoming of research; an important element, but an element amongst many. The aim of this section is to present an account for the assemblages of which ‘I’ am just a part and that are potentially significant for this study’s becoming. ‘This I is an intensity, an affective meld, a convergence of forces, always unstable, mobile, emerging, becoming’ (C. A. Taylor, 2016, p. 10).

In doing this, it must be acknowledged that any such account is never whole, nor complete, but rather a glimpse of an ongoing process. The concept of reflexivity in research is well developed. Reflexivity, ‘often drawing on poststructuralist thought, involves turning one’s reflexive gaze on discourse—turning language back on itself to see the work it does in constituting the world’ (Davies et al., 2004, p. 361). In other words, it is an interpretation of how a researcher’s perspective is involved in the development of research. In contrast, however, a relational posthumanist framework specifically shifts the focus away from the ‘individual’ researcher and discourse to consider what can be termed material-discursive ‘assemblages’.

The first aspect of these assemblages I examine is the ‘environment’ in which I spent the first ten years of my life; the ‘Otway Ranges’, an area south west of Melbourne, in Victoria, Australia, that is made up of large nature reserves and parks, plantations, towns, and farming

pastures. This land is historically the home of a few Indigenous<sup>5</sup> language groups, including the Gadubanud, Gulidjan, and Girai Wurrung (Horton, 1996). In the 1970s, my environmentally-conscious parents built a mudbrick house ‘off the grid’ on land outside of a small town not far from the Otway Forest Park. Our 36-acre block comprises gum trees, tea trees, large grasses and many other animal species, including notably uncountable species of birds, as well as snakes, wallabies, echidnas, and frogs. We also cared for various other animals, such as dogs, cats, ducks, chickens, and horses.

I spent most of my free time outdoors, exploring this land. To use Barad’s concept, ‘I and this land and its other animal occupants ‘intra-acted’ (Barad in Kleinman, 2012, p. 77)<sup>6</sup>, which emphasises a ‘becoming with’, rather than an a priori separation. There was a mutual agency of affects; I was forever curious and mindful of the other life and matter I encountered. I relate this childhood home, and now what is an occasional holiday home, as especially significant for my beliefs about the importance of sustainability/conservation, and my critical perspective on the negative effects of human activities on environments and other species. I also, therefore, acknowledge an alignment of these beliefs with a relational posthumanist ‘ethico-political’ framework. Thus, in other words, this land might be considered as one aspect of the becoming of this study. It both becomes with me and through me, in ways I can be somewhat conscious of but that also exerts agency in ways that I cannot account for.

In a similar sense, my interests in science and speculative/science fiction is also significant for this account of mutual becoming. I became interested in science from a young age but especially in my teenage years when I developed a fascination with astronomy, which

---

<sup>5</sup> In this dissertation, as reflecting much of the literature, capitalised ‘Indigenous’ refers to Australian Aboriginal and Torres Strait Islander people, while non-capitalised ‘indigenous’ refers to the original inhabitants of all nations. The issues to do with this language is discussed in Chapter 1 and 6.

<sup>6</sup> This reference is an interview of Karen Barad by Adam Kleinman.

involved my joining the Victorian Astronomical Society and spending countless hours observing the night sky. Concurrently, I read a lot of speculative/science fiction. My parents were also undoubtedly part of this assemblage, as my father became a secondary physics teacher when I was around eight-years-old and my mother was an avid science fiction reader. Although she died when I was six, I later discovered and began to read the many classics she owned, such as those by Arthur C. Clarke and Isaac Asimov. These interests allowed for intra-actions that I would otherwise not have encountered, and were undoubtedly involved in shaping my views, beliefs, and understanding of science in ways that go far beyond my 'self'.

My passion for reading, and reading across many genres, is no doubt strongly linked to my childhood aspiration to become a fiction writer. This was not fully realised, however, until after I finished secondary school. I completed a diploma of professional writing and editing, followed by a Bachelor degree with professional and creative writing as one of my majors. During this time, I was interested more in writing literary fiction than other modes, though I explored other areas. For my Honours dissertation, I wrote a collection of magical realist short stories that had an integral relationship with queer politics. It was in this that I began to develop appreciation for how fiction is entangled in the world's development.

Identity remains important in this posthumanist account of research-related assemblages; however, it matters more what identity does, and what it connects with, rather than what it is, or might be for a 'self'. Additionally, identity is understood as a non-essentialist, non-deterministic affective continuity between social forces and a 'self', in which a 'body' and a 'mind' are not separable. I consider my identities as involved in specific pathways I have chosen. Notably, my identity as queer and my non-binary gender identity, has resulted in my strong interest in questions of 'gender-sex', sexuality, and how these phenomena are involved in the becoming of societies and knowledge.

The terms ‘gender’ and ‘sex’ are much debated. A simplistic understanding is that gender is ‘sociocultural’ while sex refers to ‘biological/sexual difference’. However, this relationship is not nearly so clear-cut, as various aspects of this study seek to further illuminate. Just as some theorists argue that nature and culture cannot be separated, I argue that neither can gender and sex. But to combine them with a hyphen is not to collapse their meanings together; rather, this is an attempt to illustrate and understand how biology/matter is concurrently materialised with culture/society/language and, further, what impact this has on the constitution of society and knowledge.

Overall, these identities might be understood as ‘becoming-Other’, a becoming that can, but does not necessarily, lead to awareness of norms and the effects of norms. Similarly, Braidotti argues that ‘becoming-woman is the necessary starting point for the deconstruction of phallogocentric identities precisely because sexuality as an institution structured around sexual dualism and its corollary—the positioning of women and sexual “deviants” as figure [sic] of otherness’ (Braidotti, 2012, p. 30). That is, a non-normative, marginalised identity does not precede agency, but can involve affective capacities. I discuss this further in Chapter 5, in relation to my analyses of interviews with beginning teachers.

For now, what is important is that my becoming-Other in terms of gender-sex-sexuality, may be significant in expressing a broad entanglement of gender-sex and sexuality within the becoming of knowledge and societies, and then again within this research study. This is particularly so in my analysis of masculinist hegemony. Masculinist hegemony here refers to, primarily, the characteristics, or ways-of-being, most often associated with ‘being male’.

Lastly, my identity as Caucasian marks me as in some way privileged, in understanding privilege as not an either/or equation. My whiteness is pronounced as a becoming that is in tension with the framework of relational posthumanism and the critiques of Euro-Western

hegemony. I acknowledge that ‘Euro-Western’ is a contentious and imperfect term. Attempting to define cultural lineages is an extremely difficult task, and always a fragile shorthand, considering culture is such a dynamic and subjective set of characteristics. As Stuart Hall argues, ‘We have to use short-hand generalizations, like “West” and “western,” but we need to remember that they represent very complex ideas and have no simple or single meaning’ (Hall, 1992, p. 276).

By Euro-Western hegemony I refer, loosely, to the philosophy/ideologies, values, beliefs, customs, and characteristics most often described as having come from, or being central in, countries now situated in Europe, as well as those colonised by such nations, and continually affected by colonisation. This includes Australia, New Zealand, Canada, and the United States of America. Overall, this term should be thought of as a ‘tool to think with [as it] sets a certain structure of thought and knowledge in motion’ (Hall, 1992, p. 277) rather than a concrete, contained description. Additionally, by using the term ‘ideology’, I refer to the way certain ideas, ideals, and values sometimes ‘stick’, or become dominant in society.

The material/ontological/posthumanist turn has mainly involved research conducted within the Euro-Western world, by white researchers, and therefore there is an ongoing question concerning its engagements with cultural and ethnic/racial issues. Awareness of this tension led me to attempt to connect with critical approaches in this area, including the precarious but important and necessary engagement with Indigenous ways-of-knowing, included in Chapter 6.

It would be impossible to comprehensively account for all aspects of an assemblage related to the becoming of a ‘self’ as a researcher and a research venture. What I have presented here are, however, some potentially important aspects of this assemblage, which will be further developed throughout this dissertation.

---

## SUBSEQUENT STRUCTURE

Following this introduction, I present my review of research literature engaged with questions about science and ethics in school education. In the first chapter, ‘Stories of school education, science, and ethics’, I identify the major theoretical/conceptual shifts and epistemologically critical accounts of science. This includes questions about entangled phenomena, such as gender-sex and Euro-Western culture. In the section ‘Ethical concerns’, I cover developments in how ethics has been defined, especially as related to science and school education. The last section, ‘Moving beyond ‘science’’, comprises considerations of speculative fiction and how it relates to research in school education.

My review of the science and education research literature leads into a review of the theoretical ideas I have drawn on, and worked with, for this study. Consequently, the second chapter ‘Posthumanist provocations’, contains my analysis of the material/ontological/posthumanist turn, including a brief history of feminist materialisms and critical posthumanism. Following this, I outline the concepts inspired by the theorists who have helped define these theoretical frameworks. These theorists include Karen Barad, Donna Haraway, Rosi Braidotti, and others, whose work make up my understanding of ‘relational posthumanism’. The section ‘Connecting theory with research’ is where I connect this framework with renewed ideas about ‘doing’ research.

By combining developments in the above theory with developments in thinking about empirical research, I contribute to the discussions concerning what this convergence might mean. Accordingly, in Chapter 3, ‘Plugging in/to data’, I describe how I have worked with theory in my data generation processes. In this chapter, I discuss the ethical considerations of this study, with some consideration of how ‘posthumanist ethics’ might relate to conducting research. I then outline my fiction writing research practice as it both informs, and is informed by, relational posthumanism and the other aspects of this study. Finally, I chart my inclusion,

and diffractive method of analyses, of major research reports, the Australian secondary school curriculum, secondary textbooks, and interviews with beginning teachers.

The second half of this dissertation contains my analyses of this data. In Chapter 4, I examine the current constitution of this nexus in Australian secondary school education. I begin by reassessing how the understanding of issues in ‘science education’ might be renewed via a posthumanist viewpoint. I then consider how the Australian secondary school curriculum constitutes ethics. This is followed by an assessment of how science textbooks demonstrate the presence of anthropocentrism within this nexus.

My next analytical chapter turns the attention to beginning teachers’ assemblages and their views of science and ethics. In Chapter 5, I diffract the relational posthumanist concept of ‘onto-epistemologies’ in my analyses of interviews with beginning teachers, to demonstrate an alternative way of examining how their views about science and ethics develop. By using a posthumanist approach, I demonstrate the implications of onto-epistemological assemblages along with the participants’ ‘becomings’. Here, I consider how this approach, which incorporate more than the ‘discursive’, has implications not only for renewed thinking about views but also for the science-ethics nexus broadly.

My last analytical chapter brings together the two previous chapters. In Chapter 6, I develop the discussion forward from what the current science-ethics constitution is to how relational posthumanism, with provocations of speculative fiction, might re-envision the science-ethics nexus in Australian secondary school education. This includes considering the potential benefits of emphasising ‘world-science-education’ relationality and conceptualising a ‘posthumanist ethics’ in school education. Finally, I also utilise relational posthumanism to challenge disciplinary and cultural boundaries within school education, including considerations of speculative fiction and Indigenous ways-of-knowing.

The conclusion of this dissertation ties together my main arguments by bringing the most important elements of each chapter into conversation with each other. I address the significance of my arguments in relation to research in this area, as well as to broad interests concerning science and ethics in school education. This includes outlining what this study specifically contributes. Additionally, I consider how the renewed imaginings offered in this dissertation might inform further renewed thinking and renewed approaches.

CHAPTER 1: STORIES OF SCHOOL EDUCATION, SCIENCE, AND ETHICS

---

...ways of life are at stake in the culture of science.

—(Haraway, 2004, p. 69)

---

The stories that are engrained into the fabric of society, which includes science, influence ways of life. The above quote by Haraway comes from her work ‘The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others’ (Haraway, 2004). Her argument about the consequences for ‘ways of life’ highlights the importance of reviewing and re-examining the ethical dimension of how science and technology is developed. In this chapter, I address the stories at work, and the stories under examination, in science, ethics, and school education.

The complexity and impact of scientific and technological development around the world is ever increasing. Some of this development has significant consequences for the world’s becoming. There are also issues, such as climate change, that require scientific and technological expertise to understand and manage. The ‘ways of life at stake’ therefore are not just human but can refer to all life on this planet. What Haraway appears to be suggesting is that we are in a time now wherein the present and future are largely predicated on the choices made in, and beliefs about, science.

The paragraph the Haraway quote is from is within her discussion of how theory is ‘bodily’ and ‘literal’; it is about *generation*, not reproduction. Within this generative framework, therefore, science or ‘technoscience’, as Haraway writes, ‘must be made into a paradigmatic model not of closure, but of that which is contestable and contested’ (Haraway, 2004, p. 69). Science already questions itself but that has not prevented aspects of scientific knowledge from sticking, or becoming ‘normative’. There are also many kinds of questions that may yet be overlooked.

To be ‘inappropriate/d’, Haraway argues, is about being ‘in critical, deconstructive relationality’ (Haraway, 2004, p. 69) and it is this idea I utilise to position myself for this review. Applying these ideas to research around science, ethics, and school education requires an opening to possibilities and a search for provocations that allow for renewed thinking. Consequently, the main purpose of this literature review is to outline the various entwined pathways in research that has interrogated the *epistemological* constitutions of science and ethics, with offshoots that have contextualised these issues within education research in the last 15 or so years.

I identify some possibilities for renewal in this area of research as, firstly, that certain theoretical frameworks have become dominant over time on the topics of science, school education, and epistemology; chiefly social constructionism and poststructuralism. However, while it is noted that various aspects of school education have improved since such critiques began, such as improvements in addressing gender inequality, the identified issues (outlined further below) largely remain. This suggests that there is certainly opportunity for revitalised thinking. More precisely, I outline how posthumanism and related feminist materialist frameworks are especially suited to offering alternative thought in this area but have not yet been much applied; especially not to the area of the ‘science-ethics nexus’ in Australian school education.

The second possibility I identify is that while there is considerable research on science education and entangled phenomena (such as gender-sex, class, race, ethnicity, or culture more broadly), and there is considerable research on ethics/values in science and school education, there is much less on bringing these areas together, despite the many crossovers. Additionally, most research situates itself comfortably within the paradigm of ‘science education’. This means that there is limited research attempting to develop transdisciplinary approaches to the science-ethics nexus in school education, involving connections outside traditionally-defined science.

There are two main reasons as to how and why in particular school education is a crucial aspect of understanding and managing the role of ethics, science, and technology. The first one is simply that the science-ethics nexus is already present in school education. Indeed, in Australia, the national curriculum states that:

As cultural, social, environmental and technological changes transform the world, the demands placed on learners and education systems are changing. Technologies bring local and distant communities into classrooms, exposing students to knowledge and global concerns as never before. Complex issues require responses that take account of ethical considerations such as human rights and responsibilities, animal rights, environmental issues and global justice (Australian Curriculum, Assessment and Reporting Authority, n.d. <sup>a</sup>).

Indeed, this extract highlights the certainty that a typical secondary school student in Australia currently faces a future with unparalleled implications in the development of science and technology. They may or may not be concerned over, for instance, the increasing negative effects of climate change, the upheavals brought about by technological advancements in relation to jobs and careers, the increasing extinction rates of Australian and global species. However, these issues will undoubtedly affect them, and all of us, in some way.

Thus, examining the ideological and epistemological foundations of the approaches of Australian school education to these issues is necessary to determine how and if it is meeting these other ethical imperatives. Ideology, here, means a dominance of certain ideas and ideals, while epistemology refers to the foundations of how we know the world. Following this, the second reason school education is important is acknowledging the role of education as entangled in how science and ethics is conceived. Education, and educators, are certainly not

the only aspect of how science, technology, and ethics are conceived and developed but they are a significantly important part of the world-science entanglement.

Consequently, my approach is also to expand the boundaries for what is considered relevant for the science-ethics nexus in school education. This includes, for example, consideration of curricula outside of the specific science area. I also consider beginning secondary school teachers who intend to teach humanities subjects in addition to those who intend to teach science. The questions posed are: what relevance does the separation of subjects in curricula have for the science-ethics nexus? How might humanities teachers also contribute to, and be continually implicated in, the science-ethics nexus?

The science and education field of research is large but there are some commonly identified problems, relevant to thinking generally about how science and education is performing in Australia. These problems include inequality, such as related to gender, class, race, and ethnicity. This is identified as a problem because disadvantaged students are said not to do as well in science as they face more barriers in learning science at school.

Other problems are students' declining interest in science and students' declining performance in science. There are increased pressures on schools and teachers due to globalisation, affecting things such as workloads, funding, and the requirement to attend to multiculturalism. Lastly, other concerns include the lack of relevance to 'real world' science, too many teachers without a science background teaching science, schools' and teachers' struggle to enact reforms, and a lack of support for teachers' professional development. These problems are outlined in 'Reimagining Science Education' (Tytler, 2007) and 'STEM: Country Comparisons' (Marginson et al., 2013).

The research and literature that broaches the epistemological arguments around the topics of science, ethics, and school education is also complex. Particularly as this area crosses

through the period often referred to as the ‘science wars’<sup>7</sup> beginning in the 1990s, a time of very contentious critiques and backlash around understanding the nature of scientific inquiry. While there have been many changes in the world since this period, the contentiousness and complexity of the science wars remain alive. It is therefore necessary for me to carefully narrow my focus down in several ways, with the primary concern of relating this literature to my theoretical framework, research questions, and research context.

Firstly, I focus on the theoretical trajectories most related to the development of a relational posthumanist framework, such as social constructionism and poststructuralism. Secondly, in terms of examining the most recent school education literature in these areas, I exclude most work published before 2000. I also further focus the literature down to the context of secondary school education and research with beginning secondary teachers. While the science-ethics nexus is no less important in primary education, the secondary school education and related teacher education context has clearer links already in place, providing for a more in-depth analysis. Examining secondary school education also allows for an understanding of a mid-point in school education, in which students are expected to be developing more complex participation.

The first section of this review ‘Shaking the foundations of science’, focusses on the broad critical epistemological questions around science. These are examined in terms of how the theoretical branches behind these questions have been applied more recently in school education research. I focus on those theorists who begin at the fundamental question: how do we know what we know? It is also these theorists that have drawn links between the entanglements of various phenomena, such as gender, sex, race, ethnicity, and class, as to how

---

<sup>7</sup> See “Science Wars” (1996), included in references.

science is continually constituted. For example, the argument that science has often been associated with middle class, white, cisgender men.

Consequently, the second section ‘Entanglements of phenomena’ expands upon these developments in more detail. Here, I examine the work being done to define and understand the above phenomena, which are argued to play a large part in the constitution of science (and therefore also the science-ethics nexus in school education). In the following section, ‘Ethical concerns’, I link the previous two sections to outline how such arguments can also be applied to an in-depth examination of how ethics is (re-)defined and constituted in science and school education.

Within the last section, ‘Moving beyond ‘science’’, I include a succinct examination of the work on opening the research field of science and education, to consider links to the creative arts and arts/humanities, such as speculative fiction. This relates to my creative practice of writing speculative fiction and challenges put to disciplinary boundaries. I therefore include work that examines speculative fiction and the potentials therein to imaginatively address the ethical development of science and technology in school education.

---

## SHAKING THE FOUNDATIONS OF SCIENCE

---

The most radical critique shakes the very foundation of science, questioning the assumptions of objectivity and rationalism that underlie the whole enterprise.

—(Shulman, 2001, p. 409)

---

What is science? The definition of science is continually developed in this dissertation but might, at this beginning point, be contingently understood as the systematic pursuit of knowledge about the universe, obtained via the ‘scientific method’. Theorists in the 1960s-70s began to critically question the epistemological foundations of science. These critiques came

from across various disciplines: the history and philosophy of science, sociology of science, and education. While I acknowledge these various contributions, in this section I focus on two areas as most relevant to my research. I divide these two areas into ‘radical critiques’ and ‘feminist epistemologists’.

Thomas Kuhn, the American physicist and historian of science, is widely known for challenging the idea that scientific knowledge occurs in a predictable linear and objective manner. In his book *The Structure of Scientific Revolutions* (Kuhn, 1996), first published in 1962, Kuhn argues instead that scientific knowledge develops via, and reflects, ‘paradigm shifts’ and that subjectivity must be acknowledged as part of this identification. Kuhn argues:

Scientific development becomes the piecemeal process by which these items [facts, theories, methods] have been added, singly and in combination, to the ever-growing stockpile that constitutes scientific technique and knowledge (Kuhn, 1996, p. 1).

While Kuhn’s theories faced criticisms from both objectors and sympathisers, it has been argued that his work paved the way for further developments in questioning science, including instigating more sociological approaches. Duran, for instance, argues that Kuhn and other similar theorists lead to the feminist and radical science critiques (Duran, 1998, p. 66) and that ‘Sociology of science also helped merge the lines of radical critique and nascent feminist critique’ (Duran, 1998, p. 70).

Bruno Latour, the French philosopher and sociologist of science, was instrumental in the development of ‘Science and Technology Studies’. This is a science reform initiative that inherently challenges the traditional conception of science as separate from society, by focusing on the effects of science on society and vice versa. Latour’s early work developed critiques of science, utilising social constructionism and highlighting the social processes of science. For

instance, in pointing towards the confirmation of scientific theory as more social than empirical (Latour, 1999)<sup>8</sup>. Latour's later work involved the development of 'Actor-Network Theory' described as 'the breakdown of the typical modern distinction between humans and the world, or culture and nature' (Graham, 2014, p. ix).

The 'Science and Technology Studies' development instigated various other trajectories, both in broad sociological research but also specifically within school education. For instance, in education there is the developments of 'Science-Technology-Society' (STS) strand (e.g. Akcay & Yager, 2010; Bennett, Lubben & Hogarth, 2007; Dolu, 2016; Hughes, 2001; Nasser, 2009; Tsai, 2002) and the 'Science-Technology-Society-Environment' (STSE) strand (e.g. S. E. Barrett & Pedretti, 2006; MacLeod, 2014; Pedretti, Bencze, Hewitt, Romkey, Jivraj, 2008; Pedretti & Nazir, 2011; Yoruk, Morgil & Segken, 2010).

Although the latter includes a focus on environmental consequences, both have similar ideological impetus in that they promote the idea of 'contextual-based learning'. In other words, these trajectories involve advocating that science education should always be understood in its cultural, economic, social, and political contexts:

An STS movement has promoted the learning of science in its human and social context to provide a contemporary relevance for science and to de-emphasise abstruse laws and theories which alienate the majority of learners (Hughes, 2001, p. 277).

Another similar but newer branch has also emerged, known as 'Socioscientific Issues' (SSI) (e.g. Eastwood et al., 2012; Sadler & Donnelly, 2006; Sadler & Zeidler, 2004; Yeung & Grace,

---

<sup>8</sup> However, Latour has since moved on from social constructionist methods. In the article 'Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern' (Latour, 2004) he considers the negative effects of poststructuralist and social constructionist critiques.

2012; Zeidler, Herman, Ruzek, Linder & Lin, 2013). Socioscientific issues include open-ended and often controversial problems related to both science and society, such as climate change. Conceptually, SSI is very similar to Science-Technology-Society and Science-Technology-Society-Environment; however, it differs in its focus on the development not only of conceptual content knowledge but also ‘moral reasoning’ as related to scientific issues. This will be further examined in the section ‘Ethical concerns’.

Meanwhile, feminist critiques of science generally:

take it as a given that the intellectual structure of science, its results, its effects on the culture, and its social network are positioned in ways that make science androcentric, class- and race-biased, insensitive to the needs of the oppressed, and hierarchical with respect to social indicators and markers (Duran, 1998, p. 6).

Feminist critiques of the nature of science were initiated by theories such as Donna Haraway’s ‘situated knowledges’, Evelyn Fox Keller’s ‘dynamic objectivity’, Helen Longino’s ‘contextual empiricism’ and Sandra Harding’s ‘strong objectivity’ (Barad, 2007, p. 61).

Feminist epistemologists who examine science can be further divided into three groups: feminist empiricism, feminist standpoint, and feminist postmodernism (Duran, 1998, p. 109). The first group is characterised by those who argue that the core of traditional science is solid and that only slight adjustments or changes should be made to reduce instances of ‘bad science’. Members of the other groups, such as Sandra Harding and Donna Haraway, however, tend to question the very fundamental ideas that traditional science has rested on, particularly its so-called ‘objectivity’ and neutrality. It is these latter branches that I have drawn on for my own research, with the intention of continuing provocative epistemological discussions around

science, ethics, and school education. However, Haraway's work has been more useful to this study, particularly in relation to the work by Karen Barad and Rosi Braidotti.

Feminist epistemology theorists not only critique the nature of science but also developed theories with the idea of changing science in specific epistemological and ethical ways. They have argued that science is not neutral and that it has in various ways been influenced by an inequitable society driven by masculinist hegemony. '[R]eason, fact, and object represent rational discourse and scientific knowledge [...and] are, not surprisingly, qualities synonymous with masculinity' (Lederman & Bartsch, 2001, p. 231).

This has meant that not only have there been more male scientists throughout history, but also that the way science is engaged with, thought about, practiced, and constituted in society—via the media, and school education—has been influenced by a masculinist hegemonic society. As Brotman and Moore argue:

the fact that historically men were primarily the ones who did science not only has led to an association between masculinity and the practice of science, but it has also impacted the scientific understandings we possess (Brotman & Moore, 2008, p. 987).

Feminist theorists who challenge the objectivity ideal in science argue that science's abstract and so called 'neutral' form of objectivity is closely linked to the socially dominant form of masculinity, which privileges the male over the female and masculine over feminine. A major argument of Haraway's, for example, is for a 'situated knowledge' that is in contrast with this disembodied omniscient 'objective' knowledge associated with masculinist hegemony. She argues feminist objectivity is both about embodiment and developing a 'better account of the world' (Haraway, 1988, p. 579).

For Haraway, this embodiment is somewhat material-discursive; it is not fixed but instead is ‘about nodes in fields, inflections in orientations, and responsibility for difference in material-semiotic fields of meaning’ (Haraway, 1988, p. 588). In other words, to be ‘situated’ is to be in an embodied place that is at the same time a place of multiplicity. Consequently, Haraway’s work provides many provocations for considering how objectivity and subjectivity in science play out in school education, which is an area this study takes up.

By analysing certain areas of science, such as primatology, Haraway also highlights that in many ways, social needs can determine both scientific research topics and the conclusions formulated. Additionally, using the metaphor of the cyborg (cybernetic organism), Haraway attempts to disrupt dualisms and to interrogate the human relationship with ‘technoscience’. This idea challenges the ability of a totalising theory, especially from science, to fully capture all of reality but is also an attempt to embrace science in a positive construction of responsibility (Haraway, 2004, p. 39).

---

## RECENT EDUCATION LITERATURE

This section offers an analysis of recent literature (from 2000) in the school education research field as to how the nature of science is currently conceptualised and questioned. For ease of understanding, the literature has been split into two groups: radical and feminist critiques of science. Radical critiques of science are often drawn into education reform literature that seeks to introduce a renewed definition of the ‘Nature of Science’ (often abbreviated to ‘NOS’). This literature is also often combined with the developments Science-Technology-Society, Science-Technology-Society-Environment, and Socioscientific Issues.

The renewed definition of the epistemological nature of science cannot be easily summarised but there are various theorists and researchers that define it in very similar ways. For example, Jennifer Eastwood et al. define the ‘Nature of Science’ as acknowledging that:

‘scientific knowledge is tentative, empirically based, influenced by social and cultural factors, and inspired by human creativity and imagination, scientists’ interpretations are subjective, theories and laws are different kinds of scientific knowledge, and making observations and inferences are distinct activities (Eastwood et al., 2012, p. 2290).

Correspondingly, Tsai and Liu characterise the nature of science as tentative and contingent on historical as well as general social and cultural contexts (Tsai & Liu, 2005, p. 1621). Other similar definitions can be found in related articles, including Allchin (2012), Shibley (2003), and Wan, Wong, & Zhan (2013). Overall, the core philosophy might generally be understood as acknowledging the interrelationship between science and society, while the exact specifications can differ.

It is evident that recent literature advancing radical critiques of science do so to argue for science education reforms that not only change the nature of science, to understand it as socially implicated, but also to examine the *ethical* implications of this. For example, Eastwood et al. point out the possibilities of renewing thinking about science by implementing socioscientific issues in classrooms (Eastwood et al., 2012, p. 2290). There is, however, a concern about whether these arguments account for all the issues involved when social factors such as gender-sex, race, ethnicity, and class are not brought more strongly into the debate. As many feminist theorists have pointed out, and shown evidence for, social structures as well as various phenomena are related to how science is thought about and constituted.

Feminist critiques of science have also inspired science education reform that advances a renewed conception of the nature of science. However, they also advocate reform that insists on the importance of including the specific implications of social stratifications, or systems of

gender, sex, race, ethnicity, and class. Many researchers in education draw on the feminist epistemologists noted earlier to contextualise the androcentric/masculinist nature of science education (e.g. Carlone, 2004; Hughes, 2000; Lederman, 2003; Wilson & Kittleson, 2013).

Some feminist researchers argue that avoidance of these issues only serves to reproduce a masculinist, ‘traditional’ science and that STS, STSE, or SSI streams remain marginalised (and ‘feminised’). Gwyneth Hughes, for instance, argues that socioscientific content is gendered in that it is associated with femininity, while ‘decontextualized’ science is given prominence via association with masculinity (Hughes, 2000, p. 438). Feminist researchers also argue that traditional, masculinist science remains imbued with structures of inequality due to the historical trend of science as practiced in the majority by ‘an intellectual elite’ (Carlone, 2004, p. 395) and by ‘white, male, and Western’ scientists (Lederman, 2003, p. 604). This will be examined in more detail in the next section.

Lastly, it was of interest for this study’s purposes that a proportion of related research focusses on how teachers and students understand science; in other words, their ‘epistemological views’. This research is sometimes general but is more often related specifically to the nature of science or socioscientific issues, or both. For example, one study ‘aimed to assess grade 10 Turkish students’ and science teachers’ conceptions of nature of science (NOS) and whether these conceptions were related to selected variables’ (Dogan & Abd-El-Khalick, 2008, p. 1083).

These studies typically utilise surveys, questionnaires, and interviews to generate data. They also typically utilise common coding and/or quantitative statistical analysis techniques, and discourse-centric models (Der-Thanq Chen, Tsai & Chai, 2011). Some of this area of research specifically focusses on the participants’ views but most also extend, at least somewhat, into considering how such views might form. For instance, one study examines cultural implications,

in comparing Chinese and ‘Western’ conceptions of science (Wan, Wong & Hin Wai Yung, 2011). Dogan and Abd-El-Khalick also consider the variables of ‘teacher disciplinary background, years of teaching experience, graduate degree, and the type of teacher education program’ (Dogan & Abd-El-Khalick, 2008, p. 1088).

The findings of these studies suggest that backgrounds and identities are considerably implicated in teachers’ and students’ views. For example, one study found that ‘Significant differences were found between male and female students’ (Tsai & Liu, 2005, p. 1621). This is supported by another report, titled ‘Gender Differences in High-school Students’ Views about Science’ (Miller, Slawinski Blessing & Schwartz, 2006). However, overall this area of study has been inconclusive (Der-Thanq Chen et al., 2011, p. 973).

While such studies provide valuable insight, it is worth considering what alternative methods might bring into this area, especially considering the dominance of a narrow range of approaches and analytical techniques. As Der-Thanq Chen et al. note, the dominant methods ‘may not fully address the context-dependent nature of VNOS [views of the nature of science]’ (Der-Thanq Chen et al., 2011, p. 974). Certainly, it has yet to be much examined how the material/ontological/posthumanist turn in theory may provide renewed thinking for approaches to this area, as well as for understanding how views about the nature of science, and its relationship to ethics, form.

---

## ENTANGLEMENTS OF PHENOMENA

---

### GENDER-SEX

---

Gender is...one of the most common figures for thinking the basic differences or difference from which all life emerges.

—(Colebrook, 2004, p. 1)

---

Gender and sex remain contentious subjects in public life as well as in academic research. Three frameworks, social constructionism, poststructuralism, and queer theory, are most often drawn on to challenge traditional hierarchical and (biologically) ‘natural’ conceptions of gender-sex. These conceptual frameworks are, however, not easy to define definitively. They have been adopted in many disciplines (e.g. gender and sexuality studies, feminist studies, and sociology) which has resulted in an array of different interpretations. There is also quite often some overlap between the frameworks. Even so, some common characteristics will be offered here to frame the way in which ‘gender-sex’ has come to be examined as a major aspect of how society, science, and school education are constituted.

Social constructionism typically understands gender as constructed by language and symbols:

The widely accepted notion of the ‘social construction’ of gender presupposes that our experience of the world is necessarily mediated by forms or structures that ‘we’ as language users construct, and are constructed by (Colebrook, 2004, p. 77).

Poststructuralists also typically challenge the idea of biological essentialism, or any essential self before culture. Albeit, more often with a focus on the role of language/discourse, and sometimes power, in shaping and normalising gender, sex, and sexuality. Queer theorists often focus on disrupting normative heterosexuality (heteronormativity), as well as unequal binaries. In contrast, they argue for an understanding of identity as dynamic and involving numerous articulations outside of any binary construct (female/male, homosexual/heterosexual).

Judith Butler is one of the most well-known and popular theorists on gender. She is often associated with poststructuralism and/or queer theory. Butler’s theoretical work began with the idea of gender as ‘performative’:

acts, gestures, enactments [...] are *performative* in the sense that the essence or identity that [people] otherwise purport to express are *fabrications* manufactured and sustained through corporeal signs and other discursive means (Butler, 1999, p. 173; original emphasis).

In other words, she argues gender is reconstituted through acts and gestures that are discursively (re)constructed and come to be thought of as ‘normal/natural’.

Following from this, I include here some consideration of feminist scientists who critically engage with questions of biology as related to gender-sex. This focus is not often incorporated into poststructuralist or theory based on the ‘material/ontological/posthuman turn’. However, I argue critical questions about the scientific perspective on gender-sex is necessary, as these are another component of how gender-sex ‘becomes’. Furthermore, I argue that it is necessary to close the gap between natural/physical sciences and social sciences, in ways that actively disrupt essentialist or normative views. This is especially important to consider, as I do later, in relation to how ‘gender-sex’ becomes not just an epistemological question but an *onto-epistemological* one. I draw on two seminal examples here: Anne Fausto-Sterling, a professor of biology and gender studies, and Joan Roughgarden, an ecologist and biologist.

Fausto-Sterling interrogates the widely-held belief that human beings (and most other living beings) can be easily sexed as ‘male’ or ‘female’: ‘biologically speaking sex is not such an either/or construct’ (Fausto-Sterling, 2001, p. 329). This becomes especially clear in her strong critique of the ongoing surgical interventions for children that are born intersex<sup>9</sup>, motivated by the imperative of maintaining the status-quo of the gender-sex binary. Indeed, Fausto-Sterling’s

---

<sup>9</sup> That is, not clearly definable as ‘male’ or ‘female’ in relation to traditional biological-based definitions.

article ‘The Five Sexes Revisited’ (Fausto-Sterling, 2000) proposes we replace the two-sex binary model with one that accounts for five sexes. While this is somewhat tongue-in-cheek, this article and Fausto-Sterling’s work in general highlight the tensions between science, culture, and gender-sex. It is not just that gender-sex is entangled in science but that it also changes scientific and medical approaches to understanding gender-sex.

Joan Roughgarden has contributed some crucial arguments that do not just address how science influences gender-sex norms (Roughgarden, 2004) but also challenge the dominant neo-Darwinian sexual selection theory<sup>10</sup> in *The Genial Gene: Deconstructing Darwinian Selfishness* (Roughgarden, 2009). In this latter work, Roughgarden argues that ‘a male/female binary at the whole-body level is nowhere close to being universal across the plant and animal kingdoms’ (Roughgarden, 2009, p. 106). Roughgarden also contests the neo-Darwinian sexual selection theory, arguing that it is fundamentally incorrect and yet contributes to widely-held beliefs and assumptions about gender and sex and supposed natural ‘male’ and ‘female’ behaviour. Not to mention, of course, that it contributes to the denial that such constitutions are entangled inequitably in the constitution of societies.

Whereas Butler demonstrates a discursive approach to gender-sex, and Fausto-Sterling and Roughgarden demonstrate a critical focus on our understandings of biology/matter, Haraway and Barad advocate for a combined ‘material-discursive’ framework. This approach accounts for matters of discourse and performativity but also the dynamics and agency of matter. As mentioned earlier, Haraway uses cyborg imagery to think through gender and sex in light of scientific and technological developments. Her work ‘A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s’ (Haraway, 1987) remains relevant and widely

---

<sup>10</sup> Neo-Darwinism is the ‘current theory of the process of evolution, formulated between about 1920 and 1950, that combines evidence from classical genetics with the Darwinian theory of evolution by natural selection’ (E. Martin & Hine, 2014).

cited today. She argues that ‘Cyborgs might consider more seriously the partial, fluid, sometimes [sic] aspect of sex and sexual embodiment. Gender might not be global identity after all’ (Haraway, 2004, p. 38).

In other words, the cyborg is not particularly one thing or another, but a mesh of organism and machine. It can therefore, Haraway claims, be used to disrupt binaries, such as female/male, human/machine, nature/culture. Overall, Haraway argues that the cyborg, or high-tech culture in general, can be utilised to highlight how gender, and sex, are non-binary and dynamic, and that aspects of ontology, or bodies, are necessarily part of the relational aspect of gender. Haraway also contends that gender is implicated in the development of knowledge, having highlighted this in her work on primatology. I agree generally with these assertions, although it may be questionable how far ‘high-tech’ culture can literally disrupt binaries or norms in general, or may just reproduce them in different, perhaps subtler, ways.

Barad agrees with many aspects of Butler’s theory concerning performativity but argues the relationship with the material could be stronger: ‘it is not at all clear that Butler succeeds in bringing the discursive and the material into closer proximity’ (Barad, 2007, p. 64). What Barad perhaps highlights more so than Butler is the agency and dynamism of matter. This is not to say there is a nature before culture, that can be knowable to humans, but rather that there is no separable ‘nature’ and ‘culture’ to begin with. Barad insists that understanding nature and culture as inseparable phenomena is not to collapse them together, exactly, but to understand their entangled materialisations. Therefore, the term I use, ‘gender-sex’, becomes a material-discursive entanglement in onto-epistemology (knowing-being).

---

## RECENT EDUCATION LITERATURE

A critical focus on the definition and understanding of gender and sex began to be brought into the literature in the field of gender, sex, science, and education in the 1960s-70s,

under the conceptual frameworks of social constructionism and poststructuralism<sup>11</sup>. Theorists began to argue that to improve issues such as gender inequality as it relates to science, more had to be done in developing ideas concerning how gender and sex are conceptualised and constituted in society. Furthermore, that inequality issues in science cannot be overcome by merely taking steps to increase numbers of girls, women, racial minorities, and people from lower socioeconomic backgrounds in science classrooms and careers<sup>12</sup>.

Much current literature on science and school education maintains a traditional understanding of gender and sex; that is, there are usually no detailed explanations or analysis of these concepts, and assumptions about normative binary thinking and gender-sex differences (attitudes, participation, learning styles) are evident. As Jane Gilbert and other feminist education researchers have noted, there is some concern about how effective changes and new policies can be if they do not question assumptions about gender and sex (Gilbert, 2001; Gilbert & Calvert, 2003).

There is, however, a substantial amount of research that does take a questioning and more nuanced approach to understanding gender-sex and identity in school education. For instance, Gilbert's stance is mainly poststructuralist in that she disputes biological essentialism for a discursive construct of sexual difference (Gilbert, 2001, p. 295). She argues that 'sex' is not a given fact of nature but a discursive construct arising from power/knowledge relations. This common poststructuralist perspective is to argue that science curriculum reforms cannot be successful if they only address discriminating practices, leaving out a thorough engagement

---

<sup>11</sup> This critical perspective around definitions contrasts with approaches such as 'gender role' theory.

<sup>12</sup> For example, in their review of gender and science education research, Brotman and Moore point out that a major shift in thinking was to consider that 'to engage girls and other marginalized groups in science, we need to challenge portrayals of the nature and culture of science in the classroom and, in some cases, in the world at large' (Brotman & Moore, 2008, p. 982).

with the relationship between the nature of science and the (hetero)normative dualism of female/male and feminine/masculine.

Hughes points out that when it comes to gender, sex, and science education issues:

gender is not the only dimension; there is a multiplicity of subject positions of gender, sexuality, ethnicity and class produced in a range of constantly shifting discourses and practices so that subjectivities can be multiple, complex, contradictory and fluid (Hughes, 2001, p. 278).

Similar arguments about the need for understanding gender-sex as complex, dynamic, changeable, and entangled with other social facets, in the area of science and education, can be found in Abbiss (2011), Bury (2011), Danielsson (2012), and Nyström (2009).

It is evident that in current research in the field of gender-sex, science, and school education, the dominant paradigms that take an anti-essentialist approach to gender-sex are social constructionism and poststructuralism. However, within education there are gestures towards how feminist materialisms offer a revitalisation of ideas about gender-sex, which in turn offer renewed thought in science. For example, the 2013 special issue ‘Feminist Materialisms’ in the journal *Gender and Education*, has studies that demonstrate this, including Ivinson and Renold (2013), H.L. Taguchi and Palmer (2013), and C. A. Taylor (2013). Additionally, *Posthuman Research Practices in Education* (C. A. Taylor & Hughes, 2016) also provides seminal examples, such as Gannon (2016) and Ivinson & Renold (2016).

Gabrielle Ivinson and Emma Renold use a feminist materialist approach in thinking about girls’ bodies and agency in their ethnographic study about their participants’ experiences in a former coal-mining town (Ivinson & Renold, 2013). Their other study examines ‘camera-girl

assemblages’ to also consider the implications of place. In focussing on the material, Ivinson and Renold articulate how their participants’ bodies are entangled with their environment, objects and places, and others, in dynamic assemblages. They also demonstrate how these assemblages dictate fluctuations in the girls’ experience of agency. Therefore, their subjectivities ‘cannot be separated from places, history and corporeality’ (Ivinson & Renold, 2013, p. 718).

Susanne Gannon’s study similarly considers the importance of ‘more-than-human’ contexts, as well as how ‘affective flows [...] shape young people’s desires and ways of being in the world’ (Gannon, 2016, p. 128). Her study is an examination of how bodies and more-than-human materialities, such as a bear suit, might be examined through the lens of feminist materialisms. Specifically, Gannon considers a female students’ agency in undertaking a creative task to represent her career aspirations, which involved the student putting on a bear suit and taking photographs.

Such studies might purposefully ask more questions than can be answered. However, overall, these feminist materialist approaches highlight this framework’s ability to examine matter, including bodies, objects, and environments, and how it is as important as examining discourse around students’ experiences of schooling. However, despite there being an open avenue in doing so, applications of feminist materialist thought have yet to be much applied in terms of interrogating gender-sex as an *onto-epistemological* entanglement in the constitution of school education, especially for science and ethics.

---

EURO-WESTERN HUMANISM

---

In the traditions of “Western” science and politics—the tradition of racist, male-dominated capitalism; the tradition of progress; the tradition of the appropriation of nature as resource for the productions of culture; the tradition of reproduction of the self from the reflections of the other—the relation between organism and machine has been a border war.

—(Haraway 2004, p. 8)

---

A cultural ‘Euro-Western’ hegemony is another major phenomenon argued to contribute to the constitution of science, and education about science, particularly within Euro-Western nations. In other words, this hegemony is:

those ways of thinking that assert or claim the superiority of the European; [...] that inform and justify European dominance; [...] the social practices that seek to bring about such superiority; and all the political, economic and other cultural relations of European privilege, dominance or superiority (Hostettler, 2012, p. 2).

Many of the theorists and researchers noted earlier, particularly the feminist epistemologists, include a critique of ‘Eurocentrism’ in companionship with arguments concerning science’s general cultural entanglements and masculinist hegemony. One particular element is that the charges against science’s supposed ‘objectivity’, ‘reason/rationality’, and the ‘mind/body’ split is not just a challenge against masculinist hegemony but also against Euro-Western hegemony. In other words, there is an intrinsic entanglement between masculinist and Euro-Western hegemony in the Enlightenment-era-based philosophy that still underpins much of science’s epistemology and practices.

As Sandra Harding argues, the ‘science question asks, “How can we use for emancipatory ends those sciences that are apparently so intimately involved in Western, bourgeois, and

masculine projects?” (Harding, 1991, p. 49). Another feminist theorist of note in this area is Rosi Braidotti. Much of Braidotti’s writing, including *The Posthuman* (Braidotti, 2013), examines science and philosophy partly in relation to Euro-Western hegemony. Braidotti argues that Europe’s ‘universal consciousness’ has crossed the boundary around Europe and has become not just a ‘matter of attitude’ but ‘a structural element of our cultural practice, which is also embedded in both theory and institutional and pedagogical practices’ (Braidotti, 2013, p. 15). Consequently, it is not enough to argue for a more ‘multicultural’ approach to science (and school education) without comprehensively examining the epistemological foundations of a Euro-Western entanglement in the constitution of science.

Although not all aspects of Euro-Western hegemony are necessarily negative, or can be understood as a concrete set of characteristics, a lack of epistemological interrogation insinuates an acceptance of the status-quo of Euro-Western dominance, to the detriment of all that might be considered ‘Other’. As Harding argues:

we need a more complex understanding of how the development of Western sciences and models of knowledge are embedded in and have advanced the development of Western society and culture but have also led to the simultaneous de-development and continual re-creation of “others”—Third world peoples, women, the poor, nature (Harding, 1991, p. ix).

The quote at the beginning of this section, by Donna Haraway, adds to this entanglement the progress of capitalism and a concern about the appropriation of nature. Euro-Western hegemony in science is thus not just the acknowledgement that Euro-Western culture(s) permeate science but this entanglement is of great concern in relation to inequality, justice, and the ‘environment’.

Entangled with this conception of Euro-Western and masculinist hegemony is also ‘humanism’, as broadly defined in this context as ‘human exceptionalism’ or ‘anthropocentrism’. It has come to be especially defined as such in posthumanist frameworks. This form of humanism is understood to be:

either as a charge of human chauvinism, or as an acknowledgement of human ontological boundaries. It is in tension with nature, the environment and nonhuman animals (as well as nonhumans per se) (Boddice, 2011, p. 1).

I recognise that there is tension in any attempt to differentiate between ‘humans’ and other animals, and that the human-nonhuman designation still describes a problematic dualism. I suggest, however, that it is not that there is a clear boundary line between the two, but rather there has long been the pretence of such a line that must therefore be unpacked. We might eventually move to other configurations of animals-including-humans.

Humanism is charged as positioning the human as privileged ‘knower’, as separate from ‘other animals’ and bestowed with a unique intellectual agency. This is represented in the Euro-Western dualisms of nature/culture and mind/body. Additionally, it is not just that humans are positioned as privileged ‘knowers’ and agentic actors but that the development of our science and technology has been skewed towards the primary benefits of humanity, to the detriment of those made and re-made as ‘Others’. Science and technology, from this perspective of humanity’s primacy, is the result of ‘rational’ progress, wherein it makes no sense to critically question the ‘why’, ‘how’, or overall outcomes of such a momentum. In Euro-Western humanism, humans are at the top of all hierarchies:

That iconic image is the emblem of Humanism as a doctrine that combines the bio-logical, discursive and moral expansion of human

capabilities into an idea of teleologically ordained, rational progress. Faith in the unique, self-regulating and intrinsically moral powers of human reason forms an integral part of this high-humanistic creed (Braidotti, 2013, p. 13).

While concern over humanity's impact on the world is hardly new, there are several issues that have propelled the critique of both Euro-Western hegemony and particularly Euro-Western humanism. For instance, climate change represents a crucial apex, in response to which humanity must ultimately decide how we see ourselves through the mirror-prism of 'rational' scientific and technological development that disregards consequences for the world.

---

#### RECENT EDUCATION LITERATURE

Research that contains a challenge to Euro-Western hegemony in school science comes from an array of different strands in the field. These multiple strands differ in the problem they identify and the approaches taken. They are consequently too diverse to summarise all in detail. Instead, I present some of the main strands as those most relevant to this study. The first strand is the research focussed on race-ethnic equity but is more epistemologically focussed, such as concerning the arguments about universalist versus multicultural ways-of-knowing in science education (e.g. Bang & Medin, 2010; L. Carter, 2010; Irzik, 2001; Lewis & Aikenhead, 2001).

A second strand proposes to be a middle ground and employs the idea of 'hybridity' or 'third space' to bring together Euro-Western science with students' diverse backgrounds and ways-of-knowing (e.g. Adams, Luitel, Afonso & P.C Taylor, 2008; Glasson, Mhango, Phiri & Lanier, 2010; McKinley & Gan, 2014; Quigley, 2011). A third strand is predominantly focussed on indigenous students, either for general equity concerns and/or including an epistemological focus around indigenous ways-of-knowing (e.g. El-Hani & Souza De Ferreira Bandeira, 2008; Glasson, Frykholm, Mhango & Phiri, 2006; Michie, 2002).

Lastly, a slight divergence of research is a fourth strand marked by the rise of ‘environmental/sustainability’ education, some of which includes a critique of Euro-Western hegemony in science, and some that presents indigenous ways-of-knowing as an alternative (e.g. Somerville, 2014; Snively and Corsiglia, 2001).

I argue that research that advocates a ‘third/hybrid’ space does not go far enough to address the broader concerns. Specifically, such research may be limited by not considering balances of power, especially in the sense of acknowledging Euro-Western hegemony. I agree that discussions concerning multiculturalism generally is important. However, I identify the research that includes special consideration of indigenous ways-of-knowing as more aligned with considerations of ethics. Consequently, I identify the last two strands in this research area as most useful for this study. That is, research that both incorporates a critical focus on epistemology and Euro-Western hegemony, along with indigenous ways-of-knowing.

Before going further, however, I first acknowledge that ‘indigenous’ is a contested term. To the best of my knowledge, there is no term that is uncontested in referring to indigenous peoples, who might elsewhere be described in various ways, such as aboriginal, tribal, first nations, or original custodians. In a similar sense to how I use ‘Euro-Western’, I use the term ‘indigenous’ while acknowledging that it is a fragile shorthand way to refer to highly diverse and complex groups of people. I recognise that this is not a comprehensive description and that culturally-based ways-of-knowing are porous and dynamic, with as many similarities as differences. Consequently, I do not characterise Indigenous ways-of-knowing and Euro-Western ways-of-knowing as completely separate.

It is noteworthy that much literature in this strand of research is North American based. Indeed, one of the most widely cited authors around multicultural/indigenous science education is Glen Aikenhead, a Canadian researcher. He has been involved in, and spearheaded

much of, this field of research since its beginning days in the early 1990s. While things may be changing, it is a concern that these conversations are dominated by Euro-Western researchers.

In Australia, this area of research is very small, particularly in comparison to the whole of school education and science research. It is smaller again if narrowed down to epistemological interrogations of Australian Indigenous cultures/knowledge in relation to science education. A few examples, however, include the projects *Indigenous Knowledge and Science Pedagogy: A Comparative Approach* (Nash, 2009), *Indigenous Engagement with Science: Towards Deeper Understandings* (Expert Working Group, 2012) and *Living Knowledge: Indigenous Knowledge in Science Education* (Living Knowledge, 2008). Despite my attempts to do so, I was not able to find literature in this area led by Indigenous researchers. However, I did find Indigenous-led studies concerning Indigenous ways-of-knowing more broadly (e.g. B. Martin, 2013; Nakata, 2010; Whap, 2001; and Yunupingu & Muller, 2009). These studies outline some characteristics such as the concepts of 'Country', 'living knowledge', and concerning 'one's identity of 'belonging' to a specific country, land, sea, wind, people, sky and how these areas interrelate or interconnect' (Whap, 2001, p. 23).

Within the indigenous-focussed literature, one of the main critiques of Euro-Western science is its (would-be) universalist and 'objective' characteristic: 'In science, myths such as science is value free, culturally neutral, and an exclusively European/North American enterprise are still prevalent' (Mujawamariya, Hujaleh & Lima-Kerckhoff, 2014, p. 273). That is, Euro-Western science in education, within Euro-Western countries, silences/marginalises its multicultural history and at the same time devalues alternative ways-of-knowing. The 'presumed objectivity and universalism of Western science rationalizes our failure to acknowledge other ways of knowing' (Brayboy & Castagno, 2008, p. 739).

In similarity to feminist arguments about masculinist hegemony, researchers in this field also argue a characteristic of Euro-Western science is the Cartesian dualisms, including nature/culture, mind/body: ‘This foundational presupposition bifurcates existence into two substances: matter and mind. They are distinct, independent, and non-interacting’ (Aikenhead & Ogawa, 2007, p. 549). In other words, the argument is that because nature and culture, as well as mind and body, are split, this enacts hierarchies (mind over body and culture over nature). This is also considered erroneous because such aspects of the world are not actually possible to separate. For example, there can be no culture without nature.

In line with this, it is argued that a Euro-Western science education advocates the view that ‘nature’, as a distinct entity, is knowable and that the main goal of science is to accumulate knowledge about nature (Aikenhead & Ogawa, 2007, p. 547) while maintaining a separation between ‘knower’ and what is known. These claims lead into the arguments about Euro-Western science’s humanist prerogatives; that is, the intrinsic anthropocentrism enacts a false split between humanity with ‘the rest’ of nature.

One of the major issues in literature about cultural implications in school science is a lack of diversity in methodological approaches in this field; much of which has been quantitative and constructivist (E.C. Parsons, 2014, p. 180). However, one example highlights that while posthumanism has its own unique emphasis there is a high degree of complementarity between posthumanism and the above approaches. This is the chapter ‘Decolonizing School Science: Pedagogically Enacting Agential Literacy and Ecologies of Relationships’ by Marc Higgins (Higgins, 2016).

Higgins utilises Karen Barad’s agential realist theory, and posthumanism, to challenge Euro-Western science education’s marginalisation of alternative ways-of-knowing. He argues that a goal of science education is to think/ behave like a scientist, but that this imagining of

‘scientist’ ‘is emblematic of the masculine, Eurocentric and anthropocentric subject of humanism that is presented through Western modern humanistic modes (e.g., representationalism, universalism, nature/culture divide)’ (Higgins, 2016, p. 186). Higgins utilises Barad’s theory and posthumanism mainly to bring together knowing and being and by arguing that ‘learning is always a relational process’ (Higgins, 2016, p. 188).

Other examples of similar developments include the project ‘Thinking through Country’ outlined in Somerville (2014) and Somerville & Green (2015), as well as the studies ‘Indigenous More-Than-Humanisms: Relational Ethics with the Hurunui River in Aotearoa New Zealand’ (Thomas, 2015) and ‘Transgressions of the Man on the Moon: Climate Change, Indigenous Expertise, and the Posthumanist Ethics of Place and Space’ (Watson & Huntington, 2014). This shows promise towards developing space for renewed thinking in this area, as well as more of an emphasis on Euro-Western humanist hegemony. However, there is very little yet in the field of school education.

There are several issues for researchers to contend with regarding these various arguments. The first is a strong caution against enacting a false dichotomy between Euro-Western science and other ways-of-knowing (Aikenhead & Michell, 2011, p. 33). This would miss a closer interrogation of Euro-Western *sciences* as diverse, dynamic, and multicultural, as well as the many crossovers and similarities in all ways-of-knowing. Secondly, it is also important not to romanticise alternatives to Euro-Western sciences (Adams et al., 2008) and to focus instead on diverse epistemologies that are continually becoming in their entanglements with each other and power-knowledge fluxes. With this in mind, the next section is a closer examination of how ethics has been defined and interrogated in research around science and education.

---

## ETHICAL CONCERNS

---

...ethical concerns are not simply supplemental to the practice of science but an integral part of it.

—(Barad, 2007, p. 37)

---

‘Ethics’ is a difficult concept to characterise definitively, as it morphs shape depending on cultural, disciplinary, historical, and religion/non-religion implications. As another term for ‘moral philosophy’, which is what is most commonly linked to Euro-Western education, ethics has been predominantly understood as a way to ‘formulate guidelines or norms for our actions and behavior’ (Fløistad, 2014, p. 1).

In philosophy, ethics is also split into different ‘kinds’, such as applied and metaethics, where ‘applied’ refers to ‘practical’ approaches, while ‘metaethics’ asks how we determine what is right or wrong in the first place. These approaches analyse what we base ethics on, typically through processes of ‘reason’, how to determine ‘moral standards’ of right or wrong conduct, as well as how to apply ethics to specific issues, such as climate change and animal rights (Fieser, n.d.).

Ethics in science that goes beyond scientific methods has been developed in the philosophy of science but has also been examined by other theory. This other theory includes the philosophy of education, cultural/sociological studies of science/education, and feminist theory. In the following section, I therefore bring together the previous arguments concerning the nature of science, the entangled phenomena of gender-sex/masculinity and Euro-Western humanism, into a more detailed examination of the consequent relationship with ethics. I focus on Barad’s theory especially, for providing renewed thinking about conceptions of ethics in science. For example, Barad’s arguments consider an understanding of science as *inherently*

related, on all levels, to ethics. Furthermore, ethics is redefined as relational and posthumanist. More on this will be discussed in the following chapter.

---

## RECENT EDUCATION LITERATURE

There is current research that brings together science, ethics, and school education by employing a critical or feminist perspective, which focusses on values, justice, and/or ‘socially responsible’ science. This work may or may not draw from the philosophy of science. However, most recent research in science and education that centralises ethics is the Socioscientific Issues (SSI) stream, as mentioned at the beginning of this chapter. I focus on this stream not just because it is popular but because it also relates more strongly to this study, in the sense of bringing together the entangled relationship between science, society, and ethics in school education. To date, I have found no other studies that have taken up Barad’s, and others’, feminist/new materialist or posthumanist frameworks to specifically assess *ethics* in science and school education.

Research publications about socioscientific issues highlight this stream as; ‘situating social and ethical issues in science education’ (Zeidler & Sadler, 2008, p. 800). Researchers typically highlight the importance of students’ ethical development, how SSI might better connect students to school science, as well as illustrating the necessity of acknowledging students’ cultural background, identities, and personally-based values in coming to ethical reasoning (Zeidler, Herman, Ruzek, Linder & Lin, 2013, p. 252).

Some studies also tend to promote not just the general good of ethics in education about science but how this might pave the way for students to become better ‘global citizens’ who are ‘sensitive and compassionate about moral and ethical aspects of the SSI, and who are concerned about ramifications of those issues in relation to broader ecological systems’ (Lee et al., 2013, p. 2081). Therefore, SSI is promoted to develop a better ‘compassionate’ society made up of people

who are concerned about the development of science and technology directed towards the ongoing sustainability of ecosystems and living beings.

However, SSI research does not often define ethics itself (let alone focus on ethics and epistemology or ontology) except to define what ethical questions might be asked. For instance, questions include: ‘How ought science and society interact?’ and ‘How ought science be conducted?’ (Zeidler & Sadler, 2008, p. 802). Another possible limitation of this research is that a focus on specific ‘ethical issues’ may reduce thinking about ethics and science in school education down to particular scenarios, rather than a more fundamental relationship between ethics and ‘onto-epistemologies’.

Lastly, because this stream often marks some separation of SSI to ‘normal’ science, it is also in danger of being marginalised against what is considered the masculinist (and, I would argue, Euro-Western) ‘core, factual knowledge’ in school education about science. As Hughes contends: ‘Socioscientific content is gendered through association with social concerns and epistemological uncertainty, and because gender is asymmetric, socioscience is devalued with respect to the masculinity of abstract science’ (Hughes, 2000, p. 246). This consideration is extended in chapters 4 and 6.

---

#### SPECULATIVELY MOVING BEYOND ‘SCIENCE’

---

While facts can persuade us, sometimes emotions and shared experience can persuade us more efficiently. However, even if we wish to work for change, we cannot move in directions we do not see. We cannot work for a future we have not imagined.

—(Jakober, 2008, p. 30)

---

Most research in science and school education is, unsurprisingly, focussed on science as a distinct discipline and is conducted by researchers with a background in science and school

education. However, as mentioned in the introduction, my research strategy is about attempting to open boundaries in the sense of bringing in aspects outside of ‘science education’ to the science-ethics nexus in school education. To this end, I have included my own speculative fiction short story as a creative research practice. Additionally, I have included a broader analysis of possibilities between the science-ethics nexus in school education and the utilisation of speculative fiction, which makes up part of Chapter 6. Therefore, in this section, I cover literature that defines speculative fiction and recent school education research that includes this topic.

---

## SPECULATIVE FICTION

Defining fiction genres has never been easy but ‘speculative fiction’ poses its own unique challenges. For a start, there are fervent contentions over how it is or is not different from ‘science fiction’, fantasy, and other genres. Speculative fiction is sometimes used as a broad mega-genre, that encompasses science fiction, fantasy, and horror. Conversely, how I use the term is in similarity to ‘science fiction’, albeit with a specific emphasis on the development of *recognisable* science and technology. This is similar to the reason as to why and how Margaret Atwood defines this genre; as about ‘things that really could happen but just hadn’t completely happened when the authors wrote’ (Atwood, 2011, p. 6). In other words, it is about examining what is possible in relation to science and technology, considering the world as it is now and what we currently ‘know’. Of course, what is defined as ‘real’ and ‘possible’ is nebulous but as Brian Attebry argues, genres should be defined by their ‘fuzzy’ centre rather than by strict boundary lines (Attebry, 1992, p. 12).

Understanding speculative fiction in this way is therefore relatable to posthumanism and ethics, by imaginatively speculating about the ethical development of science and technology that is considered at least feasible. Science fiction can also contain ethical considerations but speculative fiction might be considered fiction that does so in a specific

‘realist’ manner. So, whereas ‘science fiction’ might encapsulate fiction that has a primary focus on science and technology, the term ‘speculative fiction’ has a more specific intention: to *speculate* on what might come to be, from what already is, and to raise ethical questions. Still, if we keep in mind ‘fuzzy centres’ rather than boundary lines, as Attebry argues, then the two terms should not be thought of as entirely separate.

The potential power of speculative fiction to ethically scrutinise the becoming of science and technology in ways that non-fictional accounts might not, as well as its potential to enact social change, is considered by various theorists. For example, Mark Bould and Rhys Williams, in *SF Now*, argue that:

[the] political power of sf—its “cognitive estrangement,” [...]—comes at least partly from its presentation of a system, a structure, and its articulation of alternative social, political and cultural possibilities [and that the] radical power of the genre shouts with one voice—*these are human constructions, material and ideal, and things could be otherwise, could be made to be otherwise* (Bould & Williams, 2011, p. 8, original emphasis).

While speculative fiction adheres to ‘realism’, theorists argue that it too employs the power of cognitive estrangement. The difference being that this estrangement comes about by the portrayals of what might be, or what could be, or even what might have been, in relation to science and technology. As Darko Suvin, one of the most well-known speculative fiction analysts, writes:

In the twentieth century speculative fiction has moved into the sphere of anthropological and cosmological thought, becoming a diagnosis, a

warning, a call to understanding and action and—most important—a mapping of possible alternatives (Suvin, 2005, p. 30).

Accordingly, many describe speculative fiction as important for asking the ‘big questions’, particularly regarding the world’s development in relation to science and technology. For instance, James Gunn, in *Speculations on Speculation: Theories of Science Fiction*, contends that speculative fiction is ‘the literature of change, the literature of anticipation, the literature of the human species, the literature of speculation’ (Gunn, 2005, p. xi). However, this does not mean that this genre leads naturally to presenting such questions critically and with nuance, but rather because of its nature it certainly holds the potential to do so.

There is an emerging connection being made between science fiction, speculative fiction, and posthumanism<sup>13</sup>, outlining the multiple complementary characteristics. For example, Elana Gomel argues that:

While the question of posthuman ethics is debated across many discursive and institutional sites, its most privileged arena is science fiction (SF). Not only does SF vividly dramatize the implications and consequences of new technologies and new discoveries, it is also a powerful influence upon culture, creating a feedback loop of images and ideas (Gomel, 2011, p. 340).

Similar ideas can be seen in Suzuki (2008), Ruzek (2010), Wallace (2010), and Pordzik (2012). These beginning developments help pave the way for further thought, not only as to how a

---

<sup>13</sup> Although, use of the term ‘posthuman’ can be misleading in this research, as it can often refer to theory about enhancing the human body, rather than the critical framework.

relationship between posthumanism and speculative fiction might be valuable but also for thinking about speculative fiction as a potential tool for strengthening the science-ethics nexus in school education.

---

## RECENT EDUCATION LITERATURE

There is a growing area of research that broadly looks at the benefits of developing transdisciplinary connections in school education. For example, John Cartwright's 'Science and Literature: Towards a Conceptual Framework' examines the broad benefits between science and literature, describing this field as currently seeking 'to do more than just document the impact of science on literature and regard the boundaries of both as highly permeable' (Cartwright, 2007, p. 115). There is also various work that examines the crossovers between science and *science fiction*. A recent example is Barry Luokkala's *Exploring Science Through Science Fiction* (Luokkala, 2014). To the date of writing, however, I have found no recent school education research that examines the specific utilisation of speculative/science fiction as a technique to explore *ethics* and science.

Most of the current school education literature around utilisation of speculative/science fiction is, first, much more about its use for making science education more relevant and engaging for students. For example, 'Reaching Nonscience Students Through Science Fiction' (Smith, 2009). Other research is about facilitating students' understanding of scientific knowledge by analysing representations in fiction. For example, 'Science Fiction and Scientific Literacy' (Czerneda, 2006) and 'The Role of Narrative in Communicating Science' (Avraamidou & Osborne, 2009). Some also combine both streams, such as the report 'Science Fiction in Education: Case Studies from Classroom Implementations' (Vrasidas, Avraamidou, Theodoridou, Themistokleous & Panaou, 2015).

Overall, school education literature around using any kind of fiction to develop specific understanding of ethics is very small. Research in science and school education that utilises creative research practices, let alone speculative or science fiction creative practice, to the best of my examination is also quite limited. Consequently, there is ample opportunity here for further thought and attention as to the imaginative possibilities for speculative/science fiction and the science-ethics nexus in school education. For instance, possible questions include: how might speculative fiction offer renewed ways for teachers and students to engage with ethics? What can the material/ontological/posthumanist turn in theory offer for making links between speculative fiction and a posthumanist ethics? I respond to these questions in the following chapters.

---

## CONCLUDING THOUGHTS

It is a strength of research that it builds on previous work done and therefore tests ideas out and stretches their potentials. However, it is also a strength of research to allow for ‘breaks’ in certain areas, which establish new pathways and provoke renewed thinking about how we conceptualise issues and what tools we bring into play to address those issues. In this literature review, my aim was to mark out a generative pathway through an expansive body of research and theory that is connected to science, ethics, and school education.

In the interest of working from the foundational blocks, I have focussed on critical epistemological perspectives on how science is constituted, with considerations of masculinist and Euro-Western humanist hegemony. I then also included how these arguments also relate to how ethics is constituted within science. Lastly, following my intention to stretch thinking for this area, I covered some work conducted around defining speculative fiction, and utilisations of fiction in school education, towards the idea of writing and analysing speculative fiction as a unique approach to addressing the science-ethics nexus.

I outlined some gaps in this research by highlighting, first, the promising work done by those using feminist materialisms in education research that examines gender-sex, which provides an avenue towards renewed thinking in this area. This includes Ivinson and Renold's (2013) and Gannon's (2016) studies of girls' bodies, environments, materialities, and agencies. Thus far, however, to my best assessments, researchers using feminist materialisms or posthumanism have not yet focussed on epistemological constitutions of school education, let alone the science-ethics nexus.

Additionally, most education research that does have a focus on ethics and potential Euro-Western/humanist analyses do not interrogate the epistemological entanglements behind how ethics is defined. Nor does this research yet utilise posthumanism. Lastly, there is no other current research, to my knowledge, that combines an epistemological analytical focus on the science-ethics nexus in school education, with equal attention paid to both masculinist *and* Euro-Western humanism. Nor is there much research in education that utilises the potential relationship between posthumanism and speculative fiction.

Although there always must be caution in attempting to define a global 'crisis' of any kind, there is no denying the overwhelming evidence that we are in a period that is crucial regarding how we, as humans, position ourselves. While other questions in education research, such as matters of gender, class, and race, should not be reduced in importance, questions around what role education plays, or could play, in terms of addressing this question has already begun to rise in importance in many areas. However, as I outlined in this chapter, there are still many gaps in this research. This is particularly so for epistemological considerations, more attention paid to relationality, as well as exploring alternative frameworks to bring about renewed thinking.

CHAPTER 2: POSTHUMANIST PROVOCATIONS

---

...new materialist/posthuman(ist) engagements with primary differentiability as ethico-onto-epistemological relationality show another kind of responsibility ‘at the table’ of our theoreticopolitical practices.

—(Thiele, 2014, p. 22)

---

How do we conceptualise the world and ourselves in the 21<sup>st</sup> century? What role should science and technology have? Who or what on the planet has a prevailing right to existence? How should these issues be addressed in school education? These are not new problems but the concept of new materialist/posthumanist ‘relationality’, as Kathryn Thiele suggests in the quote above, brings a renewed conception of responsibility and ethics to such questions. It is the concept of relationality that forms the basis of the theoretical framework that I call ‘relational posthumanism’, which I utilise for this study.

To engage with theory, it is necessary to acknowledge that theory is always political. It is also praxis; theory is entangled in the becoming of a research endeavour and the becoming of the world. Thus, the choice of theoretical framework for research is of critical importance, not just for the topics under examination but for what research might bring about.

This chapter identifies the main characteristics of relational posthumanism. I use this term to highlight the various crossovers between new/feminist materialisms and posthumanist thought, particularly drawing on the ideas of Karen Barad, Donna Haraway, and Rosi Braidotti. This term is also to narrow in on *relationality* as a primary principle behind the material/ontological/posthumanist turn. Relational posthumanism is an integral part of my research; it has not just guided my analyses but has shaped this study from the beginning. Furthermore, this framework has offered more than a critical perspective but, in companionship with speculative fiction, alternative possibilities for the science-ethics nexus in Australian secondary school education.

In the early stages of my study, I was interested in researching gender, and later gender and science education. I was then introduced to Karen Barad's work, which inspired me to think about ethics as related to this topic. A snowball effect consequently occurred, as I drew inspiration from other similar theorists, such as Donna Haraway, and began to glimpse the value of a specific focus on the science-ethics nexus in school education. Furthermore, I began to identify an alternative perspective that relational posthumanism offers this area.

While broad concerns about how 'gender' is constituted in society interested me from the beginning, feminist materialisms and posthumanism led me to ask questions about gender-sex and the epistemological constitution of ethics in school education. For instance, how does conceptualising gender-sex as 'onto-epistemological' help understand the development and constitution of the science-ethics nexus as involving more than 'discourse'? These questions also led me to consider phenomena other than gender-sex involved in this constitution, such as Euro-Western hegemony.

Relational posthumanism was made even more apparent as a suitable framework considering feminist materialist and posthumanist questions about how ethics is understood. This is especially so for the relationship of ethics to the development of science and technology, as well as ecological concerns. Consequently, it became evident that not only is this framework well-suited to addressing these complex interrelated issues about epistemology, ontology, ethics, and scientific and technological development, but they make doing so an ethical imperative. Relational posthumanism offers renewed thinking in this area broadly, but also specifically for contextualising these issues in school education.

This chapter is divided into three sections. In the first section, I briefly cover the history of the material/ontological/posthumanist turn and its significance. The second section describes the major conceptual shifts that inspire my understanding of relational

posthumanism and what these offer in researching the ‘science-ethics nexus’ in education. In ‘Connecting theory with research’, I outline how relational posthumanism is utilised in my study, from its early inspirations, through to guiding both my empirical and conceptual work. This section includes how this framework has guided my data analysis. This last section, overall, sets up the conceptual foundations for how my research has developed as well as the specific approaches I have taken to engaging with data. Chapter 3 extends upon these foundations in more detail.

---

### THE ‘MATERIAL/ONTOLOGICAL/POSTHUMANIST TURN’

The emerging development of what has often been referred to as the ‘material/ontological/posthumanist turn’ is often situated in contrast with the supposed ‘discursive/cultural/linguistic turn’. It is argued that this change in emphasis has significant relevance for the reality of the 21<sup>st</sup> century world. As Diana Coole and Samantha Frost put it:

[T]he so-called cultural turns [are] increasingly being deemed inadequate for understanding contemporary society. Particularly in light of some of its more urgent challenges regarding environmental, demographic, geopolitical, and economic change (Coole & Frost, 2010, p. 3).

The emergence of a ‘new’ form of materialism has arisen in the last two decades or so and continues to grow in popularity in various research fields. ‘New’ feminist materialisms are more often situated against or ‘through’ frameworks such as (feminist) poststructuralism, social constructionism and deconstructionism rather than ‘older materialism’<sup>14</sup>. Coole and Frost argue

---

<sup>14</sup> ‘Older’ materialism is commonly understood as the materialism heavily influenced by French theorist Christine Delphy, whose focus generally is on the material conditions of inequalities and oppression.

that this ‘older’ materialism was eclipsed by important challenges by poststructuralism or ‘radical constructivism’ (Coole & Frost, 2010, p. 3). Consequently, these ‘new’ feminist materialisms are not a revitalisation of this ‘older’ materialism, which faced strong critiques, but rather it is a reappraisal of matter using poststructuralist, and/or constructivist, insights. The term ‘new materialism’ is attributed to Manuel DeLanda and Rosi Braidotti, who first used it in 1990 (Dolphijn & van der Tuin, 2013, p. 48). Meanwhile, use of the term ‘posthumanism’, as a philosophical theme of the new materialisms, or a framework, has risen in popularity during the same period, from around the mid-1990s (C. Wolfe, 2010, p. xii).

There are of course many incarnations of feminist materialism; hence it is more appropriate to speak of feminist ‘materialisms’. Posthumanism also has various manifestations. I utilise ‘posthumanism’ to mean essentially ‘critical posthumanism’, which marks it as different to posthuman/transhuman studies concerning the union between the ‘human’ and technology, or ‘human enhancement’. Those using critical posthumanism tend to be highly critical of the ‘transhumanist’ developments. For example, Braidotti argues that ‘transhumanist enhancement [is] a firm reiteration of enlightenment-based values such as rationality and liberal individualism’ (Braidotti, 2016, p. 17). However, due to their various crossovers in interests, it may be impossible to definitively draw a line between the two areas of thought (Islam, 2016, p. 116). In all, as a tentative general description, these theory developments are argued to renew humanist, modernist, and poststructuralist positions about nature/culture and discourse/matter by ‘traversing’ such dualisms, avoiding ‘representationalism’, conceptualising the agency of matter, and placing critical emphasis on human exceptionalism or ‘anthropocentrism’.

The emergence of feminist materialist and posthumanist theories has not been without contestation. Exchanges between Sara Ahmed (2008), Nikki Sullivan (2012), Noela Davis (2014), and Myra Hird (2004) are illustrative of one of the major contentions. This is the argument that

alternatively points at feminist, social constructionist, and/or poststructuralist theories as largely ignoring or paying little attention to biology and matter, and the assertion that the ‘material/ontological/posthumanist turn’ has therefore arrived to rectify this so-called lapse of culture/discourse-centric analyses. On the opposing side, many, such as Ahmed, rebuff this as an erroneous or inflated argument.

The most contentious issue, and biggest challenge to face, for the broad material/ontological/posthumanist turn may be this issue regarding how these frameworks are figured in themselves and how they are, or are not, related to other frameworks; i.e. are they truly ‘post’ or ‘new’? Many proponents of these frameworks can be inconsistent in framing them and lack specific critical attention to its limitations. Some do, however, note how challenging it is to think outside of entrenched humanist boundaries. For instance, Patti Lather and Elizabeth St. Pierre note how difficult it is to conceptualise how posthumanism works or does not work within ‘categories of humanist qualitative research’ (Lather & St. Pierre, 2013, p. 630).

I would add to this that more work is necessary in developing the details of the major arguments. For example, there is a possible missing or confused link between posthumanist and feminist materialist manoeuvring of ethical imperatives of things like ‘justice’ and ‘sustainability’. It might not be yet entirely clear why and how we conceptualise these as a goal via the perspective of these frameworks. A question I have not yet seen adequately answered is how and why it is considered ‘good’ to enable ‘a sustainable livable world for mutual flourishing’ (Barad in Juelskjær & Schwennesen, 2012, p. 16). I also do not propose that in engaging with this ethical imperative that I am able to answer this question.

Additionally, as previously noted, it has been argued that these frameworks largely operate within Euro-Western boundaries, yet often researchers and theorists do not focus on this: ‘posthumanism is silent about location’ (Hinton, Mehrabi & Barla, 2015, p. 12). Juanita

Sundberg goes further in arguing that posthumanist engagements, at least in her field of geography, ‘tend to reproduce colonial ways of knowing and being by enacting universalizing claims and, consequently, further subordinating other ontologies’ (Sundberg, 2014, p. 34).

It seems probable that as these are emerging frameworks, both feminist materialisms, and posthumanism are still in the early stages of development. Further, like all theoretical frameworks, there will be internal differences and contradictions. This, however, I see only as an argument for more thought rather than a rejection. For instance, if or how feminist materialisms and posthumanist are ‘new’ or ‘post’ might be beside the point; the more useful question to ask might be: are these frameworks *provocative*? Do they entail alternative, productive ways to think about issues and to do research in today’s world? If these frameworks are understood as potentially revitalising tools of thought, rather than presented as ‘the answer’, then there are surely many useful avenues of examination.

To date, feminist materialist and posthumanist frameworks have not yet been much utilised in science and school education research. However, as I begin to highlight in this chapter, the questions and alternative ideas of these frameworks are very relevant to science and school education concerns, particularly regarding (re)defining and (re)situating ethics. These frameworks, overall, provoke alternative questions about not only the values in education but how particular phenomena, such as gender-sex and Euro-Western culture, are involved in the constitution of the science-ethics nexus, in a way that considers more than ‘discourse’ and challenges anthropocentrism.

---

## DEFINING POSTHUMANISM

In this section, I pinpoint the major ideas from the work of Karen Barad, Donna Haraway, Rosi Braidotti, and related others, which make up my understanding of relational posthumanism. I also specifically outline what these ideas have offered this study. I contend

that this framework proposes an alternative in how ethics is thought about in relation to science and school education, firstly by re-situating the human away from the centre of the world, and from the centre of theory. This framework also understands the world and knowledge differently; as *relational*.

Karen Barad's 'agential realism' theory has been identified as a form of new/feminist materialism and she is often referred to as a major representative of this framework. With a background in physics and feminist theory, Barad states she developed some of her ideas as a result of her analysis of physicist Niels Bohr's work (Barad, 2007, p. 23). This was mainly as an answer to the question of what quantum physics might offer our understanding of the nature of the world but also to rethink agency, science, and ethics. Much of Barad's work particularly corroborates or extends many others', including the work of Donna Haraway.

Donna Haraway is also recognised as a leading feminist theorist with a scientific background; in her case in biology. Her early work was a critique of objectivity in science by looking particularly at the field of primatology. She then went on to write 'A Manifesto for Cyborgs' (Haraway, 1987), in which she questions how the increasing development of technology might have the potential to disrupt normative dichotomies of, for instance, nature/culture and female/male. This work was followed by 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective' (Haraway, 1988), an argument for a different way of thinking about subjectivity and objectivity, more of which will be discussed below.

Haraway's most recent work, including *Staying with the Trouble: Making Kin in the Chthulucene* (Haraway, 2016), involves reflections on human-nonhuman relationships and living and dying together. Many ideas and concepts in Haraway's work resonate with feminist

materialisms and posthumanism, such as her concept of the ‘material-semiotic’ and her work in questioning human-nonhuman entanglements.

Rosi Braidotti’s *The Posthuman* (Braidotti, 2013) also inspires my theoretical framework. In this work, Braidotti describes ‘posthuman theory’ as:

a generative tool to help us re-think the basic unit of reference for the human in the bio-genetic age known as the “anthropocene”, the historical moment when the Human has become a geological force capable of affecting all life on this planet (Braidotti, 2013, p. 5).

Braidotti provides a critical examination of humanism and its (‘Eurocentric’) history, a revitalised proposal for understanding subjectivity, and how these relate to critical race, gender, and environmental areas of study towards the sustainability of the world.

The reason I use the term ‘relational posthumanism’ instead of ‘new/feminist materialism/posthumanism’ is because I argue it better describes what I see as the foundational concept of these related frameworks; that is, that the world is *relationally* material-discursive. It is not about privileging discourse, nor about privileging matter, but acknowledging the two as always already interwoven. This term also incorporates Barad’s ‘intra-actions’; she argues that there is never any existing ‘thing’ that then relates to some other pre-existing ‘thing’, rather entities become via their relationality. I acknowledge ‘posthumanism’ is not an ideal term, as it can be confused with the branch of theory dedicated to human enhancement. There is also an ongoing contested proliferation of ‘post’ in theory work, which means that ‘post’ has almost become meaningless. Nonetheless, it is a term growing in popularity and is used around similar questions and concepts, so its use concerns some consistency.

Various theorists in this theoretical space often use the term ‘relational’ to discuss interactions, material-discursive entanglements, and more. For example, Rick Dolphijn and Iris van der Tuin argue for a ‘positive relationality’, particularly regarding sexual difference. However, this idea can be applied to *all* difference; ‘univocity pushes difference to the limit, producing a shift to an affirmative relationality’ (Dolphijn & van der Tuin, 2011, p. 396). Braidotti discusses the ‘relational subject’ (Braidotti, 2013, p. 26). Thiele, following Barad, as noted at the beginning of this chapter, describes ‘ethico-onto-epistemological relationality’ (Thiele, 2014, p. 22). Indeed, Barad states that a ‘relational ontology is the basis for my posthumanist performative account of material bodies (both human and nonhuman)’ (Barad, 2007, p. 139).

However, I argue relationality should be at the forefront of discussions around these frameworks. This is not just to understand the world’s ‘becoming’ but as an ethical imperative towards understanding a becoming of the world in which everything comes to be via an intrinsic relationality. In this case, all entities are connected and all entities are implicated.

Relationality, therefore, is a crucial concept in considerations around society, science, technology, education, and ethics. Acknowledging fundamental relationality means first acknowledging that these topics or areas do not pre-exist each other. Instead, they come to be via their relationality. I begin to examine this shift in thinking in Chapter 4 by considering how science, society, and school education are often treated as separate entities, as well as what effects this has on school education in Australia. This is followed up in Chapter 6, wherein I present an alternative conception of science, society, and school education as inherently relational, as well as the significance of this conceptualisation for the science-ethics nexus in school education.

Barad’s argument that ethics, knowledge, and being are inseparable has diffused effects and consequences on a great lot of theory and thinking. In a relational sense, Barad’s ‘ethico-

onto-epistemology' highlights the inseparability between ethics, being, and knowing, but also emphasises the necessity of acknowledging ethics in the folds of the world's becoming. Ethics can no longer be an abstract concept, something that can be discussed or not in considerations of knowing-being. Instead, ethics is redefined as a core element of knowing-being and becomes primary and crucial.

Furthermore, 'knowing-being' reflects the understanding of the world as material-discursive and is also posthumanist by dismissing human 'knowingness' as exceptional. My understanding of relational posthumanism draws on 'discursive' theory, such as poststructuralism, that understands the power of discourse in processes of knowing-being. However, my understanding of relational posthumanism is that it, as Barad argues, makes matter *matter*:

Matter is neither fixed and given nor the mere end result of different processes. Matter is produced and productive, generated and generative. Matter is agentic, not a fixed essence or property of things (Barad, 2007, p. 154).

While this is a generative renewed perspective, how matter is conceptualised as agentic in specific terms is an ongoing process.

Barad's 'posthumanism' involves various concepts offered in difference to a 'humanist' philosophy. Her agential realist theory is posthumanist because of the ways it reassesses subjectivity/objectivity, ethico-onto-epistemology, agency, as well as a reassessment of what can be said about the human perspective and how humans are entangled in the world's becoming. Of course, we cannot escape our 'humanness' and how 'humanness' is understood is also mutable. However, this 'humanness' must be acknowledged as not an abstract positioning, or

an abstract being that is situated outside of the world, but rather it is understood that humans are *of the world*.

Furthermore, as Braidotti points out, the concept of a ‘human’ is not nearly as self-evident as it often appears (Braidotti, 2013, p. 1). The human is rather a porous and dynamic becoming. Barad argues her posthumanism is also about understanding what might be called a porous boundary between ‘human’ and ‘nonhuman’ (Barad, 2003, p. 808). Barad’s, Braidotti’s, and others’ posthumanist arguments call for humbleness, for a change in the dominant attitude that the world revolves around us and that we are special or separate from other life. The perspective on the universe’s configurations, then, must not be and cannot be entirely human-based but instead about acknowledging entangled material-discursive configurations.

Barad most commonly writes of ethics as related to science to mean actual scientific practice, but there are ample evocations in her theory that speak to scientific knowing-being. Indeed, Barad writes broadly about a posthumanist ethical accountability being a part of the world’s ongoing materialisation. Thus, it is a small step to link this with how powerful scientific knowing-being is in this very same becoming. Barad argues that fundamentally, ethics and science are always already entangled together; that ethics cannot be ‘added in’ after the science has already been done. ‘It is not possible to extricate oneself from ethical concerns and correctly discern what science tells us about the world’ (Barad, 2007, p. 37).

Consequently, ethics cannot be ‘added in’ to science in school education, whether that concerns laboratory work, or learning about theory, or learning about scientific and technological development. What specifically a ‘posthumanist ethics’ is lacks some detail in Barad’s, and others’, work. I address this in Chapter 6, wherein I envision what the science-ethics nexus might look like if ‘posthumanist ethics’ is integrated into Australian secondary

school education. In summary, I contend that this is an ethics that is less abstract, more contextualised, and necessarily put to the forefront of school education about science.

Barad's 'ethico-onto-epistemology' shifts the focus from the coherent individual subject who observes and makes meaning and knowledge, to the 'queerness of phenomena' (Barad in Kleinman, 2012, p. 81). This, too, is an ethical shift and a posthumanist shift, which therefore has the potential to be quite significant for the science-ethics nexus in school education. The idea of matter's agency is, understandably, one that is difficult to comprehend based on the dominant perception that 'things' do not 'think' or 'do', wherein agency is understood as referring to the ability *to* think and do. This concept of agentic matter therefore involves a rethink of what agency is and what matter is. Barad argues that agency is a doing, or a process, rather than a 'thing' that can be had, possessed, or given.

An example that begins to demonstrate this idea is Barad's analysis of the 'brittlestar', a living creature that does not have a brain or eyes, and yet evidently still demonstrates this 'doing agency' and 'knowingness' in its ability to respond to its environment. The brittlestar's material-discursive practices and constitution are its ability to react to its environment; changing colour when the light varies and avoiding predators, all without the use of a brain. Its ability to sense/perceive its environment and take 'reasonable' actions, without a brain, is a mutual material-discursive, onto-epistemological becoming. The brittlestar, as something without a brain, is still active; it is matter that is active and agentic, and its 'knowingness' is materialised.

This argument, however, need not stop at creatures without brains. Barad merely uses the brittlestar to begin this thinking, concerning the inseparability between knowing and being, agency as a doing, and agentic matter. In the same chapter on the brittlestar, Barad also mentions the curious nature of atoms as 'open-ended configurations of intra-acting practices' (Barad, 2008, p. 331). Elsewhere, she describes them as 'ultraqueer', referring to the way they are

ultimately indeterminate, with an ever open, unfixed ontology. Therefore, this reassessment of agentic matter does not just refer to animals but to all (known) matter in the universe.

I utilise the concept of ‘ethico-onto-epistemology’ and agentic matter to propose alternative questions concerning science and school education. The most significant question is how ethics, epistemology, and ontology are entangled within the constitution of the science-ethics nexus in Australian school education. For example, in Chapter 5, I utilise this question as an examination of how ethico-onto-epistemologies are enacted in beginning teachers’ understandings of the science-ethics nexus. In other words, I include aspects of their knowing-being as enacting ideas about ethics, acknowledging how their bodies, emotions, identities, the environments they have lived in, and their broad experiences, are all significant aspects of how they understand science and ethics.

Importantly, an ethico-onto-epistemology is not just a different way of conceptualising the world and research problems but is also a different way to think about theory work. Noela Davis, for instance, argues that differences are not absolute, and nor are theories absolute. There is political momentum in ethico-onto-epistemological accounts of the world as continually materialising, as well as the idea of theory as part of a ‘mesh of mutual reconstitution and reconfiguration of the world’ (Davis, 2014, p. 73). I discuss more aspects of how this framework connects with the doing of research in the next section.

An ethico-onto-epistemology also necessarily shifts thinking about subjectivity/objectivity. Theoretical discussions of subjectivity and objectivity demonstrably go to the heart of all forms of philosophy; i.e. how can we know the universe? Can we know the universe as it really is? Who is this ‘we’? In extending feminist epistemologists’ and poststructuralists’ questioning of objectivity, especially as it relates to scientific objectivity

characterised by the ability to obtain pure ‘facts’ about the universe, Barad considers the question of objectivity as an especially ethical one.

Just as Haraway and others do, Barad explains her agential realist objectivity in contrast to a subject who objectively can know the world from afar. This ‘view from nowhere’ understanding of objectivity, as Haraway argues (Haraway, 1988, p. 581), is one that is often associated with traditional scientific accounts of the universe and what is ‘real’ or ‘true’. Consequently, it often also forms part of education about science. As I noted in Chapter 1, rather than being a ‘neutral’ foundation of science, the ‘view from nowhere’ is often characterised as a predominantly masculinist perspective. In other words, characterisations of masculinity are fundamentally linked to this form of understanding objectivity.

Barad additionally argues against what might be considered the opposite of this ‘objectivism’ to be a ‘view from everywhere’, or what might be called extreme ‘relativism’ (Barad, 2008, p. 326). Barad argues that both objectivist and relativist arguments share much in common, i.e. those on both sides assume that scientific knowledge mediates our access to the material world. What they differ on, writes Barad, is the question of referent; objectivists assume a clear relationship between observed ‘objects’ (nature) and knowledge, while relativists argue what we assume are ‘objects’ are in fact inscribed through culture. They are both, then, ‘representationalist’.

The complexities of the arguments about objectivity are more complex than what might be relayed as the extreme sides of both in the way that Barad articulates them. However, her attempt to rethink what is often an argumentative deadlock is provocative, not only in attempting to get outside of this deadlock but also for its potential ethical consequences of this different perspective on how we can know the universe. Once again, this perspective is crucially important for the science-ethics nexus in school education, providing a foundation for

knowledge and for ethics. While Barad does not argue for hypothesising clear-cut observations of the universe, or objective truth, she, like Haraway, does insist that a form of objectivity is possible. Perhaps a better way of putting this is that a validated form of knowing-being is possible. Furthermore, that this proposed new understanding of objectivity, or knowing-beingness, is an inherently *ethical* one.

If we understand matter as agentic, and the world as a material-discursive becoming, Barad argues that the ‘objective referent’ is not the supposedly evident ‘given-ness’ of the world, but rather material-discursive ‘phenomena’ (Barad, 2003, p. 823). Discourse does not ‘produce’ matter but, in an entangled way, a fundamental way, is materialised with matter. In other words, there is no outside or split between observed and observer (the Cartesian cut), rather the two are materialised together.

How is this objectivity or knowingness ethical? Barad’s arguments towards this are perhaps less well explained than others but nonetheless have interesting possibilities, especially in relation to science and scientific knowledge. It is worth repeating here that Barad argues that it is ‘not possible to extricate oneself from ethical concerns and correctly discern what science tells us about the world’ (Barad, 2007, p. 37). In one sense, then, Barad seems intent on abolishing the perceived gap between observers (humans) and observed features of the universe. In doing so, objectivity becomes not about clear-cut representations from a distance, but acknowledging the entangled materialisations that we humans are of but a part (Barad, 2007, p. 91).

The significance of these ideas for this research project are two-fold. It first applies to reconsidering the basis on which the science-ethics nexus stands in school education. It also applies in acknowledging research as an active materialisation, which is expanded on in the following section. Rethinking subjectivity and objectivity in relation to matter-discourse and

the inherent inseparability of ethics does not just question the current constitution of the science-ethics nexus in school education but also proposes an alternative. I especially consider questions about objectivity in my analyses of interviews with beginning teachers in Chapter 5. I also examine this in Chapter 6, in which I propose a re-envisioning of how this nexus might look differently if dualisms such as subjectivity/objectivity are challenged, based on understanding we are *of the world* rather than ‘outside’ of it, or viewing the world from a distance.

These ideas about subjectivity and objectivity likewise involve reconsidering the nature of research in terms of avoiding the split between observer and the observed. I began to address this in the section ‘Entanglements of self’ in the introduction, in acknowledging that ‘I’, as a researcher, have not stood outside the processes of this study but am an active part of its becoming.

---

## CONNECTING THEORY WITH RESEARCH

The provocations of feminist materialisms and posthumanism do not just relate to interpretations of reality and topics within research but also the processes of research itself. Researchers who are engaged with feminist materialisms and posthumanism have begun to consider and test how these frameworks translate into the ‘doing’ of research. More specifically, into the processes of doing *qualitative* research, although some also question the dichotomy between quantitative and qualitative: ‘since boundaries between qualitative and quantitative cannot stand’ (MacLure, 2013, p. 659). However, qualitative research is often recognised as particularly focussing on the ‘doing’ of research at least as much as any outcomes of research (Cooper & White, 2012, p. 6) and is therefore more often invoked.

Qualitative research is commonly defined as encompassing the best form of methods for getting at the ‘micro’ of the world, and/or providing links between the ‘micro’ and the ‘macro’, as well as focussing on in-depth analysis. It may be used:

to explore, describe, or explain social phenomenon; unpack the meanings people ascribe to activities, situations, events, or artefacts; build a depth of understanding about some aspect of social life [and] build “thick descriptions” (Leavy, 2014, p. 2).

This therefore best aligns with this study and my intention to produce, overall, an in-depth account of the science-ethics nexus in Australian secondary school education.

I also suggest that qualitative research methods best align with relational posthumanism for several reasons and similarity in characteristics. For example, while not all qualitative research might do so, or might do well, this form of research is often stated as acknowledging the entanglement of researchers in research: ‘In qualitative research, we are not outside of our projects, but located and shifting within them’ (Leavy, 2014, p. 1). Thus, rethinking a connection with theory is also rethinking the researcher as entangled onto-epistemologically with research, including with participants, data, and processes of analysis. As Jackson and Mazzei argue, this renewed perspective on accounting for ourselves not only:

opens up new ways of seeing and thinking, but how they in fact produce a different encounter with our data as we interrogate our own positioning and intra-actions as researchers (Jackson & Mazzei, 2012, p. 118).

Indeed, some have argued that the material/ontological/posthumanist turn has disrupted dominant ways of doing research to the extent that this has required a ‘post-qualitative’ or ‘new empiricist’ practice. Again, using the words ‘post’ or ‘new’ is, however, highly contentious and for good reason. Both ‘post’ and ‘new’ give the impression of a linear and progressive momentum in research that is not only problematic in the face of history but also in the sense of fetishising the ‘new’. Regarding research studies using feminist materialisms,

posthumanism, or another comparably named framework, the first major question that needs to be addressed, in the consideration of empirical work, is whether employing these related frameworks requires an entirely ‘new’ way of conducting research.

These frameworks, as others have found, can be used provocatively in *thinking* about research differently and offering new techniques in data analysis. However, what has so far been less developed is the relationship these frameworks have with the ‘collection’ of data. Some researchers argue that ‘traditional’ qualitative data collection methods need not be thrown out altogether (Jackson & Mazzei, 2012), or even that attempts at an inventive method should only be an addition or complement to traditional qualitative methods (Lorimer, 2013). What is or is not traditional, however, is also hardly clear-cut.

I argue that alternative methods are always worth considering but they should be understood as additions to method diversity, rather than perhaps blanket replacements. There is potentially more strength in allowing for research to be dynamic and to allow for multiple perspectives and multiple methods. Just as I argued that relational posthumanism, while advocating and trying out alternatives, draws on the strengths of other frameworks, such as poststructuralism, it stands to reason that empirical approaches do the same. As noted by Rebecca Coleman and Jessica Ringrose, drawing from Maurice Merleau-Ponty: ‘we must seek understanding from a multiplicity of perspectives in order to gain a truer picture of the nature of anything that we are questioning’ (Coleman & Ringrose, 2013, p. 2).

Much of this explorative work around feminist materialisms and posthumanism is within the field of education. For example, Jackson and Mazzei’s chapter on Barad in *Thinking with Theory in Qualitative Research* (Jackson & Mazzei, 2012), the *Gender and Education* journal’s special issue on ‘Feminist Materialisms’ (C. A. Taylor & Ivinson, 2013), and the special issue on ‘Post-Qualitative Research’ in the *International Journal of Qualitative Studies in Education*

(“Post-Qualitative Research”, 2013). These explore how in particular feminist materialisms can be practically integrated into doing qualitative research in education. Typically, these researchers have been most familiar with employing poststructuralist frameworks and methods such as interviews, coding, and discourse analysis. However, they argue that they have found in feminist materialisms and/or posthumanism an alternative perspective, evocative of new ideas for how to understand research and data.

Nick J. Fox and Pam Alldred (Fox & Alldred, 2015) describe various attempts at new/feminist materialist inquiry after reviewing recent empirical studies by summarising characteristics in research design, data collection, analysis, and reporting. To the best of my knowledge, Fox and Alldred are the first to conduct a review of research studies that have related to new/feminist materialisms. Albeit, rather than a general overview, they focus on the links developed with Gilles Deleuze and Felix Guattari’s theory.

Fox and Alldred highlight several common elements in the 30 studies examined within the areas of research design, empirical practice, analysis, and the reporting of research. Their review corroborates my own. What is apparent is that many who are involved in this theoretical impetus still utilise common qualitative practices but do however offer some alternative ideas. There are also some commonalities in approaches. This includes the use of mixed-methods and multiple sources of data, which are a mixture of human-centred and nonhuman-centred elements, in the attempt to bring together a research assemblage that better accounts for the various material-discursive entanglements involved.

Examples include using a combination of interviews, ethnography, case studies, photographs, film, historical data, media reports, field notes, sounds, artefacts, vignettes, and drawings (e.g. Boden, 2013; Gannon, 2016; Ivinson & Renold, 2013; Jackson, 2013; Juelskjær, 2013;

Schadler, 2014; H.L. Taguchi & Palmer, 2013; C. A. Taylor, 2013; and M.J. Wolfe, 2016). I will further detail how I have translated these developments into my study in Chapter 3.

---

## CREATIVE RESEARCH PRACTICE

‘Arts-based’ or ‘creative’ research practice is argued to have various benefits. These include engaging a wider audience, personalising subject matters by appealing directly to emotions, particularly in facilitating empathy, and promoting understanding of diverse experiences (Leavy, 2015). It is also argued to be productively unpredictable and involve ‘tacit’ knowledge (E. Barrett, 2010), as well as generally harnessing the generative powers of imagination, such as in similarity to ‘thought experiments’ (Gough, 2010, p. 46). Lastly, and more broadly, it critically poses questions regarding the traditional boundaries between the sciences and humanities (P. Carter, 2010, p. 16) as well as creative versus academic practice.

This last element puts pressure on how ‘art’ and ‘creativity’ are defined. Nonetheless, I utilise ‘creative research practice’ as I find this to be more inclusive; as in, relatable to a broad array of practices and perhaps also more identifiably nebulous. In other words, as I understand this term, it is not about drawing a distinct boundary line between what is or is not ‘creative’, even while it gestures towards some specific types of practices, such as painting, dance, and fiction writing. Overall, it is considered that this method as research ‘takes form in the hyphen between art and social science research’ (Finley, 2008, p. 3).

Writing fiction as a creative research practice, specifically, has ‘been on the rise for the past two decades’ (Leavy, 2015, p. 41). In the social sciences, writing creative fiction, and ‘narrative inquiry’, has evolved to interpret data, to present data, and more broadly as ‘an act of rebellion against the monolithic “truth” that science is supposed to entail’ (Finley, 2008, p. 4). ‘Research’ might be added to ‘science’ to recognise the tension with the hegemonic traditional methods employed in the social sciences. Patricia Leavy argues that ‘both the rise in narrative

inquiry and emergence of fiction-based research are about making research more truthful, meaningful, useful, accessible, and *human*' (Leavy, 2015, p. 64; emphasis added).

The question posed here, then, is: how does the material/ontological/posthumanist turn in theory contribute to these discussions? Can creative research practice enact research that is *posthumanist*? Many engaged with these theory developments are also occupied with questions concerning creative research practice. This was made especially apparent to me when I attended 'Transversal Practices: Matter, Ecology and Relationality', the VI Conference on New Materialisms in 2015. The blurb for this conference read:

Transversal Practices focuses on how things, subjects, collectives, politics and disciplines are in the making; how they take-form and transform in relation to other elements, both human and nonhuman. Transversal Practices are concerned with ecologies where intensities of movement are aligned with and embrace hands-on attitude and artistic, scientific, ethnographical, philosophical and activist praxis (Transversal Practices, n.d.).

While many provocations are offered by feminist materialisms and posthumanism in relation to creative research practice, there are three main ideas that I will outline here. The first is that these theories add to the critical interrogation of the boundaries between art and science/research, in terms of emphasising the concept of relationality. The second is how these theories rethink the boundaries between knowing and being specifically in the context of creative practices. The third concept involves conceptualising artistic practice as an active, generative force, which engages with assemblages beyond the researcher and research project.

If art, science, and research are understood as intrinsically relational, and if they are recognised as 'intra-acting' rather than 'interacting', then the traditional hierarchical boundary

lines between them appear weak. Estelle Barrett, an Australian researcher in this area, argues that the relationality of ‘artistic research’ practices ‘results in research that is interdisciplinary’ (E. Barrett, 2010, p. 7). Extending on this in a posthumanist sense, creative research practice might be conceptualised as disrupting the very idea of separate disciplines in the first place. Specifically, creative research practice from a posthumanist viewpoint extends on poststructuralist, and other theory work, in putting pressure on traditional ideas about knowledge. What it adds is that knowledge is not ‘only’ a discursive construction, but also a relationally material one.

Furthermore, rather than emphasising humanist exceptionalism in suggesting that the world can never be known past our ‘consciousness’, this framework conceptualises ‘knowing-being’ as a material-discursive becoming. To put this another way, knowing-being does not conceptualise ‘human intelligent consciousness’, or a coherent individual human, at the centre of any kinds of practices, let alone creative ones. Or, as Barrett puts it, ‘Sensation, language and thought become *concurrent* and interchangeable and the boundaries between them are permeable’ (E. Barrett, 2015, p. 108; original emphasis).

Brian Martin, who was a keynote speaker at ‘Transversal Practices’, outlines this shift in thinking by drawing on his Indigeneity. Martin’s work highlights the Indigenous understanding of ‘Country’ as another word for ‘relationality’. His argument is that Indigenous people have no Cartesian object/subject split between Country and themselves:

Indigenous cultural practices [...] have inter-relatedness to the real everyday world and are not isolated from one another. Furthermore, the premise of producing works extends from the real world itself (B. Martin, 2012, p. 186).

Therefore, just as Martin argues that there is no separation between Indigenous cultures and ‘Country’, he also argues that there is no separation between art and the ‘real’ world. He contends that ‘ideology in Indigenous culture is not based on the imaginary conditions of existence but is grounded in the “real”’ (B. Martin, 2012, p. 186). In other words, art is a very real aspect of the world’s becoming and a way-of-knowing-being. To demonstrate this, Martin’s detailed his own artistic practices as involving travelling to Indigenous sacred places and producing detailed pencil drawings of Country. This process might also be understood as a ‘becoming-with’ (Haraway, 2016, p. 12) as ‘Natures, cultures, subjects, and objects do not pre-exist their intertwined worldings’ (Haraway, 2016, p. 13).

This naturally leads to the proposition that creative work is not just symbolically ‘representative’. This idea challenges the anthropocentric idea of creative work as a ‘reflection’ of an individual human’s experiences, and conscious or subconscious explorations. From a posthumanist perspective, creative work is also not only a ‘cultural’ production. The ‘materiality’ of art may be lost in the ‘constructivist’ definition of art as ‘always and necessarily socially and culturally mediated’ (E. Barrett & Bolt, 2012, p. 4). Thus, reinstating the material, and understanding the material as agentic, means that creative work becomes an active aspect of the becoming of the world; ‘In creative practice, matter, artist and world are engaged and co-emerge through the work of art’ (McCosh, 2012, p. 131).

It might also be argued that the becoming of a research project, as involving theory, data, participants, and more, can co-emerge *within* creative practice. For these reasons, I have harnessed a ‘fiction research practice’ as a part of this study, to work along with posthumanist concepts and with my other data. This process is further detailed in Chapter 3.

---

## MODES OF ANALYSIS

In this section, I explain some of the theoretical concepts I utilised not only broadly in my study but specifically in my processes of data analysis. This section is therefore a primer to the following chapter, making a link between my theoretical framework and the ‘doing’ of research conducted for my study. One integral component of this framework, which I have used significantly in my data analysis, is the concept of ‘diffraction’. As previously outlined, Haraway initially proposed ‘diffraction’ as an alternative to ‘reflection’ or ‘representationalism’, as a technique to *keep with* difference and to *make* a difference (Schneider, 2005, p. 19; original emphasis).

Barad has expanded on this idea by drawing on Haraway, Bohr, and physics in general. Reflection might be understood as about never-ending reflections in mirrors of the same thing, while diffraction is about patterns of difference; for instance, the ripples that spread out and cross over each other after a stone is dropped into water (Barad, 2007, p. 28). Instead of the same image or object being ‘reflected’, and in this way pre-determined, diffraction recognises differences, or patterns of differences, as they emerge. Diffraction is about ‘how different differences get made, what gets excluded, and how those exclusions matter’ (Barad, 2007, p. 30). Following this, Barad proposes diffraction as a unique perspective, or a ‘diffractive methodology’, when examining material-discursive phenomena and entanglements.

Diffraction extends upon relationality/intra-actions, wherein the focus is not on distinct entities but rather the effects/affective qualities of affirmative difference. While the concept of diffraction has significance in many areas, it has been especially useful in rethinking approaches to research and data analysis. For instance, data and theory can be considered to enact diffractive patterns, which is an alternative to thinking of data as ‘representative’. I discuss diffraction further in terms of how it can be utilised to conduct research in Chapter 3.

Deleuze and Guattari's work has become enmeshed within feminist materialisms, so much so it is somewhat difficult to define the origin of conceptual thought. This is further complicated by the nature of Deleuze and Guattari's theories, as highly dynamic (or, perhaps in their terms, 'rhizomic') rather than prescriptive. In other words, many conceptual terms, such as becoming, assemblages, and multiplicities, have been attributed to them but have perhaps taken on unique meanings within research based on feminist materialisms and posthumanism. However, in the interest of clarity, I outline here some of their ideas that have filtered into my framework and especially my data analysis.

Deleuze and Guattari's most often quoted work within feminist materialist frameworks is *A Thousand Plateaus: Capitalism and Schizophrenia* (Deleuze & Guattari, 1984) first published in 1980. Deleuze and Guattari's idea of 'becoming' links well with relationality and Barad's concept of intra-action. For instance, in *A Thousand Plateaus*, they describe the co-evolution of an orchid and a wasp as a becoming:

At the same time, something else entirely is going on; not imitation at all but a capture of code, surplus value of code, an increase in valence, a veritable becoming, a becoming-wasp of the orchid and a becoming-orchid of the wasp (Deleuze & Guattari, 1984, p. 10).

It might be understood from this that the wasp and the orchid do not precede each other but rather become via their relationality.

'Becoming' shifts the emphasis from 'being' as a static signifier to a more dynamic understanding of the world and of entities, in acknowledging that nothing in the universe is entirely static. 'Being is merely a momentary, subsidiary, and largely illusory suspension (or "contraction") of becoming; becoming is always primary and fundamental' (Holland, 2013, p.

18). Becoming is an expression of material-discursive potentialities or multiplicities. Entities become but so do assemblages, another term addressed below.

Relational becoming also describes ‘multiplicities’. Multiplicities is a term for acknowledging the dynamic potentiality of becoming, from small instances widening to the world as a whole. This is not to say that within the universe as we know it, anything and everything is possible. Rather, this is about understanding that miniscule changes can transform entanglements and that the results of all possible outcomes of such entanglements are always multiple. Multiplicities might also be utilised as a concept in contrast to individualism; that is, the idea that not only is it a ‘fact’ of reality that beings are coherent, bounded individuals but that this constitutes subjectivity. In other words, that all beings subjectively view the world as ‘individuals’ separated from other ‘individuals’ and the world. Instead, beings or entities might be thought of as multiplicities.

I utilise the concept of becoming and multiplicities especially in my understanding of my data and beginning teacher participants. In other words, I consider my participants as in a process of becoming and my analyses of the interview data as a becoming. As such, the participants are entities-as-multiplicities, rather than coherent individual beings. Focussing on becomings acknowledges that nothing is truly static, nor complete, and allows for more open-ended processes rather than neatly defined narratives. In this sense, I also understand that multiplicities are always inherent in any set of data. There is, therefore, no singular narrative in analysing data but rather a set of potentialities.

An assemblage, or ‘machinic multiplicity’, is described by Deleuze and Guattari in various ways. They write that:

We are no more familiar with scientificity than we are with ideology;  
all we know are assemblages. And the only assemblages are machinic

assemblages of desire and collective assemblages of enunciation

(Deleuze & Guattari, 1980, p. 22).

An assemblage is made up of material, semiotic, and social ‘flows’ simultaneously and this dissolves the separations between the world, representations, and subjects. Additionally, an assemblage, highly contingently, connects multiplicities (Deleuze & Guattari, 1980, p. 23).

Following this, an assemblage is never entirely static but goes through processes of territorialisation and deterritorialisation, when a ‘line of flight’ disrupts connections: ‘the line of flight or deterritorialization [is] the maximum dimension after which the multiplicity undergoes metamorphosis, changes in nature’ (Deleuze & Guattari, 1980, p. 23). In this way, it is possible to understand complex aspects of the world and society, such as school education, as an assemblage that will go through, or ‘become’ via, periods of constancy and change. An assemblage is therefore a unit of analysis, replacing the human ‘individual’. Consequently, I conceptualise the relationships and relationality around the science-ethics nexus in school education as an assemblage. Additionally, in Chapter 5, I conceptualise my participants’ science-ethics ‘views-assemblages’.

Another significant link to feminist materialist frameworks are theories of ‘affect’. These are also related to Deleuze and Guattari’s work but are linked to many other theorists, such as Baruch Spinoza and, contemporarily, Brian Massumi, who draws from Spinoza’s work. Massumi defines the concept of affect as a ‘passing of a threshold, seen from the point of view of the change in capacity’ (Massumi, 2015, p. 4). It is difficult to describe affect conclusively as interpretations of affect vary widely. This is in part due to the nature of affect theory, as an attempt to get at an ‘in-between-ness’ and the muddled ‘capacities to act and be acted upon’ (Gregg & Seigworth, 2010, p. 1). It is clear, however, that theories of affect have much in common

with feminist materialisms and posthumanism, reflecting ‘part of broader emphases on the interweaving of the material, the social, the biological and the cultural’ (Wetherell, 2013, p. 350).

I contend that affect occurs within relationalities and involves degrees of intensities. It is a fundamental aspect of an entity’s becoming ‘pulled beyond its seeming surface-boundedness by way of its relation to, indeed its composition through, the forces of encounter’ (Gregg & Seigworth, 2010, p. 3). Or, put another way, that ‘Affectivities are understood not as the feelings of individual subjects but as the intense sensation of bodies that are pre-personal and pre-discursive’ (Kenway & Youdell, 2011, p. 3). But affect need not be limited to an entity, as some using feminist materialisms speak of the ‘affective capacity of matter’ itself (Walker, 2014, p. 49).

In bringing the above ideas together, an affect is a becoming, an expression of multiple potentialities (multiplicities) within relations. I utilise affect theory in examination of my participants’ becomings, such as their capacity to be affected, or to experience distinct becomings, in relation to their understanding of science and ethics.

---

## CONCLUDING THOUGHTS

A definitive verdict of the significant usefulness or not of the material/ontological/posthumanist turn in the ‘doing’ of research may be premature to propose. The emerging ideas around these related theoretical frameworks are currently at lightning speed, relatively speaking. New books, articles, and whole conferences in various fields related to these frameworks are propagating around the world. There is no doubt that these frameworks have their weaknesses. It is also still on the whole undecided how they are constituted in relationship with other frameworks, and particularly poststructuralism; however, this is surely only incentive for there to be more critical explorations.

What I find to be the primary benefit of utilising relational posthumanism in the space of science, ethics, and school education is that its characteristics are particularly suited to

questions about the becoming of science, ethics, and knowing-being. Yet, as noted in Chapter 1, there are yet only beginning glimpses of what this, and similar, frameworks might offer this area of research. Therefore, relational posthumanism is provocative in this area not just because it raises significant questions about science, ethics, and the becoming of the world, but because it provides an alternative to, perhaps even a provocative friction against, the more established frameworks within related school education research.

As I outlined in this chapter, however, there are many more benefits to this framework. It is also particularly suited to my research project in several ways. Relational posthumanism brings about renewed questions about the nature of knowledge and ethics, as well as how we understand our (human) significance in the becoming of the world. This is particularly so as related to the development of science and technology. This framework therefore provides an alternative perspective on the issue of the science-ethics nexus in school education, by reframing the importance of this topic, the definition of ethics, and examining the various complex material-discursive phenomena involved in its constitution. In the next chapter, I provide further details of my research methods and the process of generating data in relationship to *doing and thinking* with relational posthumanism.

## CHAPTER 3: PLUGGING IN/TO DATA

---

For researchers inspired by posthumanist theorizations, the task of bridging the theory/practice divide is particularly challenging because it is accompanied by the additional need to resist the nature/culture divide that keeps our human species ‘hyper-separated’ from all ‘earth others’ in the name of ‘human exceptionalism’

—(Pacini-Ketchabaw, A. Taylor & Blaise, 2016, p. 149)

---

The process of doing research must always begin with the question: how can we know the world? Relational posthumanism requires an understanding of the fundamental relationality between theory and practice, as was introduced in Chapter 2, just as it is considered that there is a fundamental relationality between ontology and epistemology. In other words, we cannot ‘know’ something that is in some way separate from materialities. It also requires, as the above quote by Veronica Pacini-Ketchabaw et al. suggests, avoiding the centrality of the human.

While some argue that the material/ontological/posthumanist turn requires a ‘post-qualitative’ trajectory, I counter that there is greater strength in allowing for dynamic approaches to research methods. For my own study, I utilise a combination of ‘traditional’ qualitative methods along with some alternative ideas as inspired by feminist materialisms and posthumanism. I utilise such alternative ideas to expand on how the science-ethics nexus in school education is conceptualised. Specifically, this involves incorporating a creative research practice and by including the concept of onto-epistemological assemblages as very significant in understanding the science-ethics nexus.

I have been inspired by Alecia Youngblood Jackson and Lisa Mazzei’s development of Deleuze and Guattari’s theories, especially with the concept of ‘plugging in’ theory and data together (Jackson & Mazzei, 2012, p. vii). Although, I characterise this as ‘thinking-doing with theory’ to recognise the inherent onto-epistemological inseparability. In this sense,

thinking/knowing is never separate from the materialities of data and analysis. It may also be that all techniques of data analysis are essentially plugging in theory, whether a specific theory is recognised.

What I mainly take from Jackson and Mazzei's arguments is the benefit of being conscious of this process, to use specific concepts, and to think of these concepts as tools rather than as truths. I also utilise a diffractive methodology, after Karen Barad and Donna Haraway, in both my broad data generation processes as well as my data analyses. Lastly, I incorporate other concepts, including multiplicities, assemblages, becoming, and affect, as introduced in Chapter 2. These concepts come from researchers, such as from Jackson and Mazzei, who have worked with Deleuze and Guattari's theory.

Nick J. Fox and Pam Alldred's review of materialist methods (Fox & Alldred, 2015) and their work *Sociology and the New Materialism: Theory, Research, Action* (Fox & Alldred, 2016) outline the strengths of using multiple data generation processes and how this reflects a posthumanist framework. Specifically, this approach helps engagement with complex relationality, as well as decentring the human. In other words, the focus is shifted away from humans at the centre, to consider instead relationality and material-discursive assemblages. Furthermore, as Fox and Alldred argue, research itself can be thought of as an assemblage, made up of theory, data, participants, and researchers.

Taking inspiration from these ideas, I therefore utilise a multi-data approach for this study. This involves a creative research practice of writing speculative fiction, as well as some analyses of others' speculative fiction. It also involves analyses of school education data, including major reports on Australian science education, the Australian Years 7-10 curriculum<sup>15</sup>,

---

<sup>15</sup> Years 7-10 in Australia encompass the first four years of secondary school, typically including students from ages 12-16.

and Years 7-10 secondary school textbooks. While these data might be elsewhere referred to as ‘texts’, I use ‘materials’ to emphasise that my focus is on the assemblages they are a part of as well as the written word. Lastly, my approach includes semi-structured interviews with ten beginning teachers, who are intending to teach science or humanities. I also attempt to account for the research assemblage, which began with a brief account of my ‘self’ as a researcher in this dissertation’s introduction.

This chapter outlines the most important aspects of my data generation processes, including the role relational posthumanism has played within them. It also introduces aspects of my data analysis. In the first half, ‘Research ethics’, I present an account of the ethical accountability of this study, and myself as researcher, as interpreted via relational posthumanism. Under the heading ‘Data generation’, there are three subsections, ‘Fiction research practice’, ‘Education materials’, and ‘Interviews’. The first subsection begins with an outline of my creative research practice of writing a speculative fiction short story for this study. The last two sections outline the data I draw on to understand the current constitution of the science-ethics nexus in Australian secondary school education, as well as the focus on beginning teachers’ views of science and ethics. Each section describes the main processes I went through in choosing and synthesising data, followed by sections detailing my method of data analysis.

---

## RESEARCH ETHICS

My thinking about research ethics has evolved from the beginning of my investigation. At the early stage of my research, I was required to read the ‘Australian Code for the Responsible Conduct of Research (Australian Government, 2007) as well as the ‘National Statement on Ethical Conduct in Human Research 2007’ (Australian Government, 2014), which informed my early understanding of ethical obligations. There were no foreseeable ethical high risks in relation to this research study, as defined by Monash University or the Australian Government documents mentioned above. An ‘application for ethical approval of a low risk project involving

humans' was therefore submitted to the Monash University Human Research Ethics Committee (MUHREC). In addition to the common ethical concerns of a project involving humans, such as maintaining a positive and respectful relationship with participants, the potential for participants to be mildly discomforted by personal questions was acknowledged in the ethics submission, as well as the consent form (included in Appendix 1).

Participants received an outline of the research process and were asked to sign the consent form before the interviews commenced. I also reminded them at the time of the interviews that they were free to end the interview whenever they wanted and were free not to answer any questions, for any reason. Nor did they have to state a reason. Due to the difficulty in obtaining participants initially, this required an amendment to the ethics application to acknowledge changes to my recruitment strategies, as well as broadening the cohort to second, third and fourth year Bachelor of Education students at the selected university. Both the original and amended ethics applications were approved.

My reading about posthumanist ethics began to shift my thinking somewhat, in terms of not only my management of human participants but also for my consideration of the broader entanglements my study might be involved in. Towards a posthumanist perspective, I pose the question: how can a posthumanist ethics be applied to specific research undertakings? While I go into more detail about what a posthumanist ethics is later, I offer a few points here that relate to the application of this form of ethics to my study. The first aspect that is relevant is the understanding that research that is ethically posthumanist refuses the primacy of human existence. Instead, it brings into the centre relationality between different forms of life, while also acknowledging the significance of all matter. This means that research is understood as not solely for the benefit of humans.

This position has many consequences. For instance, in relation to the science-ethics nexus, the concept of sustainability is quite different from the perspective of humanism versus posthumanism. The former often situates sustainability largely for the benefit of humanity, while the second recognises humans as only one component of importance, instead placing relationality between all living forms at the centre. More on this will be examined in Chapter 6.

An additional component of posthumanist ethics is that research is understood not just as a snapshot, record, or documentation of the world, in the past or present. Instead, it is considered an active *becoming of the world*: ‘We don’t obtain knowledge by standing outside the world; we know because we are of the world’ (Jackson & Mazzei, 2012, p. 120). This is not to say, or assume, that all research will have far-reaching implications and consequences but rather that it is understood that everything is a part of the world’s ongoing constitution and that this must be acknowledged.

Therefore, a posthumanist ethical consideration of research must also ask: what possible implications does this research have for the world’s ongoing becoming? Of course, there is no clear or easy way to answer this large question. However, I am wary of the easier, and what is perhaps common, inclination to reduce this question down to the specific context of a research project. The main issue with this is the restriction on scale. Conversely, posthumanist ethics invites alternative thinking about scale and context. Specifically, that what might be called ‘small scale’ research projects should not be cut-off as if existing apart from the world. There is a danger in this of inadvertently reducing the ethical culpability.

It might be easier to see this in, for instance, scientific research where quite literally studies into the infinitesimally small, e.g. biotechnology and nanotechnology, can more obviously have the potential for far-reaching impacts on the world. Even then, because specific natural and physical scientific research projects typically work on one small aspect of a given

field, it might be all too easy for the wider ethical ramifications to be missed or disregarded. This is one benefit of a posthumanist ethics; there can be no separation of research from wider contexts, no matter how big or small a study might be considered.

Consequently, acknowledging the significance of all research as relational, and demonstrating considered attention to this, is necessary to adhere to a posthumanist ethics in research. I recognise that this research project relates to several broad issues, and a growing number of similar investigations with concerns about the current status quo regarding science, technology, ethics, and school education. I acknowledge that these connections may cumulatively lead to actual changes in the world, such as education reforms. However, to the best of my insight, I cannot foresee such changes to be harmful to any living forms or to the overall becoming of the world.

---

## DATA GENERATION

### FICTION RESEARCH PRACTICE

The idea for writing speculative fiction as a creative research practice for this study emerged organically from a convergence between my reading about posthumanist and feminist materialist theory, my data generation processes, as well as my personal interest in the genre and in creative writing. Speculative fiction became significant as it continued to appear in my data; particularly in my interviews with beginning teachers and occasionally in my analysis of science textbooks. It also emerged from arguments put forth by those, as identified in Chapter 1, who in various ways have brought together a ‘speculative’ viewpoint and speculative fiction with the material/ontological/posthumanist turn. Lastly, the prospect of utilising a fiction research practice, in partnership with relational posthumanism, presented as an applicable but unconventional, and therefore potentially stimulating, method to examine the science-ethics nexus in Australian secondary school education.

There are various ways that my speculative fiction short story, ‘The Beforetimer’, works in my research and this dissertation. My initial intention was to ‘plug in’ relational posthumanist concepts into my creative writing as an examination of the potential of this relationality. This results in directing these potentials towards renewed thinking for the science-ethics nexus in school education. The process of intentionally ‘plugging in’ theory into creative writing was difficult, as it necessitated a continual analytical frame of mind to ensure relational posthumanism was a presence in my short story. Although I do not intend for the short story to perfectly coincide with relational posthumanist concepts, I do intend for there to be various interweaved conceptual resonances. For example, ‘The Beforetimer’ partly challenges human exceptionalism by envisioning a world that has largely moved on from human dominance.

The process of ‘plugging in’ relational posthumanism became easier as, throughout the writing and re-writing process, I began to see multiple complementary characteristics between speculative fiction and relational posthumanism. For example, the ethico-political *speculative* possibilities. In other words, this is about putting together a posthumanist ethical sensibility with speculative fiction’s capacity to deal with the ‘big issues’ of scientific and technological development.

Furthermore, in conceptualising creative practice as agentic, and as involving broad material-discursive assemblages, of which I am but a part, my intention in writing ‘The Beforetimer’ is also an opening up to the ‘necessarily unpredictable’ (E. Barrett, 2010, p. 3). In this way, not only was I ‘plugging in’ relational posthumanism into my creative research practice but I am also ‘plugging in’ this into the becoming of my research study. I conceptualise this also as a process of ‘unworking’ in the sense of opening fractures in hegemonic thinking to develop a renewed perspective, and renewed ideas, concerning the science-ethics nexus. This fracturing is seen in the extracts of my story positioned at the beginning of the following chapters, and included in some aspects of my analysis.

---

## EDUCATION MATERIALS

This section covers three aspects of education data I analyse in this investigation; major research reports, the Australian secondary curriculum, and secondary school textbooks. I chose and analyse these ‘materials’ mainly to gauge an understanding of how a science-ethics nexus is currently constituted in Australian secondary school education. As this constitution goes beyond these materials, however, the knowledge gained from them is partial. Nonetheless, they do together indicate what might be called the major foundational ideas that form this constitution.

---

## REPORTS

As part of my literature review, I came across two seminal reports concerning science and school education in Australia. These reports, as mentioned earlier, included, firstly, ‘STEM: Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) education’ (Marginson et al., 2013). The second main report is ‘Reimagining Science Education’ by Russell Tytler (Tytler, 2007).

These reports provide some insight concerning the political machinations involved in the constitution of science education and the science-ethics nexus in Australia, which I highlight in Chapter 4. That is, not just for what they discuss but also concerning the ways in which the reports themselves address this topic, and principally the topic of ethics, in terms of the values, issues, and policy suggestions. Hence, these reports serve as both primary and secondary data generation sources.

---

## AUSTRALIAN CURRICULUM

From the beginning of my research study, the Australian school curricula have gone through significant changes. A new national curriculum was developed and has slowly been rolled out in the states and territories since 2013, to be flexibly merged with existing state and

territory specific curricula priorities. Improvements and amendments were made to this curriculum in 2015, and consequently there are now two versions, 7.5 and 8.3; the older version is still available to allow teachers and schools time to transition to the new version.

There are some differences between the Australian curriculum and the curricula for Australia's states and territories. However, because the intention of the national curriculum is to be the foundation of state and territory curricula, it is the national one that I focus on. Within the national curriculum, I also focus on the year levels 7-10. This is mainly because these year levels represent the typical compulsory period of undertaking the subject of science for Australian secondary school students.

In acknowledging my 'self' in the process of analysing the curriculum, areas of the curricula were of more interest to me due to my background. These interests helped guide the trajectory of my research project, which could be best described as spiral rather than linear. For instance, my interest in sustainability led to my reading those sections before I had fully developed an understanding of the broader contexts of a 'science-ethics nexus'. Overall, however, the areas I choose to examine in detail are what I deem to be the most relevant towards understanding the current constitution of the science-ethics nexus.

The Australian Years 7-10 secondary school curriculum has three major sections: 'learning areas', 'general capabilities', and 'cross-curriculum priorities'. The learning areas include traditional subjects, such as 'mathematics' and 'English'. The general capabilities include general learning skills, including 'Literacy', 'Numeracy', 'ICT (Information and Communication Technology) Capability', 'Critical and Creative Thinking', 'Personal and Social Capability', 'Ethical Understanding', and 'Intercultural Understanding'. These are intended to be included dynamically within the learning areas (ACARA, n.d.<sup>b</sup>). Lastly, the cross-curriculum priorities, to date, include three topics considered important for Australian students and

therefore are intended to be emphasised across the curriculum. These include ‘Aboriginal and Torres Strait Islander Histories and Cultures’, ‘Asia and Australia’s Engagement with Asia’, and ‘Sustainability’.

Within this expansive curriculum, I acknowledge that many areas are relevant for considering the science-ethics nexus. After initial examination of all areas, however, I ascertained that the areas that established the strongest connections to science and ethics, and that would provide the richest analyses, are ‘Science’, ‘Ethical Understanding’, and ‘English’. I chose to examine English to expand the conception of the science-ethics nexus beyond just science curricula.

Drawing from my own experience of attending secondary school in Victoria, I recall watching the science fiction film *Gattaca* (Niccol, 1997) in an English class and discussing genetic engineering. *Gattaca* is still suggested as a ‘text’ for the English curriculum but there are no prescribed fiction texts, so texts vary from teacher to teacher, and school to school (ACARA, n.d.<sup>c</sup>). Unfortunately, this means detailed consideration of the inclusion of specific science/speculative fiction in English is beyond the scope of this study. However, I did note that it seems *Gattaca* remains popular. This corresponds with some of my interviews with beginning teachers, who discussed watching and analysing *Gattaca* as part of their English classes, as well as how it informed their thinking about human genetic engineering.

After an examination of the English curriculum, which included analyses of English textbooks, I found that ethics, especially in relation to science, is largely not present. Consequently, my focus became ‘Science’ and ‘Ethical Understanding’. This is detailed further in the following section. I also incorporated some consideration of ‘Aboriginal and Torres Strait Islander Histories and Cultures’, as well as ‘Sustainability’, which informed my analyses of science, ethical understanding, and science textbooks.

AUSTRALIAN CURRICULUM STRUCTURE

<b>Australian foundation-10 curriculum version 8.3</b>		
<b>Learning Areas</b>	<b>General Capabilities</b>	<b>Cross-Curriculum Priorities</b>
English	Literacy	Aboriginal and Torres Strait Islander Histories and Cultures
Mathematics	Numeracy	Asia and Australia's Engagement with Asia
Science	Information and Communication Technology (ICT)	Sustainability
<u>Humanities and Social Sciences</u> History Geography Civics and citizenship Economics and business	Critical and Creative Thinking	
<u>The Arts</u> Dance Drama Media Arts Music Visual Arts	Personal and Social Capability	
<u>Technologies</u> Design and Technologies Digital Technologies	Ethical Understanding	
Health and Physical Education	Intercultural Understanding	
Languages		

Table 1: Summary of the Australian secondary school curriculum.



Figure 1: General capabilities graphic from the Australian secondary curriculum (ACARA, n.d. <sup>b</sup>)

---

## SECONDARY TEXTBOOKS

There are five publishing companies that produce Australian secondary curriculum student textbooks (as well as teacher resource books) for English and science. These are Jacaranda, Macmillan, Nelson, Oxford University Press, and Pearson<sup>16</sup>. I examine a collection of the publishers' textbooks for Years 7-10 English and science that were most recently published, beginning from my textbook analysis period at the beginning of 2015. Pearson and Oxford University Press have more recently, since the end of 2016, published new editions and new

---

<sup>16</sup> It is worth noting that these are transnational companies but they are far from being equal in terms of power and income. Pearson International, which is British owned, for instance, not only publishes a multitude of textbooks but also creates standardised tests, which have caused some controversy (Singer, 2013).

versions of the science textbooks, respectively. Pearson's newer editions contain much of the same content as the older ones, and consequently I updated my analyses with minor adjustments accordingly. The new Oxford versions, however, have involved different authors and consequently some substantial new content. I include some aspects of these newer versions in my analyses; however, the older versions are still included.

Overall, my analyses of textbooks are conducted for the same reasons as the curriculum analysis: for how they provide understanding of the current constitution of the science-ethics nexus. Out of the English textbooks, however, I found only two textbooks directly relevant, for containing a specific section on ethics: the Macmillan Year 10 *English for the Australian Curriculum* (Bernhardt et al., 2012) textbook, and the Jacaranda *English is...English for the Australian Curriculum Year 10* (Gardiner et al., 2012) textbook. The ethics sections in these textbooks, however, do not engage with science. Thus, my analytical focus is on the science textbooks. That said, of course, it is relevant that most English textbooks *did not* specifically address ethics, let alone the science-ethics nexus. This informs my thinking in Chapter 6, in which I consider the potential limitations of divisions between subject areas.

Given the time constraints for this study, I weighed up the differing approaches I might have taken in analysing the textbooks and chose the option that would contribute the best understanding of the overall constitution of the science-ethics nexus. This approach involved scanning through the textbooks for sections, images, paragraphs, or chapters that I considered relevant to the science-ethics nexus, which I then marked and later analysed in detail. For example, sections include those that mention ethical issues, such as genetic engineering. Whole chapters are also relevant, such as those on the topics of sustainability, climate change, and recycling.

---

## MATERIALS ANALYSIS

Using a relational posthumanist analysis of education data requires a rethink concerning the nature of materials as data and analysis thereof. As mentioned earlier, my data analysis process involves a diffractive methodology, which can be described, as Hillevi Lenz Taguchi and Anna Palmer do, as ‘a wave-like motion that takes into account that thinking, seeing and knowing are never done in isolation but are always affected by different forces coming together’ (H.L. Taguchi & Palmer, 2013, p. 676).

A diffractive analysis firstly treats data as an assemblage. In this sense, data are assemblages of relations that are always somewhat in flux. Therefore, just as I conceive of my creative practice of writing speculative fiction as an enactment of a relationality that is more than my ‘self’, I consider other ‘materials’ in the same way. Considering non-fiction materials is not so different; although attention must be paid to the different processes involved. The most obvious being that fiction is created for different reasons than materials such as reports and textbooks.

A posthumanist analysis focuses on the assemblage as part of the materials’ creation and does not reduce said creations down to the intentions of individuals. Materials are instead understood as an amalgamation of multiplicities, of which writers/authors, directors, actors, readers, audiences, and producers, are but a part of, as dynamic entities. A posthumanist analysis therefore reworks perceptions of materials not as distinct entities but involved in dynamic becomings. Consequently, a diffractive analysis is not about insisting on what the data says about the world ‘as it is’, but rather what the data brings forth in relation to other data, or concepts.

Following from this, my take on diffractive methodology and ‘plugging in’ theory is to diffract relational posthumanist concepts throughout my data and to analyse the consequent becomings. As Taguchi and Palmer contend:

a diffractive analysis can be understood as an enactment of flows of differences, where differences get made in the process of reading data into each other, and identifying what diffractive patterns emerge in these readings (H.L. Taguchi & Palmer, 2013, p. 676).

For instance, I consider how ‘posthumanism’ and a ‘posthumanist ethics’ diffracts with these materials. In other words, I question what in these materials aligns with posthumanism, or alternatively ‘humanism/anthropocentrism’. How do they align, or not, with a posthumanist ethics? How do they highlight material-discursive becomings?

Furthermore, following from this, I question what affective forces flow from these materials and what multiplicities might they enact. This is in line with what Bill Green argues, which is that matter and bodies ‘form a dynamic network of affects and relations, opening new possibilities and generating new intensities’ (B. Green, 2015, p. 127). Such ideas, inspired by Deleuze and Guattari, are an attempt to shift away from ‘representationalism’ and the idea of a bounded body.

My analysis takes from poststructuralism in the sense of rejecting a ‘one, true meaning’ in materials, particularly in fiction, and the understanding of the power of discourse and language. However, a diffractive analysis is also about staying with the messiness of multiple becomings *in relationality*, rather than seeking any possible singular ‘meaning’ or narrative. There can be no discussion of hidden or background meanings if we consider materials as a dynamic becoming in relationship to an entanglement between creators, producers, matter-discourse, and audiences.

To analyse the education materials, I conducted a basic reading of content, followed by a more in-depth analysis. I then utilised a diffractive methodology to ‘plug in’ concepts throughout the data and to assess what differences emerged. I conceptualised a collective ‘assemblage’ involved in the becoming of materials; as for instance conceptualising an assemblage that makes up ‘science education’ in Australia. I attempted to focus on what these materials ‘do’ rather than what they are, and to remain open to a messy relationality between them (between the reports, curriculum, and textbooks). As Jackson and Mazzei point out, a ‘diffractive reading [...] emphasizes not how discourses function to produce power relations, but how power relations materialize in the intra-action between/with the material and the discursive’ (Jackson & Mazzei, 2012, p. 7). This will be further clarified in Chapter 4.

---

## INTERVIEWS

A university in Melbourne, Australia was chosen to recruit ten beginning teachers for two rounds of semi-structured interviews. At the time of my participant recruitment, this university was rated highly for education by a respected international ranking organisation<sup>17</sup>. Therefore, this university was expected to exemplify the very top global standards in education. The groups selected as potential participants were students undertaking the Bachelor of Education (secondary), or the combined Bachelors of Education (secondary)/Science or Education (secondary)/Arts students. As I was intending on doing two in-depth interviews with each participant, the number of ten participants was chosen in recognition of time constraints but also as a large enough number to provide some diversity in the group.

Participant recruitment involved putting up posters, handing out flyers, and talking directly with students about the project inside and outside of classrooms in the university’s

---

<sup>17</sup> The name of the university and ranking organisation has been redacted to protect participants’ identities.

Faculty of Education. This was a difficult process and there was initially limited response. This required a rethink about recruitment methods and amendments to my methods and ethics submission before ten participants volunteered.

The interviews were qualitative, semi-structured, aurally recorded, and later transcribed into text form. I also took some hand-written notes during the interviews, as well as wrote a summary directly after each interview. This summary noted how I thought the interview went, my general sense of the interviewees, and points of interest. Interviews were conducted at the participants' university, in allocated meeting rooms. This meant that at times participants were distracted by the environment. We were sometimes interrupted due to booking conflicts and outside noises of students leaving and entering nearby classrooms. The interviews varied in intensity and interest on the part of the participants.

The interviews are semi-structured in the sense that I had a list of themes and question prompts (see Appendix 2) but allowed the interviews to develop somewhat organically according to how participants responded. There were a few main aims of the interviews. The first was to assess the participants' views of science and ethics, as well as how their views might translate into their thinking about teaching. The second aim was to assess what in the participants' backgrounds might be influencing their understanding of the science-ethics nexus. Lastly, another aim was to gauge how participants might respond to thinking about a relational posthumanist concept in relation to their teaching. Overall, this was about coming to understand the participants' 'onto-epistemological' assemblages.

I have drawn from various sources to rethink the human participant in research from a relational posthumanist perspective. As previously stated, the main conceptual moves include shifting the human from the centre, and understanding humans as 'entities-as-multiplicities' rather than singular 'individuals'. In this sense, the purpose of an interview is not to examine

the participant, as such, or the ‘social world’ the participant is a part of, but rather the entity-world relationality. To this end, in my analysis, I refer to the participants as ‘entities’. More detail on this is further outlined in Chapter 5.

Drawing inspiration from various researchers who have worked with ideas from Deleuze and Guattari, I have also conceptualised my participants not as ‘being’ a certain way, but rather as ‘becoming’ via material-discursive relationality. In enacting these shifts in thinking into the ‘doing’ of research, I conducted two interviews rather than one to better get at the ‘messiness’ of material-discursive relationality. The second interview, and the six months or so time between the interviews, allowed for tracking potential changes in the participants’ views, as well as the opportunity to further investigate elements of special interest after initial analyses. Secondly, I utilised in-depth interviews that involve attention paid to participants’ environments, experiences, identities, emotions, education, and general histories as all implicated in their dynamic becomings.

The interview ‘findings’ are not intended to be generalisable to all beginning teachers, in Australia or otherwise. Rather, the focus is on how anyone undertaking the Bachelor of Education, or similar, courses might come to their views of science and ethics, as expressed in the context of an interview. This aligns not just with a relational posthumanist perspective but also other qualitative methods, such as life-story/history interviews. These might be defined as broadly ‘focused on documenting the respondent’s life and understanding how personal narratives reveal how a life is constructed’ (Mann, 2016, p. 101), or that ‘inhabit the heartland of subjectivity and explore the multiple ways in which our subjective perceptions and representations relate to our understandings and our actions’ (Goodson, 2017, p. 3). Overall, my method is about examining becomings and to get at the complexity of entanglements within beginning teachers’ knowing-being.

This carries onto another major feature of my analysis, which is concerned with ‘messiness’, or potentialities and multiplicities instead of linear, singular narratives. Using a posthumanist framework is not an attempt to argue that complexity around entanglements can ever be completely understood. Nor can any ultimate truth be gleaned from analysing interviews, which can only ever be a ‘snapshot’ of an entity’s becoming that is also an entanglement with the materialities of research. Thus, understanding is always partial, always ongoing, and never complete.

The benefits of posthumanism include acknowledging the limits of knowing and understanding the ‘messiness’ of material-discursive entanglements. Rather than cleaning up the messiness, such as reducing data down into isolatable parts, or attempting to identify linear narratives, posthumanism is an avenue through which to stay with, and work with, the messiness as much as possible. As Barad has often pointed out, quantum physics suggests that the nature of matter/the universe is *paradoxical* (Barad, 2011, p. 138). Although, this may be another way of saying we will never/can never fully know or understand the universe, or ourselves.

Lastly, in addition to referring to the participants as ‘entities’ rather than using a pseudonym, I also refer to them using the gender-neutral pronouns ‘xe/xir’. Doing this is an attempt to trouble the gender-sex binary. It is also to avoid placing too much emphasis on the individual but to focus instead on thinking of the human as an entity-as-multiplicity. This approach will be further explained in Chapter 5.

Participants were given a one-page survey (see Appendix 2), which asked for their name, age, gender identity, nationality, birth place and religion/spirituality at the beginning of the first interview. I decided not to input any pre-determined answers but rather left the responses open-ended. The following table thus reflects *my participants’ responses*, rather than my own

designations. All their responses to ‘gender identity’ were binary and in ‘normative’ alignment with their names/gender-sex presentations. The table records age and year level at the time of the first interviews.

---

HUMAN PARTICIPANTS

Alias	Age	Gender Identity	Nationality	Birth Place	Religion/Spirituality	Degree	Year Level
Entity 1	22	Male	Sri Lankan/ Indian/ Australian	Iran	Catholic	Bachelor of Science/ Secondary Education	3
Entity 2	23	Male	Australian/ Brazilian/ Canadian	Brazil	Catholic	Bachelor of Science/ Secondary Education	3
Entity 3	20	Female	Australian	Australia	None	Bachelor of Arts/ Secondary Education	3
Entity 4	21	Male	Australian	Australia	None	Bachelor of Arts/ Secondary Education	3
Entity 5	26	Male	German/ American	USA	None	Bachelor of Science	2
Entity 6	25	Male	Australian	Australia	Atheist	Bachelor of Science/ Secondary Education	3
Entity 7	20	Male	Australian	Australia	Agnostic	Bachelor of Science/ Secondary Education	2
Entity 8	21	Female	Australian	Australia	Atheist	Bachelor of Science/ Secondary Education	4
Entity 9	22	Female	Australian	England	None	Bachelor of Arts/Secondary Education	3
Entity 10	21	Female	Australian	Australia	*Christian denomination	Bachelor of Science/ Secondary Education	2

Table 2: Human participants

\*Modified to protect identity

---

SESSION 1

The first interviews were conducted between September and November 2014 and were on average 60 minutes long. During this interview, I began with introducing myself and what led to my interest in this project. I then reiterated the overview of what my study is about, as was also included in the participants' consent forms. The initial formal questions included those about the participants' views of science and ethics, particularly focusing on the two topics of wind farms (renewable energy) and genetically modified humans. These two topics were chosen as they are often topics much discussed in news and in science education; therefore, I anticipated that the participants might already have given some thought to them.

I asked the participants to also consider alternative views to theirs, what in their backgrounds might be influencing their views, and how they might teach a class on these topics. This interview also involved a relatively detailed exploration of their general backgrounds and education history. This included first completing a diagram of cards I asked them to order from what they think has most influenced their views on either one of the ethical science topics—or both (depending on what they chose to do)—to what has least influenced them. This 'influence diagram' was an attempt to help the participants think about this idea. I took a photo of all the diagrams; an example of one is on the following page.

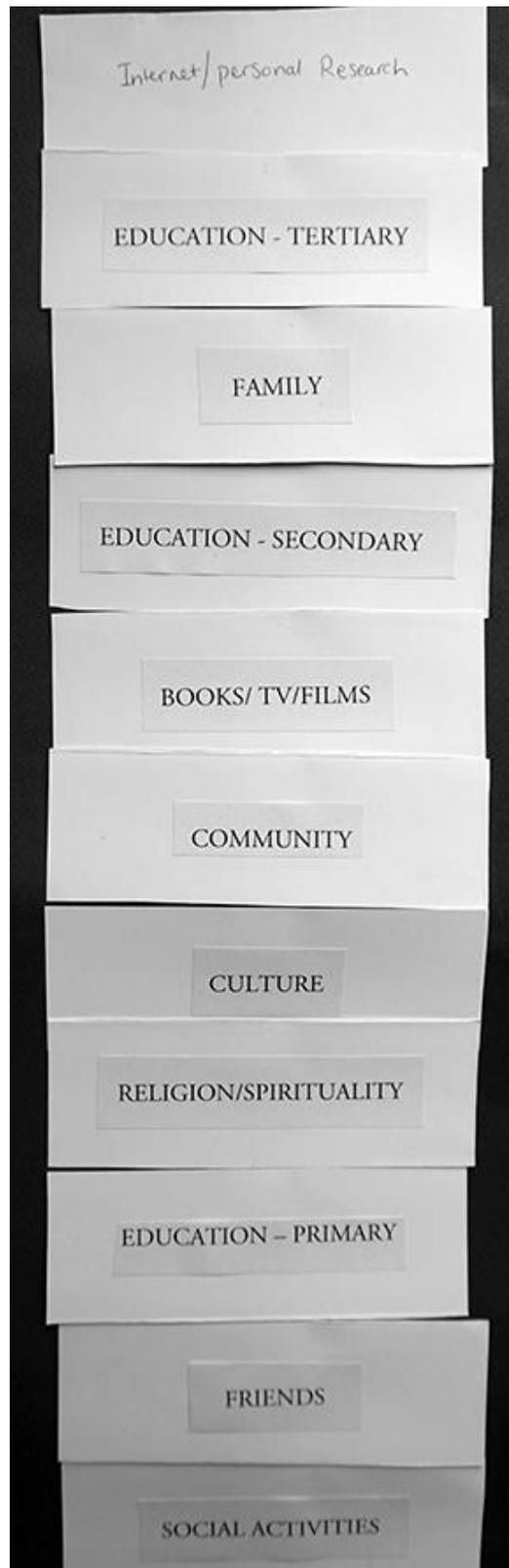


Figure 2: Entity 10's influence diagram

Along with the pre-made cards, I allowed for participants to create their own. For example, Entity 10 chose to add in ‘Internet/personal research’ at the top because as he related, he spent a lot of time reading online, such as randomly clicking through Wikipedia. How participants engaged with this activity was as interesting as the order they ultimately chose to place the cards. There were limitations to this activity, such as the overall impossibility to cleanly demarcate different areas of a person’s life. For example, how is ‘community’ different to ‘culture’? How is ‘religion/spirituality’ entangled with ‘family’? Nonetheless, the diagrams function as a gesture of relationality.

There was also an issue in the creation of a ‘hierarchy’. I addressed this in the second interviews, wherein I introduced my ‘assemblage map’ (presented in the next section). This map is based on this activity but showcases a more dynamic, non-hierarchical understanding of potential influences. Importantly, however, any attempt at mapping assemblages may always be exceeded by the dynamic and unstable nature of assemblages:

there is an inherent tension in the notion of capture of an assemblage, which, in a Deleuzian sense, is oriented towards movement rather than stasis, requiring cartographies of bodies, things and ideas as they assemble, disassemble and reassemble in fragmented and creative ways. They resist interpretation (Gannon, 2016, p. 132).

Other than this diagram, I also asked questions about participants’ families, schooling experiences, and general interests to gain an understanding of their backgrounds and their entangled becomings.

---

## SESSION 2

The second interviews were conducted in March 2015 and were also at the participants’ university. Nine interviews were conducted as one participant, Entity 3, was ill and was not able

to participate. The second interviews were on average 45 minutes long and were aurally recorded. The focus of these interviews were follow-up questions, either of aspects I wanted more detail on, questions I had left out, or ones that had arisen from the first interview initial analyses. For instance, one area I did not previously think to question the participants on was politics so I made sure to cover this in the second interview.

Some of the participants were as interested in my study as they were in the first interview, while others had seemingly lost interest, had not thought much about the study since the first interviews, and were less forthcoming. Consequently, six out of the ten participants, overall, provided me with more specific data to work with, while the other four provided general insights.

For the second half of the second interview, I asked the participants to complete a lesson plan exercise. This was a continuation of the questions in the first interview, concerning how the participants would teach a class on wind farms/renewable energy or genetically modified humans. To do this, I asked the participants to consider my ‘assemblage map’ that I created of possible influences involved in how beginning teachers’ might come to understand and think about the science-ethics nexus.

My complete mapping processes will be further outlined in the following section. Essentially, though, I created this assemblage map using the ‘mind mapping’ software ‘Freemind’<sup>18</sup>, based on the first interview data and concepts from relational posthumanism. The process of creating analysis maps led to the development of this assemblage map, depicting the combined potential entanglements behind the participants’ understanding and thinking around the science-ethics nexus.

---

<sup>18</sup> [http://freemind.sourceforge.net/wiki/index.php/Main\\_Page](http://freemind.sourceforge.net/wiki/index.php/Main_Page)

This assemblage map (included on the following page) was thus both an enactment of my initial analysis but was also utilised in the second interviews and therefore fed back into the analysis process. After the participants had time to look over this map, I then asked them to use one 'arm' of this map and attempt to relate it to teaching a class on either wind farms/renewable energy or genetically modified humans in two select-entry, single-sex Victorian secondary schools.

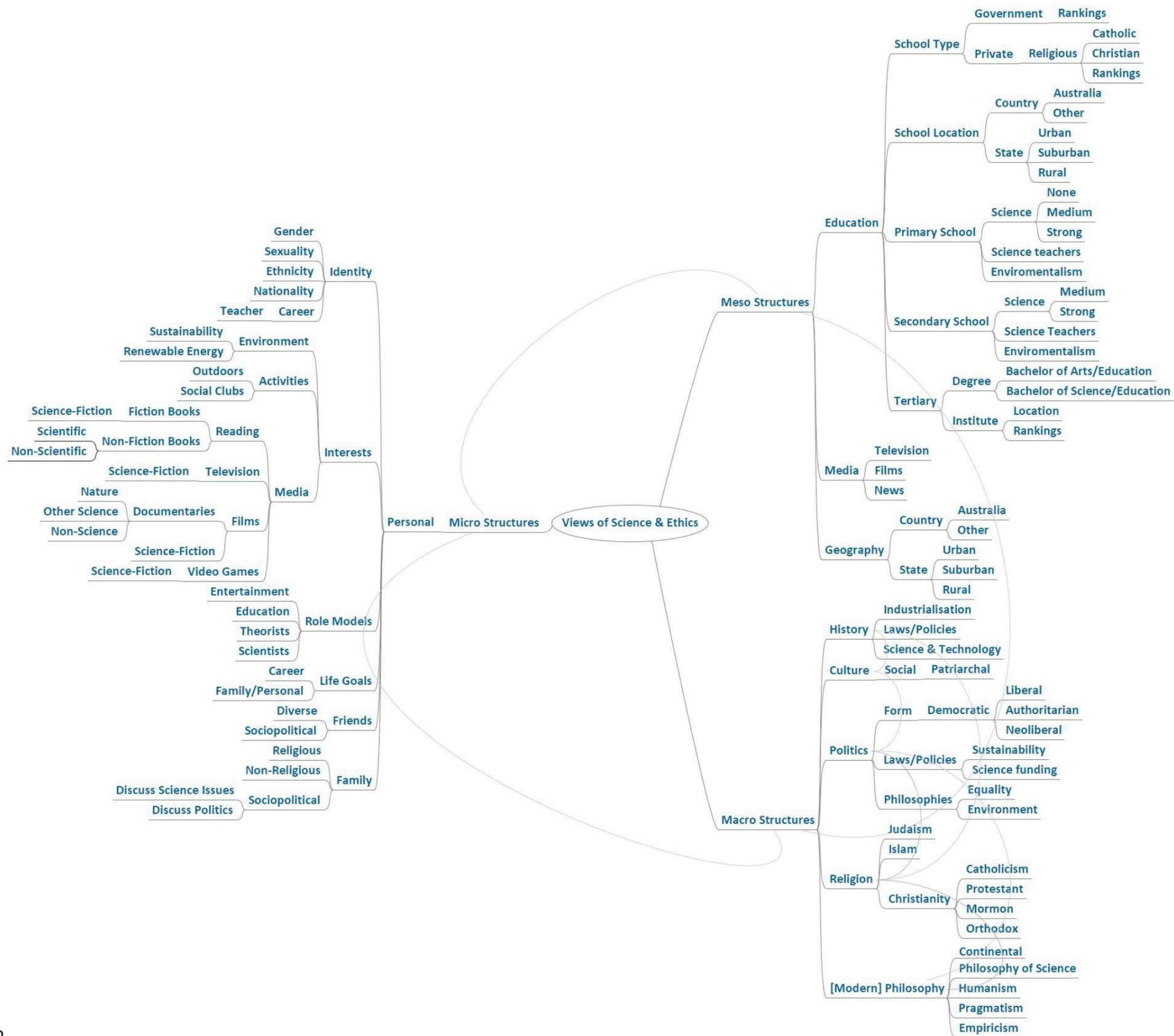


Figure 3: Assemblage map

There were two main aims for this lesson plan exercise. One was to determine if by using the two single-sex schools gender-sex would cause a 'diffraction' throughout their responses. The second was to examine how reference to the assemblage map, as inspired by relational posthumanism, would also influence them. That is, how it would influence them in general and how their responses might differ to the first interview questions. An example of a completed lesson plan exercise is included below:

Mapping Exercise  
Name: [REDACTED]  
Micro Structure Element: Micro > Personal > Interests > Media > films > Sci-fi.  
Renewable Energy of Genetically Modified Humans (circle) (GMH)  
Class 1: MacRobertson Girls High School (& Melbourne high school).  
Considering the film "Gattica", I might introduce the topic of genetically modified humans by (assuming it is a grade 12 biology class in which we have already engaged with the concepts in the "genetics" areas of study) asking how "possible" the students feel ~~generating~~ GMHs are, considering also what might need to be achieved scientifically (in a lab for this to be possible. Then maybe show them a clip or two from the film, and then discuss with the students whether they think GMHs would be "fair", & maybe an activity, depending on time, about ~~research~~ cloning to introduce the topic. i.e. have them consider the logistics of GMHs, and its relationship to the concept of ~~feedback~~ cloning, which is very possible & can be achieved. Then after this, I'd finish by bringing them back to the first question of how "possible" GMHs are, and can they see it happening in the near future.

Figure 4: Entity 10's lesson plan exercise

For example, Entity 10 chose ‘sci-fi films’ from the assemblage map, and specifically the film *Gattaca* (Niccol, 1997) to both discuss ethical questions with the hypothetical students around genetically modified humans, as well as the science of genetic modification, i.e. what is ‘possible’. Entity 10 rejected the idea of coming up with a different approach for the two schools. After this exercise was completed, I also asked the participants to verbalise their written responses.

---

## INTERVIEW ANALYSIS

My analyses of the interviews resembled my analyses of education materials but also involved some unique aspects. The similarities included again utilising a diffraction of relational posthumanist concepts with the interview data (my notes, the recordings, and transcripts). In acknowledging the ‘messiness’ of the human participants’ becomings, I also used the technique of ‘mapping’ to both synthesise the interview data, analyse it, and present some aspects of my analyses in the form of ‘views-assemblages’ maps. Overall, therefore, there are three maps for each participant. Mapping occurred to me as particularly suited to teasing out ‘rhizomic’ intra-actions/relationality and concept of territorialisation and de-territorialisation of assemblages, as inspired by those working with Deleuze and Guattari’s theory.

This process additionally acknowledges multiplicities. That is, that assemblages are never fully stable; affective flows temporarily stabilise an assemblage while others de-stabilise it. Thus, in this process, individual lives, societies, and the *worlding* of the world unfold (Fox & Alldred, 2015, p. 3). In my interview analyses, I do not assess a coherent, linear progression of participants’ becomings, but rather various contingent *potentialities*. For example, for Entity 1, I examine possible consequences of a tension between xir becomings as a science teacher and a Catholic in relation to xir views of science and ethics. These are not intended as an ultimate truth devised from xir interviews but rather considerations of the multiplicities involved.



wind farms/renewable energy. Under these sections, I began to consider some potential influences, such as xir family being ‘pro-environment’ and xir knowledge of genetics. I also noted ‘education’, ‘gender’, ‘ethics’, ‘media’, and ‘family’ as other potentially important aspects of the assemblage under examination. Notably, for xir ethics views, I noted xe considers ethics about science to be ‘controversial’.

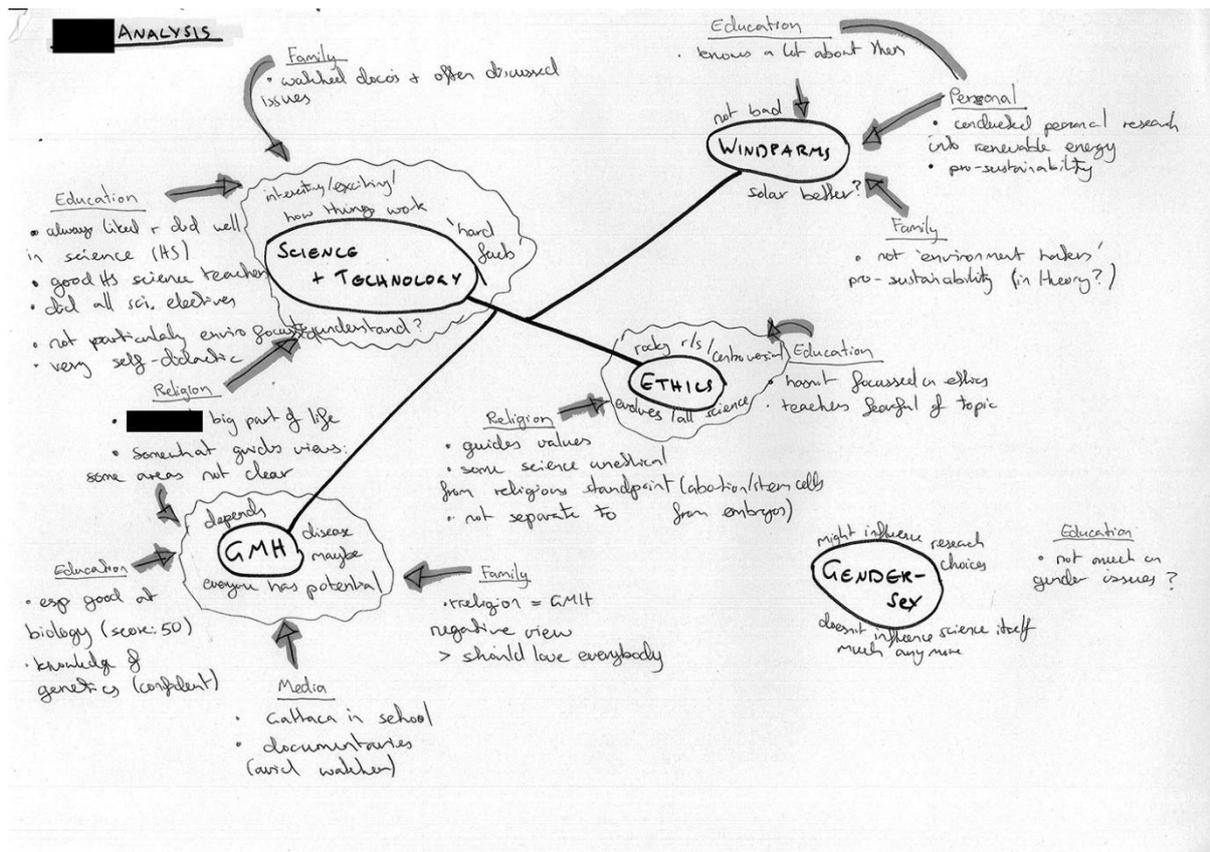


Figure 6: Entity 10’s analysis map

Entity 10’s analysis map showcases the development from the previous map to my making links between xir ideas, thoughts, feelings, and opinions with aspects of xir background, experiences, identities, and interests. For example, I consider Entity 10’s religious beliefs as especially entangled in xir ideas about ethics. Clearly, this map does not indicate all the possible links but is rather an attempt to highlight important becomings.

Lastly, to visually present my analyses of the participants' becomings for ease of comprehension, I created another series of maps, again using Freemind, highlighting aspects of my analyses of their science-ethics 'views-assemblages'. These views-assemblage maps are partly inspired by Fox and Alldred's textual illustrations of assemblages of various phenomena linked together with hyphens in a group. For example, an illustration of their 'ageing-assemblage' is:

Mr L – Mrs L – 'Springwood' residence – concrete and glass – health – medical facilities – care assistants – care plan – management – other residents – memories – fear/anxiety – Aged Rights Advocacy – government – money – national care policy – ageing population – time  
(Fox & Alldred, 2016, p. 30).

Overall, however, these maps do not form an inherent part of my process of analysis, nor do I propose they represent 'reality'. Rather, they are intended to serve as visual guide of my conception of the views-assemblages under examination and what I have focussed on in my analyses. An example of one of these maps is below:

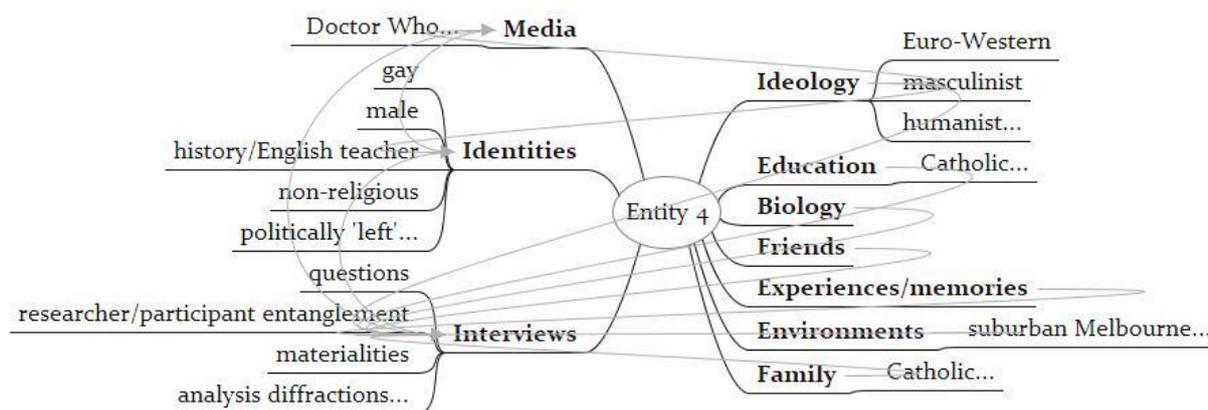


Figure 7: Entity 4's views-assemblage map

Not all elements of these maps relate to the focus of my analysis for Entity 4 but rather gesture to potential broad onto-epistemological elements of xir science and ethics views-assemblage. It is important to note that the 'research-assemblage' is also part of these maps, as

a reminder that my analyses are not inherent truths about the participants. Instead, they are the result of multiple diffractions, some of which include myself and the interview process, such as the questions asked, audio recording, and interview transcriptions. I also include ‘analysis’ as another diffraction. The ellipses and web of arrows are included to emphasise, symbolically, the incomplete and relational nature of these phenomena. In other words, it would be impossible for me to include all possible phenomena. Furthermore, while these phenomena are divided into categories they are not truly separate but rather come to be via relationality.

---

### CONCLUDING THOUGHTS

The framework of relational posthumanism involves renewed thinking in how the world is understood and how we understand ourselves, as ‘humans’, as *of the world*. Like some other frameworks, relational posthumanism does not propose that there is clean line between doing research and knowledge; data, and knowledge, are instead conceptualised as always in a process of becoming. Knowledge is developed via intra-actions and research can be understood as a specific type of knowledge that might be brought about by processes of diffraction. A relational posthumanist framework therefore acknowledges the limits of research and knowledge. For instance, that ‘the view that knowledge can be gleaned from observation of the world is itself founded in the anthropocentric privileging of human cognitive processes’ (Fox & Alldred, 2015, p. 5).

In this sense, knowledge is always considered a process of production. However, the difference relational posthumanism perhaps offers is that humans are not considered the primary ‘knowers’ and that knowledge involves more than discourse. As Linnea Boden argues:

The world is still understood as a construction, but not merely as a *social* construction. It [the ‘material turn’] is an onto-epistemological move to include what has been understood as peripheral or of less/no

importance in constructions of the world (Boden, 2013, p. 1119; original emphasis).

This re-framing of knowledge necessitates reconsidering how relational posthumanism, and related frameworks, offer alternative approaches to research methods. As I have argued, these alternatives need not be thought of as a ‘replacement’ of more ‘traditional’ methods but instead as an addition to the on-going discussions of this topic. It is perhaps more important to ask what methods might offer specific areas of interest, rather than determining that there is any one approach that is best overall.

In this chapter, I outlined how I utilise a combination of ‘traditional’ qualitative methods with gestures to alternatives posed by a relational posthumanist framework. This combines an alternative approach to understanding research ethics, data, and analysis, but also incorporates the potential benefits of creative research practice. For research ethics, I gestured to how relational posthumanism might expand on dominant ideas, via renewed thinking concerning scope of studies and the primacy of the human participant. For processes of data generation and analysis, this involves again de-centring the human, utilising ‘diffractions’ rather than representations, multiplicities/messiness, and assemblages.

Overall, the alternative approaches I utilise bring about a productive focus on areas not usually considered in this field of research, helping to expand how science and ethics in school education is conceptualised. My analyses of multi-data sources, including recognising complex material-discursive relationality, between and within these sources, helps conceptualise that assemblages are integral to how science and ethics is constituted in school education.

## CHAPTER 4: THE SCIENCE-ETHICS NEXUS IN AUSTRALIAN SECONDARY SCHOOLS

‘We’re running out of time!’ Jeorg had exploded at one point, in xir wheezy voice. Pax had almost laughed. They were always running out of time, so much so that time was a slinky thing that barely existed in xir mind. It slipped away like wet soap. Had it been a year or years since the last factory closed? When had they started to starve?

Pax slumped onto xir back. A small, tightly wound nugget of ferocity wanted to burst out of xir chest and shoot up, up and up, through concrete, rocks and dirt. To where? *This is purgatory, and we are neither alive nor dead. We cannot repent, we cannot return.* Pax knew little about the old religions. But Che, the oldest resident of Subhouse 451, and Pax’s only friend, had told xir once some of the stories; the stories about dying.

---

I take the posthuman predicament as an opportunity to empower the pursuit of alternative schemes of thought, knowledge and self-representation. The posthuman condition urges us to think critically and creatively about who and what we are actually in the process of becoming.

—(Braidotti, 2013, p. 12).

---

The broad provocations above, from my short story and Rosi Braidotti’s *The Posthuman* (Braidotti, 2013), frame this chapter. That is, the call for renewed ways of thinking about who or what we are becoming, especially in the face of concern about humanity’s increasing impact on the world. I take this gesture into the context of education about science in Australia. The constitution of science in Australian school education, and in other countries, often appears to cause significant controversy, above and beyond that of other subject areas. Russell Tytler

argues that ‘Science education in Australia, as in other post-industrial countries, is in a state of crisis’ (Tytler, 2007, p. 1).

In his report ‘Re-imagining Science Education’, which I analyse further later in this chapter, Tytler notes that despite decades of advocating for change by many researchers, academics, and teachers, science education in Australia remains largely stagnant (Tytler, 2007, p. 3). The obvious question, then, is why? What is it about school science that especially causes this reluctance, or resistance, to change? Tytler also proposes that there:

seems now to be a genuine mood for change among teachers, science policy makers at government level, and the science academy, as well as among that group of academic and reformist teachers who have been advocating and practicing change for some time now (Tytler, 2007, p. 3).

More recent reports, however, suggest that he may have been, unfortunately, too optimistic. Another report I analyse in this chapter, which Tytler also contributed to but was published six years later, ‘STEM: Country Comparisons’ (Marginson et al., 2013), identifies a range of ongoing issues. As noted in Chapter 1, these include inequality issues, students’ declining interest and performance in school science, a deficiency of teachers who have a science background, as well as limited opportunities and developments in teacher professional development, and for general reform.

Tytler’s report makes several suggestions for possible improvements, many that align with my research. I consider this more later in this chapter. To begin with, it is important to note that there have been some positive recent changes to the science-ethics nexus in Australian school education, with the development of the new national curriculum. For example, the cross-curriculum priority of ‘Sustainability’ (ACARA, n.d.<sup>f</sup>). Additionally, there is an enhanced focus

on sustainability, and humanity's impact on other species and environments in the science curriculum, especially in the stream 'Science as a Human Endeavour' (ACARA, n.d.<sup>e</sup>). This is one of three streams within the science curriculum; the other two are 'Science Understanding' and 'Science Inquiry Skills'. The 'Science as a Human Endeavour' stream includes 'Nature and development of science' and 'Use and influence of science'.

However, what I suggest in this chapter is that these changes are still constrained by 'traditional' underlying ideas and ideals about science and ethical matters. Therefore, relational posthumanism offers alternative provocations for changes to school education, especially as related to the science-ethics nexus. As noted earlier, I conceptualise the 'science-ethics nexus' as something beyond the boundaries of the specific science curriculum. Thus, the context of science and ethics in Australian school education is, in this chapter, also taken beyond the disciplinary specific science curriculum.

The relational posthumanist propositions that I address, firstly, change how the constitution of school science in Australia is thought about. This is then closely related to the ways in which the problems of Australian science education are understood. Considering this is in acknowledgement that how such problems are framed and considered important is not neutral. My second argument is that relational posthumanism emphasises the primary importance of the science-ethics nexus and how ethics is defined. Thirdly, these propositions inspire examination of issues not often brought into such discussions, such as humanism/anthropocentrism.

Lastly, relational posthumanism has also inspired my attempt to open this topic to broader methodologies. Thus, I draw on my background in creative writing and literature studies throughout this chapter. To do this, I utilise speculative fiction as another 'diffractive methodology' to illustrate, question, and provoke alternative ideas regarding the current

constitution of the science-ethics nexus in Australian school education. Specifically, this includes aspects of my story ‘The Beforetimer’ and Margaret Atwood’s novel, *MaddAddam* (Atwood, 2014).

There are three sections to this chapter. In each section, I utilise concepts from relational posthumanism to present a diffractive analysis. Each section also focusses on one area of my data generation processes, beginning with analyses of major research reports, then the Australian curriculum, and finally science textbooks. This segmented approach is to develop a relatively broad overview of the constitution of science and ethics in Australian school education, while also providing detailed examples for each area of interest.

My processes of data selection for this chapter involve rigorous attention to examples across all my data that highlight onto-epistemological issues. The following step is a choice of examples that are the best representations of such issues in Australian school education materials. In the first section, ‘Speculatively revaluating science in Australian school education’, I begin with a reassessment, from a relational posthumanist perspective, of the reasons given for the importance of science in education. I then reassess the widely identified problems of science education. In this section, I also demonstrate the relevance and provocations that speculative fiction offers, in the sense of relationality, or intra-actions.

In the second section, ‘Ethical ambivalence in the Australian curriculum’, I diffract the concept of a ‘posthumanist ethics’ to analyse how a Euro-Western cultural hegemony, also linked to masculinist ideals, is potentially entangled in the definition of ethics in the Australian secondary school curriculum. The addition of speculative fiction considerations here includes the potentiality of illustrating, via speculative fiction, the effects of this cultural hegemony in the distancing of ethics from science and humans from ‘nature’.

In the third section, ‘Anthropocentrism in science textbooks’, I bring together the two previous sections to present an argument regarding the presence of anthropocentrism in the Years 7-10 science textbooks published for the Australian curriculum. This involves special consideration of how anthropocentrism in these textbooks is implicated in the constitution of ethics. In this section, I utilise speculative fiction diffractions to illustrate how this fiction can function as an ethical manoeuvre that challenges anthropocentrism.

---

#### SPECULATIVELY REVALUATING SCIENCE IN AUSTRALIAN SCHOOL EDUCATION

The beginning of my diffractive analysis of the science-ethics nexus involves a broad assessment of how this nexus is currently constituted in Australian secondary school education. There is extensive research on the *epistemological* problems related to science and education, internationally and in Australia, as discussed earlier. The various issues I outline here are certainly not new charges, although some have been given more attention in research than others. The issues I cover include concerns about the relationship between the world, science, and education, as well as the consequences of hegemonic ideas and ideals connected with ‘Euro-Western’ culture and masculinist reasoning.

In the process of my fiction research practice for this study, I determined that speculative fiction is one method to illustrate that science, technology, and the world intra-act precariously. Subsequently, speculative fiction can also serve to illustrate why this is an area of concern. Speculative fiction can also illustrate how integral science and technology are for the way the world develops, exceptionally so in contemporary times. One such example is Margaret Atwood’s *Oryx and Crake* novel series. I focus here on the third and last novel of this series, titled *MaddAddam* (Atwood, 2014).

Atwood’s story is set in the not-too-distant future, portraying the before, during, and afterward of a bioengineering catastrophe (the ‘waterless flood’) in which most humans are

killed. Leading up to this event, Atwood's world is already spiralling out of control; most humans live in slums while the rich and wealthy live in security-controlled compounds. Genetic engineering seemingly has no restrictions, ethically or legally: 'Jimmy's early childhood was spent at OrganInc Farms, where his father was working on the pigoons – transgenic pigs with human material designed for transplants, including kidneys and brain tissue' (Atwood, 2014, p. xiv).

Atwood's trilogy describes a potential future. Her style of writing is dynamic, non-linear, and sometimes disjointed, but it also utilises thick descriptions. These thick descriptions contain the potentiality of an intimate audience-novel becoming, a material-discursive move into this imagined world. For example, Atwood defines the bioengineered human-like 'Crakers' with descriptive skill, so that their 'becoming' from the perspective of readers is likely to be aesthetically and affectively powerful: 'Their bodies gleam like gold-threaded spandex; huge pink kudzu moths are fluttering around their heads in living halos' (Atwood, 2014, p. 36).

There is nothing in Atwood's novels, scientifically or technologically, that is beyond the boundaries of possibility<sup>19</sup>. However, rather than just a simplistic warning of impending doom, they can be read as an in-depth ethico-political treatise on the becoming of humanity and the becoming of science and technology. Atwood's detailed descriptions, of both visual and other sensory characteristics, work on an affective level, having the potentiality to increase the intimacy between the ideas and themes in her novels with readers. As Estelle Barrett puts this:

language must connect with our biological processes, affects and  
feelings in a vital way if language is to take on particular meanings or

---

<sup>19</sup> Indeed, many elements of her trilogy, such as 'pigoons', appear to be becoming reality. For instance, it was recently revealed that scientists have successfully created human-pig chimeric embryos (Kaplan, 2017).

to affect us [...] language maintains the link between the semiotic and the symbolic, between discourse and our lived and situated experiences—our material being in the world (E. Barrett, 2015, p. 106).

Fiction, and in this case principally speculative fiction, perhaps contrasts in this sense to more straight-forward ‘non-fictional’ hypotheticals about where science and technology might lead the world. This is not to say fiction and non-fiction are completely opposite in this sense, but that fiction’s ability to imaginatively construct other worlds may entail a certain kind of affective potential.

Although not all elements of Atwood’s novels might be considered ‘posthumanist’, there is a posthumanist element that comes mainly from the various critiques of humanity’s manipulation of other species and the environment, and the challenges to humanity’s supposed superiority. In my story ‘The Beforetimer’ I also explore a common idea in much of speculative fiction: what happens if the negative consequences of science and technology become so great they completely change the world as we know it? Considering the issue of climate change, it is not difficult to see evidence of this already occurring.

Clearly, ‘The Beforetimer’ is much smaller in scope and complexity than Atwood’s trilogy. However, the depth is not as important as the process. That is, how my writing of this story functions for this study as a diffractive element along with my other data, part of which helps my thinking about world-science-education relationality. Although it is not explicitly stated in ‘The Beforetimer’, the potential catastrophic effects of climate change are what I imagined to be the cause of the cataclysm in this story. This is, again, one of the potentially powerful aspects of speculative fiction; for imaginatively examining the potentials out of the ‘multiplicities’ that currently make up the world as we know it.

In ‘The Beforetimer’ this future has led to there being only some human survivors who have found sanctuary underneath the ground: ‘*We’re grasping for a future that slid out of slack fingers. All the green things are dead and the world is dark*’. This is also hinted at from Cedar’s perspective, when xe recalls:

*What do you do when the storms come?* Cedar’s teacher’s voice echoed into the sudden silence. *We run, we hide, we run.* When the oldest generation were young, the storms had been worse and more frequent. They had swept up sand and loose dirt, blocking out the sun for days.

In the current world, a being like Cedar might still seem very far-fetched; however, genetic modification technology is perhaps a lot more advanced than most people are aware of, due to the current restrictions placed on the use of this technology<sup>20</sup>. There are continual questions about how such advanced technology will be regulated in the near and far future.

Writing this short story helped me to understand the crucial importance of considering world-science relationality in the context of education. I choose to include the extract from ‘The Beforetimer’, at the beginning of this chapter, because it is a significant moment of desperation as the last humans, living underground, are struggling to find a way to survive. In a similar sense, there are many assertions that we are in a period of substantial risk regarding how nations address scientific and technological effects on the world. Many signs, including specific scientific reports, currently indicate that without significant change in attitudes and behaviour, the negative effects of science and technology, combined with general human activities, will have irreversible negative consequences. For example, see the International Panel on Climate

---

<sup>20</sup> It is important to note that regulations vary from country to country, and are continually being modified. For example, the USA follows the Biotechnology Regulatory Services (USDA, 2016) while Europe has The European Regulatory System (GMO Compass, 2016).

Change assessment reports (Core Writing Team et al., 2015) and, for the Australian context, the ‘State of the Environment 2011’ reports (Australian Government, 2011). An important question therefore is; can education be one avenue through which to significantly examine, and actively change, humanity’s becoming?

Donna Haraway and Karen Barad discuss the entanglements between society and science in their work, not only in how science is enacted but the epistemological frameworks that constitute science. Such frameworks, of course, also feature in science education. For instance, Haraway points out that science is a ‘naturalcultural’ practice constituted by apparatuses of knowledge production (Haraway, 2004, p. 212). She argues that science *is* culture (Haraway, 2004, p. 135) and that ‘knowledge is *always* an engaged material practice and never a disembodied set of ideas’ (Haraway, 2004, p. 199; original emphasis).

Barad expands on these ideas by pointing out that knowledge-making practices are intrinsically ethical and material-discursive, as well as how such onto-epistemological entanglements are involved in *worlding*. That is, how the world relationally develops: ‘entanglements are actual configurations of the world, not simply epistemological connections’ (Barad in Juelskjær and Schwennesen, 2012, p. 20). I differ on this point slightly, in the sense of advocating caution about reinstating a humanist-era assumption that theory ‘reveals’ the world, rather than its usefulness as a conceptual tool. Consequently, I see the concept of entanglements as such a tool rather than an essential ‘truth’ of the world.

It is my contention that a relational posthumanist lens makes it necessary to examine this world-science relationality as crucially important for understanding the world’s development. Additionally, I see it as specifically relevant for the science-ethics nexus in school education. Relational posthumanism also offers an alternative way of understanding this relationship; *as intrinsically relational*. Taking from Barad’s theory, it can be perceived that

science, school education, and the world ‘intra-act’ (Barad, 2007, p. 33). They do not precede each other but rather come to be via relationality. Within my data on Australian secondary school education, there are moments when the importance of the world-science relationship becomes apparent. Equally though, this inherent relationality is also often taken over by, or in tension with, other concerns.

I now turn to an examination of what relational posthumanism offers regarding understanding the problems of science in Australian school education. This includes attention paid to relationality between the world, science, and school education, as well as what significance these problems have for the science-ethics nexus. While I analyse all my data for understanding the world-science relationship, the major research reports I examine provide a good overview of how this understanding is broadly framed in the context of Australian school education. I utilise Barad’s concept of ‘intra-action’ to diffractively analyse these reports in terms of how the authors frame the importance, and problems, of science education, as well as how the data they include frames such issues.

To begin, I address how these major research reports have framed why science education is important. The reasons given for why science education is important in Australia is a significant aspect of world-science-education relationality, the way the problems of science education are understood, and the science-ethics nexus. While many motives are given for the importance of science education in Australia in the ‘STEM: Country Comparisons’ report (Marginson et al., 2013), the explanations given for the inception of this report and what it mainly focusses on is very much an economic imperative.

Specifically, the concern is about how school science is seen to be essential for ensuring there are enough students who take up careers related to science, technology, engineering, and mathematics. This is stated in the executive summary of this report:

The essential mission of the STEM: Country Comparisons project is to discover what other countries are doing to develop participation and performance in the disciplines of science, technology, engineering and mathematics (STEM), and the take-up of STEM in the labour market and research system (Marginson et al., 2013, p. 12).

Additionally, in the introduction, the authors state that this report builds on ‘recent research commissioned by Australia’s Chief Scientist<sup>21</sup> to investigate the health of Australian science *and identify STEM skills shortages and capacity constraints*’ (Marginson et al., 2013, p. 28; emphasis added). The economic imperative permeates the rest of the report, not only in framing the main importance of science education, but also in how problems of science education are identified, along with the suggestions to overcome them. The authors seem to agree with international trends, by noting that governments around the world see STEM in school as necessary for national development (Marginson et al., 2013, p. 14 & 94)<sup>22</sup>. This is the case not only for STEM-specific careers but others as well, such as management and finance occupations.

The authors also contend that the goal of improving STEM school education need not be separate from issues of equity. They point out that the Organisation for Economic Co-operation and Development’s (OECD) ‘nations/systems’ (their term) that have achieved the best results in international assessments of science education also have the least underperformers (Marginson et al., 2013, p. 14). Their list includes, for example, Shanghai in China, Finland, and Switzerland. Due to the lack of further clarification or more in-depth

---

<sup>21</sup> ‘Australia’s Chief Scientist provides high-level independent advice to the Prime Minister and other Ministers on matters relating to science, technology and innovation’ (Australian Government, n.d.)

<sup>22</sup> See Appendix 3 for these examples in full.

explanation of this, there are many unanswered questions, such as: what kind of inequities did these ‘nations/systems’ have to begin with? Are they comparable to Australia? However, the main important consideration here is that the authors continually forefront this economic imperative, in which equity concerns are subsumed.

Tytler takes a somewhat different perspective in his individual report ‘Re-imagining Science Education’ (Tytler, 2007). Although he acknowledges an economic imperative, he argues for a somewhat broader emphasis:

It is the pipeline into this pool of [scientific and technological] expertise that seems in danger of drying up. The concern is thus largely economic, but as this review will point out, the issue is wider than this, and encompasses the need to maintain a citizenry that is literate in and well disposed toward science (Tytler, 2007, p. 1).

Throughout the rest of this report, Tytler includes several initiatives towards a more ‘humanistic’ scope for science education (Tytler, 2007, p. 10, 17, 19, 23 & 30)<sup>23</sup>. Humanistic, in this context, appears to mean one that considers social and ethical considerations and how science might be made more ‘personal’ for students. For instance, drawing on various studies, including his own, Tytler argues that along with an ‘economic purpose’ science education should also include a cultural, democratic, personal development, and utilitarian purpose (Tytler, 2007, p. 19). Tytler’s definition of ‘humanistic’ therefore appears to be different from the ‘humanism’ that posthumanism puts pressure on. Nonetheless, Tytler does not put critical emphasis on what ‘humanistic’ means.

---

<sup>23</sup> The full quotes are in Appendix 3.

Although Tytler uses different terminology, he does however also mention some degree of relationality as an important aspect of science education. This is present in the discussion of the renewed understanding of the nature of science and sociocultural perspectives. For instance, he argues that ‘the curriculum should strongly represent the way science interacts with society and technology and include concepts such as risk and questions of value and ethics’ (Tytler, 2007, p. 64). However, it is questionable how far this can go if such content remains anthropocentric. Such suggestions like Tytler’s may put pressure on ‘traditional’ modes. However, if anthropocentric (and other) values are not considered, the question is whether such potential or actual changes go far enough.

An important question is, then, is it possible to go a step further from what Tytler suggests, to consider a ‘posthumanist’ science education? Furthermore, might such an approach be ethically necessary for the 21<sup>st</sup> century? Can we consider a different becoming of humanity, as present in science education, which is not based on what Braidotti calls ‘the image of Man as a rational animal endowed with language’ (Braidotti, 2013, p. 143)?

From a relational posthumanist viewpoint, an emphasis on an economic imperative for education about science is concerning for several reasons. While economic concerns are important<sup>24</sup> an undue emphasis on them might well be limiting. It is likely that an economic imperative, as it is widely understood, drives a science education based on ‘disciplinary science interests as opposed to students’ and society’s interests’ (Tytler, 2007, p. 22). Not to mention the interests of the world as a relational whole. Consequently, it seems likely that an economic

---

<sup>24</sup> This is particularly so regarding the broad context of the scientific professions in Australia. Indeed, there is evidently great conflict in an apparent drive for science education towards producing professional scientists to contribute to Australia’s economic prosperity, and the continual reduction or stagnation of funding for the scientific industry by the Australian Government. This has led to many job losses, as well as Australian-based scientists moving overseas or changing careers (Scott & Griffiths, 2016).

priority driving science education may lead to the relational and ethical dimension of science being given much less credence.

I agree with many of Tytler's assessments for the broader scope of science education's importance and purpose; however, I argue that relational posthumanism places much more emphasis on an *ethical* imperative. It also inspires a renewed definition of ethics and a critique of the primacy of human exceptionalism (anthropocentrism) associated with ethical concerns. Relational posthumanism suggests that school education is, relationally, an intrinsic and important aspect of how science, and the world, intra-act. Thus, it can be considered that how science education is constituted has consequences for world-science intra-actions. This includes the way people understand science, the implications of science in the becoming of the world, and the relationship with ethics.

Haraway's statement that 'ways of life are at stake in the culture of science' (Haraway, 2004, p. 69) can also be extended in this sense to the culture of science translated in school education. A 'posthumanist' perspective on science education therefore focusses on the relational aspect of science and technology, and does not place human benefits and concerns at the centre: 'Posthumanism doesn't presume the separateness of any "thing," let alone the alleged spatial, ontological, and epistemological distinction that sets humans apart' (Barad, 2007, p. 153). Consequently, the ethical focus is on 'a sustainable livable world for mutual flourishing' (Barad in Juelskjær & Schwennesen, 2012, p. 16). While what this means specifically may not yet be comprehensively determined, this positioning shift is still useful in reassessing science in school education.

Tytler acknowledges that one basis of attempting to reform science education is tenuous; that is, the idea that citizens of today require specialist science knowledge. In contrast to this is the argument that, with the way technology has advanced, the public require *less*

specialist knowledge to use, and benefit from, technology: ‘it is clear that many citizens in technologically advanced societies operate very effectively, with only very rudimentary science understandings’ (Tytler, 2007, p. 21). Tytler covers many of the limits of this ‘science literacy’ argument, pointing out for instance that the term ‘literacy’ itself is questionable due to its ambiguity.

However, one aspect that he does not consider in detail is an argument that enforces the importance of science education. This is not for specialist technological knowledge, nor even individuals being able to engage in ‘socioscientific’ debate. Instead, this aspect is the acknowledgement of the broader consequences of humans as inherently entangled with social and ethical consequences in their day-to-day encounters with technological and scientific advancements. Furthermore, in a posthumanist sense, such consequences must go further than understanding this as an issue only for humans, but rather the sustainability of the world as a relational whole, as Barad argues.

As indicated, the ‘STEM: Country Comparisons’ report (Marginson et al., 2013) is skewed towards certain values, based as it is on the main value of an economic imperative. This value has significance for the way this report addresses the identified problems within Australian science education. Indeed, very little attention is paid to ethical concerns, or to increasing the relationality between science and the world in the context of education. In other words, how science affects society, and vice versa. In fact, the term ‘ethics’ is not mentioned at all in the 180 pages of the report and the connections made between science and sociocultural/socioscientific issues are very limited, most often characterised as individualist benefits to better get by in the world. Individualism here refers to putting the individual first before more collective concerns.

For example, while the authors include reference to social goals and benefits, these still circle back to an emphasis on the individual as well as economic benefits. In the section ‘Generic

role of STEM’ they state that science and mathematics in school education is ‘a powerful intellectual formation that can be foundational to many different kinds of *individual achievement*’ (Marginson et al., 2013, p. 69; emphasis added) and that ‘Preparing students in STEM helps to prepare them to be good citizens and persons *able to shape the course of their own lives*’ (Marginson et al., 2013, p. 68; emphasis added).

Furthermore, following consideration of the STEM skills students might need, such as understanding of ‘global warming’, the authors immediately follow this observation by stating ‘More specifically, in terms of the economy, we need an ever-growing proportion of the workforce to have quantitative and symbolic skills and basic scientific knowledge’ (Marginson et al., 2013, p. 69). Thereby, once again, returning such considerations back to an economic imperative.

The suggestions made for overcoming the problems of Australian science education are also questionable, particularly because this report does not acknowledge broader complexities and concerns. To present an example, I draw attention to where the authors identify an issue with diversity in science education, and mainly note the poor performance and low numbers continuing with science of female-identified and Indigenous students. The authors treat this primarily as an issue due to less students overall continuing with science, and thus into a scientific career. In stating the goal of improving students’ attitudes to science and mathematics, this is followed by ‘and to STEM-related work and careers’ (Marginson et al., 2013, p. 21).

In similarity to much research literature, the suggestions made also largely recommend an ‘additive’ approach to science education, to supposedly better attract female-identified students and Indigenous students. The authors state that there should be:

inclusion, in curriculum resources, of materials that speak to the identity needs of the diverse range of students. This includes girls (e.g.

science material related to health, or the environment.), Indigenous students (e.g. materials that embody respect for Indigenous knowledge), and contextual science that relates to youth interests (Marginson et al., 2013, p. 21).

It is not made clear why material related to health and the environment should, or supposedly does, appeal more to girls. Such a statement is problematic by not only reinforcing stereotypes about girls but also by suggesting that boys and people of other genders (not acknowledged in this report) are not concerned with health and the environment. It is also problematic to suggest that the inclusion of Indigenous knowledge might *only* be a concern of, or benefit to, Indigenous students. This suggestion, however, is mainly a concern because it advocates a surface-level additive approach. Subhashni Appanna, an Australia-based researcher in this space, argues that cultural additive approaches ‘have often resulted in tokenistic inclusivity in that they produced caricatures of cultural knowledge’ (Appanna, 2011, p. 19).

Tytler notes that previous attempts to emphasise the relationship between science and the world, via Science-Technology-Society (STS) and Science-Technology-Society-Environment (STSE) developments, as outlined in Chapter 1, ‘like previous calls for change, [...] have not been successful in challenging the disciplinary status quo’ (Tytler, 2007, p. 18). These developments remain marginalised against ‘traditional’ approaches, which focus primarily on technical knowledge (Hughes, 2000) and, as Tytler argues, ‘sequential conceptual understandings’ (Tytler, 2007, p. 13). Relational posthumanism highlights that an additive approach treats these STS and STSE issues as just one aspect of learning about science, rather than emphasising an intrinsic relationality. The consequence of this is that such issues are marginalised from the outset.

Another posthumanist provocation regarding how the problems of science education are addressed, is by reconsidering the dilemma of students' declining interest in learning science in school. Several studies addressed in major reports note various factors to explain why Australian secondary school students develop negative feelings towards school science, and often choose not to continue with it past compulsory years. One of the most recognised reasons is due to a disconnection with what is taught in school science and the world, including particularly students' localised experiences of the world.

As noted in a report on the status and quality of Year 11-12 science in Australian schools, 'Some non-science students report that if science was more 'interesting and relevant to their lives' then they would consider enrolling in it' (Goodrum, Druhan & Abbs, 2012, p. 23). Tytler also supports this, by stating that 'Students' negative view as to the relevance of science course content for their lives was a strong theme in the report' (Tytler, 2007, p. 8).

The struggle for proponents to have the STS and STSE developments be incorporated substantially into school science has demonstrated the difficulty of 'additive' approaches. Correspondingly, adding into science education various aspects that might appeal to the interests of secondary school students could also continue to be marginalised against 'traditional' content. In contrast, it is possible that a relational approach to science education could be successful in shifting the 'traditional' foundations. This might mean that, at all levels, content and learning of science in education could always be contextualised, and learning for students could also be a material-discursive endeavour, overtly linking themselves to their localised and contextualised experiences, with *knowing-being-of-the-world*.

As an example, Tytler argues students should learn the periodic table, not as a set of facts but for understanding the processes of ordering properties of materials (Tytler, 2007, p. 41). From a relational posthumanist perspective, such a lesson would also require relational

context. In other words, the periodic table and what it represents could be related to broader society and students' day-to-day environments and encounters. Furthermore, the knowledge, categorising, claiming, and use of the elements would include an ethical dimension.

Science education might also, in a similar sense, be more relationally developed with all other major subjects in school, to break down the borders within which it has long been contained. As Tytler includes in his report: 'Unfortunately, science education has been inclined to isolate itself from the rest of education and has tended to be separated by society into its own subculture' (High Level Group, 2004, as cited in Tytler, 2007, p. 12). I will expand further on these ideas in Chapter 6.

Lastly, it is also potentially informative to consider the relationality between the identified problems of Australian science education. It is beyond the scope of this study to present a detailed analysis of this but I include this gesture towards the benefits of 'relationality' as a way to appreciate the intrinsic connection of the issues. For instance, the influences behind why there is a disconnection between school science and the world might be considered in relation to why students have declining interest in school science. It might be that students *require* such connections to be motivated to learn science.

Additionally, from the perspective of understanding implicit intra-actions, attempting to isolate a problem, or addressing any one problem without relation to others, also seems unlikely to be successful in the long term. Overall, this framework reinforces an understanding of the various intra-active, or 'onto-epistemological entanglements', potentially at work. Consequently, this highlights how shifting away from 'traditional' science education, and thereby bringing science education in line with 21<sup>st</sup> century needs, may well require a more relational approach.

---

## ETHICAL AMBIVALENCE IN THE AUSTRALIAN CURRICULUM

In this section, I examine ethics as it is defined in the Australian secondary school curriculum. Specifically, my attention is mainly on the ‘General Capabilities – Ethical Understanding’ section, with some consideration of the science curriculum. It is important to note that my analysis of the General Capabilities has focussed on the 7.5 version of the curriculum. In version 8.3, the most recent to date, the content is largely the same as 7.5 but the supporting information has been heavily reduced. For example, there is no longer a document that includes the background, or references, to ‘Ethical Understanding’.

For this analysis, I use the concept of ‘posthumanist ethics’ diffracted throughout the curriculum data to examine what emerges. Or, as Barad puts this, to see ‘how different differences get made, what gets excluded, and how those exclusions matter’ (Barad, 2007, p. 30). My analysis highlights that overall there is an ambivalence, or lack of clarity, as to how ethics is defined. Additionally, however, there are also implications of Euro-Western, and masculinist, hegemony in the emphasised ideals about ethics.

In Chapter 1, I discussed feminist theory that highlights how cultural hegemony and gender-sex are entangled in science (and, consequently, science education). For instance, that:

Feminist philosophers, historians, and sociologists of science have demonstrated how science has grown out of a Western male tradition that celebrates objectivity, distance, power, and technological progress, and is often used to support social injustice and the status quo (Richmond, Howes, Kurth & Hazelwood, 1998, p. 916).

I also observed, however, that issues to do with cultural hegemony in science education are more typically related to the exclusion of marginalised students rather than the *epistemological* foundations. In Australia, for example, it has been stressed that Indigenous students are less

likely to do well in science, and are less likely to continue with science, than non-Indigenous students: ‘Previous research has shown that indigenous [sic] students in Australia do not enjoy equal educational outcomes with other Australians’ (McConney, Oliver, Woods-McConney & Schibeci, 2011, p. 2017).

While this is a very important concern, in this section I utilise relational posthumanism to consider the relationship between cultural hegemony, onto-epistemology, and the science-ethics nexus. This area, as previously noted, has been given much less attention in education research. I suggest that focussing on this aspect of science education still has great significance for the exclusionary nature of Australian science education for Indigenous students, as well as those who do not have a Euro-Western cultural background. However, it is beyond the scope of my study to address this specifically.

Additionally, when it comes to issues of gender-sex, the main research trajectory is often a focus on discrimination, individual gendered experiences of school education, and unequal gender representation in those continuing with post-compulsory science. While also worthwhile foci, what I focus on is how gender-sex, and principally masculinist hegemony, are onto-epistemologically implicated in how ethics is defined in the Australian curriculum.

For the most part, while gender-sex features relatively strongly in feminist materialist and posthumanist research, others using these frameworks do not often focus on cultural issues. Indeed, as pointed out in my dissertation’s introduction, those using these frameworks are mainly from a Euro-Western background (like myself) and such research is mainly being undertaken in Euro-Western countries (Hinton et al., 2015, p. 4). Consequently, this lack of attention to cultural matters, as well as my encountering related research into indigenous ways-of-knowing, have led me to enact this analysis.

Firstly, I outline how broadly there is ambivalence in the way ethics is defined and thus 'becomes' in the Australian curriculum. In examination of the reference list, for the section 'Ethical Understanding', I note that there are references from different disciplines, different schools of thought, and significantly different time periods. The theory, and theorists, referenced are a mixture from philosophy and psychology disciplines. The list includes ancient Greek philosophy, specifically Plato, Aristotle, and Aquinas, as well as German philosopher, Immanuel Kant. It also includes a handful of more contemporary Australian philosophers, including Peter Singer. From the field of psychology, the list includes American psychologist, Lawrence Kohlberg, and Australian education psychologist, Dennis M. McInerney (ACARA, n.d.<sup>a</sup>).

This scope of theory drawn on to define ethics in the Australian curriculum is expansive, in terms of time and disciplinary areas. However, it is also clear that, culturally speaking, this list of references, and consequently the ideas and ideals included, significantly lacks diversity. Indeed, the one major thing that might bind the resources used is a Euro-Western cultural background. It seems evident, therefore, that the way ethics is defined in the curriculum is culturally skewed. The significance of this can be further elaborated on by a diffractive analysis of specific sections.

My analytical method of diffracting relational posthumanist concepts through the curriculum has led me to speculate that not only is there a Euro-Western cultural hegemony in how ethics is defined, but that some sections of the curriculum reinforce specific ideals about ethics. This includes understanding ethics as an 'abstract' topic and the Cartesian mind/body split. It also includes the supposed stable ground of objective 'reason'. As Braidotti argues:

Faith in the unique, self-regulating and intrinsically moral powers of human reason forms an integral part of this high-humanistic creed,

which was essentially predicated on eighteenth- and nineteenth-century renditions of classical Antiquity and Italian Renaissance ideals (Braidotti, 2013, p. 13).

Due to the messy nature of accounting for historical developments, I do question how clear we can be concerning an historical account of idealising ‘reason’, in the manner argued by Braidotti. Nonetheless, the way ‘reason’ is often characterised and understood is in relation to Euro-Western philosophy.

What I mean by ethics as an ‘abstract’ subject is that ethics is primarily constituted in the curriculum as a subject that can be debated without a context given, without much reference to everyday processes, and without connections made to matter/materiality/bodies. There is also little consideration of subjectivity. I first highlight the following beginning statement, from the ‘General Capabilities - Ethical Understanding’ section: ‘students develop ethical understanding as they identify and investigate the nature of ethical concepts, values and character traits, and understand how reasoning can assist ethical judgment’ (ACARA, n.d.<sup>a</sup>). This continues with the vague definition that ethical understanding involves students ‘building a strong personal and socially oriented ethical outlook’ (ACARA, n.d.<sup>a</sup>).

From the outset then, what it is to ‘develop ethical understanding’ is not specific. There is a circular or tautological interpretation, whereby ethical understanding is related to an ethical outlook but neither of these is specified. This beginning statement is followed by similarly ambiguous declarations. For example, that ‘Building ethical understanding throughout all stages of schooling will assist students to engage with [...] more complex issues’ and ‘Students learn to behave ethically as they explore ethical issues and interactions with others’. Additionally, that:

As ethics is largely concerned with what we ought to do and how we ought to live, students need to understand how people can inquire collaboratively and come to ethical decisions (ACARA, n.d.<sup>a</sup>).

These extracts have in common a lack of specificity and a lack of contextual examples of, for instance, what an ‘ethical issue’, instance of ‘ethical behaviour’, or an ‘ethical decision’ actually is. Consequently, the circular logic and abstractness continues throughout.

A further issue is that ethics in the curriculum overall is also often referred to as a subject that is only applied to specific ethical issues or areas. For example, ‘ethical issues’ mentioned include ‘animal rights [and] environmental issues’ and ‘global warming, sustainable living and socioeconomic disparity’ (ACARA, n.d.<sup>a</sup>), as stated in the ‘Ethical Understanding’ section. Furthermore, in the overall structure of the science curriculum, ethics is incorporated in only two main ways; in relation to potentially being relevant for science and technology solutions, as well as doing science experiments.

Under ‘Science as a Human Endeavour’ it states that ‘Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and *may involve ethical considerations*’ (ACARA, n.d.<sup>c</sup>; emphasis added). Additionally, under ‘Science Inquiry Skills’ it is stated that students ‘Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and *ethical guidelines* are followed’ (ACARA, n.d.<sup>c</sup>; emphasis added). The ‘ethical guidelines’ are not further explained.

I suggest that this understanding of ethics, as limited to certain areas and issues, may be a legacy of Euro-Western and especially Cartesian ideals. As subject is split from object, and mind from body, so too is ethics split from everyday materialities and becomings. In contrast, relational posthumanism understands ethics as ‘a system of relation’ (McCormack, 2012, p. 2),

whereby ‘ethics takes us away from the God toward which humanist metaphysics aspires — be that capital, logic or religious dogma - toward the flesh which constitutes life’ (McCormack, 2012, p. 4). I extend this thinking in the following chapters.

There are some suggestions in the curriculum of more relational ideals to those examined thus far, such as that students will be facing a ‘world of competing values, rights, interests and norms’ (ACARA, n.d.<sup>a</sup>). It is also stated that ‘there is need for an open-minded, ongoing endeavour to create an ethical life’ (ACARA, n.d.<sup>a</sup>). However, it is difficult to understand what these broader considerations mean exactly, again due to what is largely an ambiguous circular logic. What might be competing values is not further defined and what an ‘ethical life’ might be is not further explained. Consequently, although the ambiguity of these statements means it is difficult to say definitively, it might be inferred from the curriculum’s definition of ethics that there is only, ultimately, ‘one’ way to be ethical, and ‘one’ way to live ethically.

As a result of my diffractive analysis, I also identify the focus on ‘reason’ as an instance of Euro-Western and masculinist influence. As per the beginning statement in ‘Ethical Understanding’ it ends with the contention that students should ‘understand how *reasoning* can assist ethical judgment’ (ACARA, n.d. <sup>a</sup>; emphasis added). Additionally, it is stated that ‘Ethical understanding can be informed by *reason*, character, values and ethical principles’ and, further, that Plato, Aristotle, Aquinas, Kant, and Peter Singer ‘identified the importance of *reason* as a human attribute’ (ACARA, n.d. <sup>a</sup>; emphasis added).

As previously discussed in Chapter 1, the concept and definition of ‘reason’ can be related to masculinist hegemony, implying a ‘view from afar’ form of supposed objectivity. As Haraway argues, science’s ‘masculinity seemed more and more simply the nature of any non-dependent, disinterested truth-telling’ (Haraway, 2004, p. 232). However, it is also associated strongly with

Euro-Western characteristics and particularly ‘Enlightenment-era’ philosophy. Braidotti argues that:

By virtue of the economic, cultural, and symbolic importance that Western culture has attributed to sexuality, it follows that gender and sexual difference have historically evolved as a primary—though by no means unique—site of the constitution of subjectivity (Braidotti, 2012, p. 38).

Indeed, from a relational posthumanist viewpoint, masculinist and Euro-Western characteristics intra-act to produce the definition of ‘reason’ that the curriculum appears to be utilising. That is, this form of reason relies on the separation of the mind from the body, and especially emotions. To be ‘reasonable’ is, therefore, a state of supposed objectivity, of being ‘neutral’ to the potential implications of identity, emotions, culture, environment, and bodies.

Once more, there is some ambivalence here, as the ‘Ethical Understanding’ area also does mention that ‘principles, concepts, experiences, senses, emotions and reasoning’ (ACARA, n.d.<sup>a</sup>) are involved in ethical ‘judgements’. However, this is followed by an emphasis again on ‘reason’, by the requirement for students to develop ‘their practical *reasoning* abilities associated with their thoughts and actions’ (ACARA, n.d.<sup>a</sup>; emphasis added). This, therefore, suggests that ultimately reason rather than emotions, experiences, and senses, is primary.

In addition to my curriculum focus, the implications of the Cartesian separations and Euro-Western ‘reason’ is significant for this study’s overall becoming. This is so especially regarding how I draw on speculative fiction to consider implications of cultural hegemony in the science-ethics nexus. For example, the implications of cultural issues led me to be more conscious of my speculative fiction creative writing in combination with cultural entanglements. Undoubtedly, my writing of ‘The Beforetimer’ was much more influenced by my

reading and watching of Euro-Western speculative/science fiction than fiction with a more diverse cultural background. That said, I intended to include elements in ‘The Beforetimer’ that interrogated aspects of Euro-Western philosophy. Consequently, this serves as a demonstration of how speculative fiction can be utilised as an ethical manoeuvre in this space.

In ‘The Beforetimer’, the character of Cedar, and the *Homo adaptos* generally, were very much influenced by my appraisal of critiques of Euro-Western ideals, especially those that distance humans from nature. I therefore incorporated a sense of an intrinsic relationship with nature that Cedar and xir kind has, as well as an intrinsic awareness of the balance required within ecosystems:

There was a saying amongst Cedar’s kind. *If a tree cannot bend in the wind, it will break.* In fact, it was more than a saying, but a relationship of the world that they all upheld. They also said *if it has no harmony, it cannot exist.*

My intention here is an attempt to highlight that the Euro-Western-influenced negative associations concerning intrinsic relationships between humans and other species, and ‘environments’, is ethically problematic. Specifically, it is an enactment of a ‘humanist’ violence, which promotes an impossible divorce between humans and the rest of the world. This divorce may be impossible but its idealisation still has significant consequences for the world, particularly in relation to the science-ethics nexus.

If humans are considered different, or special, then our ethical culpability is drastically skewed. This is demonstrated in our still largely unheeded destruction of the environment and the consequent increasing rates of extinctions of other species. Markedly, it is claimed that Australia has one of the highest rates of human induced extinction in the world (Rule et al., 2012; Woinarskia, Burbidge & Harrison, 2015). Furthermore, troubling how we think about

knowledge, in the sense of onto-epistemology, also carries over to issues of culture: ‘We need to remember that the subject/object split inflicted by the legacy of Descartes is a western ontological problem exported via colonialism’ (C. A. Taylor & Ivinson, 2013, p. 666).

What is particularly concerning about this understanding of humans as separate from nature, and our supposed special powers of ‘reason’ in relation to ethics is that, on the one hand, it reinforces a requirement to be ‘objective’, while on the other hand it does not typically acknowledge a cultural hegemony. In other words, the curriculum makes no clear reference or acknowledgment that these ideas about reason and ethics are strongly associated with Euro-Western culture, or that other cultures may have significantly *different* interpretations of ethics.

This leads on to my next point, regarding the curriculum’s statements and implications that, when it comes to ethics, it is possible, or at least desirable, to arrive at a ‘right’ or ‘wrong’ answer. As is stated at the end of the ‘Ethical Understanding’ section:

Although the basis of justification of what is right or good for the individual and for others is contentious, it is misleading to confuse disagreements in ethics *with there being no right or wrong answer*. There may be different positions, each with their strengths and weaknesses, and often there is the need to make a judgment in the face of competing claims (ACARA, n.d.<sup>a</sup>; emphasis added).

This enacts a supposed cultural neutrality and objective standpoint in the process of ethical deliberations. Indeed, this section is significant for what is not said as much as what is said. Particularly, there is no mention that one of the reasons for ‘competing claims’ may be cultural differences. Nor does it note that culture plays a role in ethical justifications. This section also links the following values and concepts to ethics: ‘justice, right and wrong, freedom, truth, identity, empathy, goodness and abuse’ (ACARA, n.d.<sup>a</sup>). Overall, the section ‘Ethical

Understanding’ promotes certain ideals about ethics without acknowledging that such ideals are not universal, or neutral, and are predominantly based on Euro-Western philosophy. Therefore, cultural subjectivity ultimately does not supposedly matter for this understanding of ethics.

That said, there are some elements of the curriculum that indicate ways of thinking about science and/or ethics that *do* acknowledge culture. For instance, in the science curriculum section titled ‘Science as a Human Endeavour’ it is stated that ‘This strand also recognises that science advances through the contributions of many different people from different cultures’ (ACARA, n.d.<sup>e</sup>). This therefore acknowledges that science is multicultural. Albeit, the wording could be much stronger in this regard, as stating that science advances due to ‘people from different cultures’ is different from acknowledging that science practice and knowledge is entangled with diverse ways-of-knowing-being.

In other words, the influence of culture in science goes far beyond people from different cultures *doing* science. Rather, culturally diverse ways-of-knowing-being impact on science in numerous ways. As Jennifer Adams et al. question in their report about cultural inclusivity in science education: ‘Why is science (so called ‘Western science’) still the only discourse accepted in our institutions (schools, universities, etc.)? Why are no other epistemological discourses accepted in education?’ (Adams et al., 2008, p. 1006).

The question of Euro-Western and masculinist hegemony in defining the science-ethics nexus in schools is a crucial issue for broad considerations of humanity’s becoming. The insinuation of values, such as ‘reason’, being neutral, the limited acknowledgement of diverse ways-of-knowing-being, as well as the overall separation of ethics with everyday contexts have significant consequences. To link this again to the ethical manoeuvres of speculative fiction, I suggest Margaret Atwood’s series, like my story ‘The Beforetimer’, and many other speculative

fiction stories, illustrates a potential result of Euro-Western hegemony in relation to science and ethics. Jennifer Wagner-Lawlor argues that Atwood ‘mines the predilection of modern society to ignore the risk we ourselves present [...] to the physical survival of our kind and our planet’ (Wagner-Lawlor, 2011, p. 175).

Atwood’s novels are not just about critiquing humans ‘ignoring risk’ but rather also ignoring, or at least not often engaging with, the epistemological foundations that exist concerning how we even begin to consider what is ‘risk’. Part of this is the ‘humanist’ constitution of ethics. This is also the case in ‘The Beforetimer’, as my story hints at a human-influenced cataclysm. In this story, I also examine aspects of the human-world estrangement; for example, in the contrast between the human survivors living unhappily underground in their human-made concrete-metallic environment, and the *Homo adaptos* living in ‘harmony’ with their trees-grass-soil environment on the planet’s surface.

Wagner-Lawlor also argues that Atwood’s novels depict a ‘cultural moment’ which connects ‘cotemporary science with hegemonic global capitalism and corporatized technology’ (Wagner-Lawlor, 2011, p. 175). In other words, Atwood’s novels challenge the Euro-Western influenced combination of ideals about capitalism and science. Specifically, they depict the result of this as leading to a future wherein the problems of today, such as inequality, unsustainable practices, and dangerous technologies only increase exponentially.

Importantly, ‘The Beforetimer’ is not ‘apocalyptic’, in the sense that the cataclysm destroys every living species. This is despite the belief of the humans living in the ‘subhouses’ underground that ‘all the green things are dead and the world is dark’. Clearly, as Pax/Entity discovers, the ‘cataclysm’ was not as bad as they believed, as many species, including *Homo adaptos*, have survived. Furthermore, the period focussed on in this story is wherein ‘all the

green things thrive'. Also, rather than humanist-oriented stories in which humans are the ultimate saviours of the world, no humans have contributed to this 'greener' future.

Overall, then, the ethical manoeuvring possible in speculative fiction is to imaginatively, and affectively, challenge the way things are in relation to the becoming of science and technology. If we truly wish to critically engage with the becoming of humanity and the world, then examining the foundational onto-epistemological basis of how ethics is defined is crucial. Part of this consideration needs to account particularly for the implications of culture in the conception of ethics. This is so especially given the ways in which this relates to the development of science and technology, and the ways in which ethics is constituted within the context of school education. I expand on this further in the following chapters.

---

#### ANTHROPOCENTRISM IN SCIENCE TEXTBOOKS

In this section, I focus on how anthropocentrism may influence the content, as especially related to ethics, in science textbooks used in Victorian secondary schools. I contend that a combination of masculinist and Euro-Western hegemony has contributed to an anthropocentric perspective still very much in evidence in the science-ethics nexus in these textbooks. This is the case even though there are also some indications of a challenge to this way of thinking.

I acknowledge that sustainability, and awareness of humanity's impact on the environment and other species, has recently become a more significant element of school education in Australia. This includes within the national curriculum and consequently within science textbooks. However, there remain many questions as to how far such initiatives can go, or what they might be achieving, due to the uncritical reproduction of masculinist, humanist, and Euro-Western ideals.

By diffracting a posthumanist critique of anthropocentrism in analysing science textbooks, I emphasise some prevalence of anthropocentric thinking by presenting specific examples that showcase such threads throughout these textbooks. This is not to say that anthropocentrism is an aspect of *all* the content in these textbooks, or even that it is the dominant perspective. It is more the case that it is a significant feature of certain parts of these textbooks, and principally so in relation to ethics. Albeit, this is the case within some of the textbooks more than others.

In addition, I include sections that demonstrate a growing tension between anthropocentrism and alternatives to anthropocentrism, while also outlining the limitations of the latter. Overall, I suggest that there is considerable evidence of conflicts in these textbooks between anthropocentric ideals/values and thinking more critically about humanity's place in the world. This suggests that anthropocentrism retains a hold within Australian science education, and therefore the science-ethics nexus, but that there are alternative developments that provide a glimpse of the possibilities that posthumanism offers and can contribute to.

One of the significant issues covered by all the textbooks that I analyse is climate change. For this reason, and because it is a global-wide issue, as well as an issue that I address throughout this dissertation, I present here analysis of extracts concerning this topic. The textbooks for Year 10 feature this issue as a major component of the content and, in some, it makes up whole chapters. Different textbooks present this issue in quite different ways, and vary greatly in terms of how anthropocentrism is present. However, I argue that none are completely free of anthropocentric aspects.

The most common anthropocentric perspective is presenting climate change as mainly a concern for the ongoing survival of humans, or what humans need to survive (i.e. livestock, crops, and so on). In *Nelson iScience for the Australian Curriculum 10* (Champion, Smith,

Termaat & Pappas, 2012), a section called ‘What is climate change?’ focusses on humans by stating that:

Scientists predict that, over the next two to three decades, climate change due to global warming will see higher death rates from heatwaves, floods and droughts. Diseases such as malaria and dengue fever, which are traditionally found in human populations in tropical areas such as equatorial African countries, will spread to Europe. Temperature rises of 4-5°C are expected to lead to increases in other health problems, such as malnutrition, diarrhoea and cardio-respiratory and infectious diseases (Champion et al., 2012, p. 198).

In *Science Quest 10 for Victoria* (Lofts & Evergreen, 2014) a section of Chapter 7 is called ‘Heating up for Thermageddon?’. The readers are invited to imagine how climate change will affect humans specifically. For instance, the authors ask:

Could Earth get too hot for humans? Is there enough variation within our species so that if things do get too hot to handle at least some of us will survive and our species will continue? (Lofts & Evergreen, 2014, p. 233).

In *Oxford Big Ideas Science 10* (Quinton, Cash, Tilley & Craven, 2012), in the Chapter 3 section, ‘How do humans impact the environment’, there is an activity for students to ask questions about endangered and extinct species. As part of this, the authors state the following:

It would be a fair comment to suggest that the greatest concern regarding the effects of climate change would be the impacts on humans. Many populations will be forced to relocate, or perish, and

standards of living will shift sideways and down for most as resource availability decreases (Quinton et al., 2012, p. 126).

Finally, in the newer Oxford version, *Oxford Science 10: Victorian Curriculum* (Silvester, 2016<sup>c</sup>), the first mention of climate change also focusses on the dangers to humans:

We can also expect to see an increase in the loss of human lives [...]

Higher temperatures in summer have increased heat-related deaths. A heat wave in Europe in 2003 was estimated to have killed between 22 000 and 35 000 people (Silvester, 2016<sup>c</sup>, p. 134).

What these extracts suggest overall is that climate change is mainly a concern for the survivability of humans and that the survival of other species, ecosystems, and resources (i.e. fresh drinking water) all come back to what *we* need to survive. Such suggestions, therefore, mainly put humans at the centre of the world. Some might argue that these aspects are just a ‘common sense’ approach, to appeal to and engage students, by emphasising that climate change may very well impact on *their* health, or longevity. However, at the basis of this is still the anthropocentric assumption that the main reason to be concerned by climate change is that it does, or will, negatively affect humans.

Anthropocentrism is also possibly significant for the reason why, in at least some textbooks, the authors present climate change as still a debatable issue in terms of how much it is caused by humans. It is not just that these ‘debates’ are mentioned but that they are sometimes presented as if the differing sides are equal, despite the overwhelming numbers of scientists and research reports that support claims of significant human influence on the climate (Core Writing Team et al., 2015).

For example, *Science Quest 10 for Victoria* suggests it is valid that scientists still debate the question ‘Are humans responsible for global warming?’ (Lofts & Evergreen, 2014, p. 240). On the same page, it is stated that ‘alternative theories’ exist, which include the idea that climate change is part of a ‘natural cycle’ rather than human behaviour (Lofts & Evergreen, 2014, p. 240). In *Nelson iScience for the Australian Curriculum 10*, evidence for and against global warming are presented as equal (Champion et al., 2012, p. 184). The authors also include consideration of climate change as being not due to human behaviour (Champion et al., 2012, p. 199 & 206)<sup>25</sup>. The implications here suggest an unwillingness to account for humanity’s negative impact on the world, or to own up to the *effects* of anthropocentrism and the political pressure from the denialists.

Another major topic the textbooks address is genetic engineering, and this is also one of the topics I address throughout this dissertation. While this issue, like climate change, is presented in quite different ways, an anthropocentric commonality was to focus on the benefits genetic engineering does, will, or might have for humans. Additionally, I note that some of the textbooks downplay actual or potential negative effects. This includes negative effects on humans but also, more importantly for this context, on other species. There is usually no mention of whether such technology should be used at all, but only that some aspects of its use are considered an ‘ethical issue’.

The discussion of this type of technology is often strongly favourable for its benefits. This includes providing human food production and curing human diseases or other health benefits. This is so even at the potential cost for other species. For example, a passage in *Oxford Big Ideas Science 10* reads: ‘new transgenic organisms can be produced, such as pigs that can produce more muscle or bacteria that produce a human protein that can be extracted and used

---

<sup>25</sup> The full quotes are included in Appendix 3.

to treat illnesses’ (Quinton et al., 2012, p. 162)<sup>26</sup>. However, no ethical questions are about the use of pigs in such ways.

In *Pearson Science S.B.* [student book] 10 (M. Parsons et al., 2016), the initial introduction of gene technology compares it to playing with Lego and notes that scientists ‘experimented with ways of modifying [genetic information] that were beneficial to humans: for example, to increase food production and improve human health’ (M. Parsons et al., 2016, p. 71). On this same page, it is mentioned only briefly that gene technology ‘has benefits but it also causes controversy’ (M. Parsons et al., 2016, p. 71).

Even while, in most cases, potential negative effects of genetic manipulation are mentioned in the textbooks, the fact that the benefits for humans are often highlighted first, and given a larger weighting, or more space, in comparison to discussion of negative effects on other species, is significant. Other examples include highlighting the potential to cure diseases and impairments, such as ‘paralysis or spinal cord injury’ and ‘Alzheimer’s disease, motor neurone disease, Parkinson’s disease, diabetes and arthritis’ (Lofts & Evergreen, 2015, p. 139). Also mentioned is the possibility of enhancing humans via ‘artificial evolution’ using DNA technology (Lofts & Evergreen, 2014, p. 289, 290, 299 & 300)<sup>27</sup>.

Some textbooks advocate the benefits of transgenic organisms, with limited focus on potential negative consequences (Williamson & Garton, 2011<sup>a</sup>, p. 241) as well as use of stem cells (Williamson & Garton, 2011<sup>b</sup>, p. 111). Lastly, textbooks occasionally suggest students specifically

---

<sup>26</sup> It is interesting to note the similarity of this and Atwood’s transgenic ‘pigoons’, as mentioned at the beginning of this chapter.

<sup>27</sup> The full quotes are included in Appendix 3.

focus on developing arguments for DNA technology, such as parents being able to choose their children's genetic characteristics (Williamson & Garton, 2011<sup>c</sup>, p. 97)<sup>28</sup>.

Overall, these examples demonstrate an anthropocentric perspective. Specifically, that even if scientific or technological developments carry great risks to other species, or environments, if there is a chance that this would result in significant positive effects for humans, then these developments are considered in a more positive light. This is so even when such developments may *require* negative impacts on other species. The possible or actual negative consequences are given less attention, and less presence. Consequently, issues such as genetic engineering are not ethically considered regarding the overall balance/relationality of ecosystems, or the overall right of all species to live, and to 'flourish', but rather are based on how they may benefit humans. Furthermore, this evident anthropocentrism is not acknowledged; it is presented as 'common sense' and 'self-evident'.

Speculative fiction is one avenue through which such anthropocentrism can be readily challenged. This is because, as covered in Chapter 1, speculative fiction largely focusses on the 'big issues', as well as possible outcomes of current scientific and technological trends for potential futures. In 'The Beforetimer,' I demonstrate the fragility of humanist exceptionalism by having a species of animals that is genetically modified (the result of previous human experiments in genetic engineering) in contrast with the '*Homo sapiens sapiens*' of today.

The *Homo adaptos*, similar to Atwood's 'Crakers', are intended to problematise human exceptionalism by literally blurring the boundary between 'human' and 'nonhuman'. Or, in other words, to 'occupy the very slash situated between the binary of human/nonhuman' as Jessica Ruzek argues concerning Atwood's 'Crakers' (Ruzek, 2014, p. 19). The *Homo adaptos* are

---

<sup>28</sup> These examples are included in full in Appendix 3.

ape-like in appearance and manner, with ‘black fur’ and ‘large nostrils’, yet in their human-nonhumanness, do not merely reflect ‘human nature’ back at us. Rather, they envision something more, something possible, in our becoming.

Speculative fiction is potentially powerful, not only in functioning as a critique of human behaviour, and anthropocentrism, but also in *envisioning alternatives*. It is my intention to present Cedar, and the *Homo adaptos*, as such an alternative. That is, beings who have, and manage, advanced technology but do so in a way that is in ‘balance’ with nature. For example, they live in homes that are living trees. Of course, what this balance might be, or require exactly, could be entirely subjective and context-specific. However, if we cannot even envisage the possibility of a more liveable future for all, then certainly a more sustainable future seems less likely.

It can be posited that speculative fiction is ‘a discourse that allows us to concretely imagine bodies and selves otherwise, a discourse defined by its ability to estrange our commonplace perceptions of reality’ (Vint, 2007, as cited in Gomel, 2011, p. 340). While non-fiction speculations are also necessary, Vint’s point gestures to the potential of speculative fiction to specifically ‘imagine otherwise’. It may be going too far to say that such imaginings can be ‘concrete’ exactly, given the dynamic relationality of audience/reader becomings, which bring in different interpretations.

However, there surely is a distinction to be made for deeply imagining and bringing to life that which is ‘otherwise’ in the context of fiction. For example, it would be a world without pollution, without habitat destruction or human-induced extinctions, and without reliance on fossil fuels. In addition, it can be argued that:

Imaginariness shape how we see ourselves in relation to certain phenomena, and our relations to others in the context of those

phenomena. In doing so, they help create the reality we live out (Neimanis, Åsberg & Hayes 2015, p. 2).

In other words, it may be advanced that within speculative fiction, it is possible to trouble the current conception of ourselves as well as contribute to *how we might become*.

As noted at the beginning of this section, while I have presented here extracts that demonstrate an anthropocentric perspective, a perspective that has a significant influence on the science-ethics nexus, there are also many examples in the textbooks that suggest some tension with anthropocentrism. These examples include a critical focus on how humans impact negatively on the environment and other species (such as, in Australia, the significant extinction rates since European colonisation). They also include concern about recycling, ‘green’ energy, water saving initiatives, and other sustainability issues.

Markedly, these are not always entirely presented as centring around humans but rather include a concern for other species and ecosystems in general. While most of these examples cannot be said to be posthumanist, as such, because they still largely centre humans as the main concern, they indicate possibilities wherein posthumanist thought can strengthen non-anthropocentric outlooks.

For example, there are instances in the textbooks that do take a critical perspective with humanity’s negative effects on the environment, particularly around concerns about the fast-growing numbers of the human population. In *Oxford Science 7: Victorian Curriculum* (Silvester, 2016<sup>a</sup>), the author states:

Human impact on environments is considerable because of our population numbers and our ability to manipulate our surroundings to suit our needs. People are able to make both positive and negative

changes to the environment. Most environmental changes so far have been detrimental—understanding these impacts is the first step to reducing and reversing them (Silvester, 2016<sup>a</sup>, p. 124).

Other sections draw attention to the resources of the world as necessary for *all* life, not just for humans. For example, in *Pearson Science S.B. 7* (Rickard et al., 2016<sup>b</sup>), it is noted that

All life depends on these [natural] resources. Protecting them gives all living things (including us) a better chance of survival (Rickard et al., 2016<sup>b</sup>, p. 86).

Some textbooks even take a more philosophical perspective. In *Pearson Science S.B. 9* (Rickard et al., 2016<sup>a</sup>), it is stated that:

Compassion is humans feeling sympathy for other organisms [...] The idea of compassion is that all organisms have a right to live, and that humans have no right to exterminate any species (Rickard et al., 2016<sup>a</sup>, p. 367).

That said, this is followed up by emphasising humanity's supposed intellectual superiority: 'If humans are the only organism on Earth capable of understanding the possible fate of all life, then surely we have a responsibility to make wise decisions' (Rickard et al., 2016<sup>a</sup>, p. 367). This section also follows a list of reasons ecosystems should be protected, which are all based on an anthropocentric viewpoint. For example, for 'cultural values', 'economics', and human 'survival' (Rickard et al., 2016<sup>a</sup>, p. 366-367).

Essentially, however, this type of content emphasises a significant development in the Australian curriculum and textbook content. Certainly, in comparing textbooks currently in use at the time of my research with older versions, and with the textbooks that I had myself in

secondary school during the years 7-10, environmental concern, sustainability, humanity's impact on the environment and other species make up a new but seemingly growing area. This, then, is something of a departure from not only the more 'traditional' science curriculum, based on learning 'facts', but also a departure from explicit anthropocentrism. This is especially so regarding the perspective that the world, its resources, and other species exist for human needs and wants. Instead, there is a growing critical awareness of the negative effects humanity has on the world, and not just that this is a concern about our continual survival. While other species might not be considered equal, their right to life is at least also acknowledged.

Nevertheless, overall, tensions occur in these textbooks between different schools of thought about humanity's place in the world. Furthermore, anthropocentrism is still a significant feature of content in science textbooks and is not overtly addressed as an issue. Even while noting concerns around sustainability, and the right for other species to live, the phrasing is often still anthropocentric. For example, in *Science Quest 10 for Victoria*, the authors reinforce the importance of sustainability because: 'Wild plant and animal species provide a source of wonder and beauty for large numbers of people' and that rainforests 'provide a huge store of untapped genetic material, much of which may be useful to humans' (Lofts & Evergreen, 2014, p. 119).

Other instances include the undisputed claim of humanity's use of the world's 'resources', with their limited supply most often noted as a concern only as this may affect humans into the future (Bishop et al., 2012, p. 80; Cash, Quinton, Tilley & Silvester, 2011, p. 195; Williamson & Garton, 2011<sup>a</sup>, p. 204)<sup>29</sup>. At times, this can be quite subtle, such as in the sentence

---

<sup>29</sup> The full quotes are included in Appendix 3.

‘Our supplies of fossil fuels’ (Williamson & Garton, 2011<sup>b</sup>, p. 176; emphasis added), wherein the ‘our supplies’ suggests an always already ownership of anything that humanity finds useful.

These types of qualifications around sustainability, that ‘nature’ is there for us to enjoy aesthetically, and to *use*, or rather exploit, is very much an anthropocentric perspective that puts humans at the centre of the world, and yet at the same time as also separate from ‘nature’. As Haraway argues though, ‘We must find another relationship to nature besides reification, possession, appropriation and nostalgia’ (Haraway, 2004, p. 126).

Posthumanism emphasises that humans are just one component of the world and consequently have no more of a right to existence and wellbeing than any other species. This framework also underscores the idea that ethics is a part of all knowledge and knowledge-making processes. Consequently, there can be no such thing as specific ‘ethical issues’ because ethics is entangled with all ways-of-knowing-being.

---

## CONCLUDING THOUGHTS

Russel Tytler’s report ‘Re-imagining Science Education’ (Tytler, 2007) provides an in-depth examination of weaknesses of science education in Australia. It also provides several strategies towards developing a crucial and significant shift away from ‘traditional’ approaches. In this chapter, I have added to his and similar arguments. Specifically, I have contributed to this area of thought by utilising relational posthumanism to provide some alternative ideas about how science in Australian school education might be reevaluated. This is with consideration of how school science, in relationship with ethics, has implications for the becoming of humanity. Aspects of this framework, such as its emphasis on relationality, material-discursive phenomena, and the inseparability between knowing, being, and ethics, enable this ability to think differently.

In addition, I have utilised speculative fiction diffractions to further draw out the broad implications of how the science-ethics nexus is constituted in Australian school education, as well as how speculative fiction can function as an ethical inquiry. By drawing on my story ‘The Beforetimer’, and Margaret Atwood’s novel *MaddAddam* (Atwood, 2014), I emphasised and illustrated how speculative fiction can bring to light interrogations of relationality, the becoming of humanity and science/technology, implications of cultural hegemony, and anthropocentrism.

I incorporated several propositions in this chapter. Firstly, that relational posthumanism, in strengthening an understanding of the ways in which science and technology are not separate from other aspects of the world, provokes alternative thinking about this issue in school education. Consequently, I posed that this necessitates that stronger attention be paid to this relational entanglement *within* school education. Essentially, the concept of relationality suggests that when considering science as constituted in school education, the complex world-science-education intra-active relationality involved should be at the forefront. Understanding this intrinsic relationality also means that ethics becomes a major component, and imperative, of science in school education.

In including analysis of the report ‘STEM: Country Comparisons’ (Marginson et al., 2013) I contrasted this potential ethical imperative with the popularised (especially by governments) ‘economic imperative’. This argument has several consequences for how the problems of science education are defined and understood, such as students’ declining interest in school science, as well as the propositions to overcome these problems. Here I contended that previous approaches have been largely ‘additive’ rather than truly transformative and the concept of relationality may be utilised as an alternative. In other words, as an alternative method to examine, and potentially reform, the onto-epistemological foundations of the science-ethics nexus in Australian school education.

Another area that relational posthumanism offers some shifts in thinking is the focus on the relationality of phenomena as entangled in the constitution of the science-ethics nexus in Australian school education. This includes attention paid to masculinist, humanist, and Euro-Western ideals. Most importantly, I suggested that the hegemony of these phenomena implicated in the science-ethics nexus are most often situated as a ‘neutral’ perspective, discounting diverse ways-of-knowing-being.

In the last section of this chapter, I proposed how these phenomena may also be heavily implicated in the prevailing anthropocentrism in science textbooks used in Australia. The issue is not just the hegemonic ideals at work but rather the lack of diversity and consequently the lack of acknowledging alternative ways-of-knowing-being. It is not that all Euro-Western ideology is bad, and all alternatives are good, or better, but that opening to diverse perspectives, and diverse ideas, might ensure a more nuanced approach to the science-ethics nexus in school education.

Relational posthumanism does not just provide an alternative perspective to the issues addressed in this chapter, but an alternative vision of science and education. That is, an alternative to the current constitution of science and education but also some alternatives to ideas, such as Tytler’s, in a shift away from the ‘traditional’ model. These areas of concern set up my inquiry into potentially further developing alternatives, such as furthering diverse ways-of-knowing-being in Australian school education, presented in Chapter 6. First, however, in the following chapter I provide a more detailed examination of the current constitution of the science-ethics nexus, by considering beginning teachers’ views.

CHAPTER 5: TEACHERS' SCIENCE-ETHICS VIEWS AS ONTO-  
EPISTEMOLOGICAL ASSEMBLAGES

Entity was abruptly pulled away from a perpetual dream of nothingness, into a hazy state of bewilderment; xe did not know life, xe did not know xirself, xe did not know this world. Existence was cold and blinding and wet. Entity thrashed and slowly apprehended the body that xe was, a body that trembled and slid inside the confined slick space xe found xirself within. The body knew without language to think; confinement was unwanted. Yet, striking out only resulted in a hot spike of pain and Entity stilled, blinking repetitively as disused lenses began to adjust.

---

...knowledge is always an engaged material practice and never a disembodied set of ideas.

—(Haraway, 2004, p. 199)

---

In the interest of expanding on the current constitution of the science-ethics nexus in Australian secondary school education, I examine what I call my beginning teacher participants' 'views-assemblages' of science and ethics. The significant aspect of this approach is by understanding the development of these views-assemblages as onto-epistemological. In other words, I approach this question by not just considering discourse, or considering areas such as culture and identities, but rather the complex intra-actions of multiple material-discursive phenomena. Such consideration does not separate matter/bodies from discourse. My interview analyses are intended to be gestures to multiplicities rather than in-depth considerations.

There has been interest in teachers' views about science in education research. This approach recognises the overall importance of their views in relation to the ways in which pedagogy, curriculum, and other factors are enacted. There has also been research attempting to determine what factors in teachers' backgrounds might be implicated in their views. Taking this latter as a starting point, my interviews with beginning teachers are an examination of how

relational posthumanism might offer a renewed way to investigate the *becoming* of teachers' views about science and ethics.

The scene in 'The Beforetimer' included at the beginning of this chapter is my creative writing exploration into the fundamentals of onto-epistemology. By taking away Pax/Entity's memories and identities, xe is reduced to 'knowing' purely by xir body-sensation-world relationality. The sentence 'the body knew without language to think' is my attempt to appreciate 'knowingness' that is more than discursive. As the introductory quote from Haraway also suggests, knowledge is not ethereal, in the typical Cartesian sense of knowing from outside of the world. Knowing is entangled with the agency of matter-being.

By 'plugging in' posthumanist concepts into 'The Beforetimer', the process of my creative writing functions as a mediation between these concepts and speculative fiction. However, it is important to recognise this relationality as an 'assemblage' that involves much more than my conscious intentions as 'the author'. We are always more than a 'self', and as such there is always more than a 'self' at work in processes of knowing-being.

Speculative/science fiction features strongly in many of my interviews with beginning teachers. For example, one participant, Entity 4, mentioned a film xe had recently seen, that made xir think about how humans relate to 'the environment' and sustainability. This discussion directed me to also viewing the film, titled *Snowpiercer* (Bong, 2013), which is a 2013 Czech-Korean production, directed by Joon-ho Bong and written by Bong and Kelly Masterson. I classify this film as speculative fiction because the overall premise is evidently based on the world as we know it and the very real problem of climate change.

The film's setting takes place after a great climate cataclysm, which has resulted in a planet-wide ice age. This cataclysm occurred because an attempt by humans to mitigate global climate change, by controlling the climate using chemicals ('CW-7') dispersed in the

atmosphere, failed drastically. However, a group of human survivors live on the ‘Snowpiercer’ train, which travels around the world, never stopping. Those at the back of the train live in harsh conditions, and their children are mysteriously taken to the front for unknown purposes, while those at the front live and party in luxury.

The people at the back of the train eventually begin a revolt, led by Curtis (Chris Evans). Ultimately, Curtis confronts the ‘man behind the curtain’, Wilford (Ed Harris), in the engine of the train, but it is Minsu Namgoong (Kang-Ho Song), the drug-addicted engineer, who foils all the political machinations by blowing out a door of one of the carriages and de-railing the train. I weave a posthumanist analysis of this film throughout this chapter as a diffractive component that interrogates the implication of speculative fiction as an element of ‘views-assemblages’. This also, however, continues my examination of speculative fiction as an ethical manoeuvre in relation to science and this study overall.

This chapter is divided into two main sections. The first, ‘Entangling with objectivity’, addresses the three participants, entities 1, 6, and 7, who strongly stated a belief in the objectivity of science. My analytical focus is on Entity 1, while my analyses of interviews with entities 6 and 7 provide some further gestures of interest. These three participants define their beliefs as largely about maintaining objectivity by rejecting emotions. I consider the implications of Euro-Western, humanist, and masculinist hegemony, as per the previous chapter, in the participants’ understanding of ‘objectivity’. However, I also address the further complexities of their onto-epistemological becomings as potentially involving unique aspects of their backgrounds and affective experiences. After sections for each entity, I further diffract my analyses of their interviews together to bring together the main points of interest.

The second section extends the preceding discussion to the participants’ views of ethics. My focus is again on the first analysis presented, which is of my interviews with Entity 10. This

includes consideration of how hegemonic conceptual understanding of ethics and science may limit Entity 10's desire to engage with ethics. Following this, however, to provide a somewhat different inflection, I also present my analyses of entities 4 and 9. With these participants, I consider how their 'becoming-Other' may, in some way, 'deterritorialise' hegemonic conceptual understanding of ethics. Once again, there follows a section that diffracts my analyses of these three entities together.

---

## ENTANGLING WITH OBJECTIVITY

It is still puzzling that, as Russell Tytler and others have argued, 'traditional' content and pedagogy of science education largely continues to prevail in Australia, and elsewhere, despite many attempts to modify and shift this mode (Tytler, 2007, p. 3). As outlined in Chapter 1, the developments 'Science-Technology-Society' (STS), 'Science-Technology-Society-Environment' (STSE), and 'Socioscientific Issues' (SSI), as well as the renewed 'Nature of Science' (NOS) ideas, characterise broad attempts at shifting away from the 'traditional' constitution of science education based on learning facts. Part of these conceptions, as especially highlighted by feminist researchers, is the implication of humanist, Euro-Western, and masculinist ideals in science, such as the prevailing idea of science as 'objective'.

Accordingly, in this section, by analysing interviews with the beginning teachers, entities 1, 6, and 7, who expressed a traditional conception about the objectivity of science, I propose an alternative relational posthumanist approach to understanding the development of such views. It is noteworthy that these three participants intend to teach science or mathematics, as this suggests a connection between disciplinary area and views about science and ethics. Given that I interviewed a small number of beginning teachers, it is difficult to particularise this relationship. However, disciplinary boundaries are of great interest from a relational posthumanist perspective. This is especially so as to how they might be relationally

implicated in teachers' and students' conceptions of ethics and science. Thus, this consideration guides some of my analyses.

Interrogating views of science as 'objective' is not to say that all aspects of traditional ideas about objectivity in science are negative. Undoubtedly, objectivity has led to numerous developments in knowledge and contributed broadly to scientific progress. Nonetheless, as I covered in Chapter 1, there are still issues associated with some hegemonic beliefs about objectivity, including the implications of various sociocultural phenomena. Consequently, I consider the implications of masculinist, humanist, and Euro-Western phenomena. However, I also consider, in a relational posthumanist sense, the influences of the entanglements of matter-bodies-environments-emotions-experiences-identities.

By building on the more common focus in research on discourse and identities this is also therefore an attempt to get at the finer complexities of such entanglements. Additionally, I conceptualise the participants as plural 'entities' who are 'becoming', wherein becoming 'is not a linear process between two points. There is no origin, no destination, no end point or goal' (Jackson, 2013, p. 115). Lastly, to trouble gender-sex and other binaries, as well as static conceptions of 'being', I refer to the participants using the gender-neutral pronouns of 'xe/xir'.

Relations that the participants are involved in are understood as a 'dynamic flowing entanglement of matter and meaning' (Daugbjerg et al., 2015, p. 777). To accentuate this, I consider here the idea of watching the film *Snowpiercer* as illustrating such a process. I contend that understanding films from a relational posthumanist standpoint constitutes them as a becoming, via multiple complex intra-actions. Not just involving the actors, writers, and directors, but broad assemblages including history, politics, and the materialities that feature in, or make up, the sets as well as the final visual and audio product. *Snowpiercer* is certainly an experientially stimulating movie. This is the case not just because of the scenery and

environments, of the inside of the train and the surrounding iced-over and desolate world. Other subtle elements, such as the design of the train carriages, the costumes of the human characters, as well as the camera's focus on their movements and gestures, are also significant.

The instrumental music, when included, is often quiet and understated, except for dramatic moments when it becomes fast and loud, with beating drums and screeching strings. This, combined with the few graphically violent scenes, make for a strong affective potentiality of unease in the 'film-audience becoming'. Accordingly, certain scenes in this movie may function *onto-epistemologically* with the overall potentiality of the film as a critical question about science and technology, as well as humanity's relationship with the world. That is, this film might function in relationality with its audience as an 'engaged material' (Haraway, 2004, p. 199) and affective experience. It is not merely symbolic, or representational, of discourses. For instance, Estelle Barrett argues that:

Aesthetic experience implies a heterogeneous sentient and *relational* subject—one that is, at the same time, constituted through material biological processes and language [...These experiences] result in transformations of language and have the potential to transform discourse, because the subject is not only material process but is also *in and of* language (E. Barrett, 2015, p. 103; original emphasis).

Consequently, this film might be understood as one 'transformative' component of Entity 4's onto-epistemological becoming, and specifically for xir views of science and ethics. However, it is not just that an 'entity' is a material and relational body, but that films are *also* material-discursive and relationally 'assembled' with a multitude of phenomena. By watching/experiencing a film, therefore, an entity becomes a part of this assemblage. There are

also other assemblages that an entity is ‘within’, which means the outcome of a film-audience becoming is always contingent on complex intra-actions.

My examination of the participants’ understanding of science and ethics includes two specific issues: the genetic modification of humans and the use and development of renewable energy. I chose these two issues for several reasons. Firstly, they are both prominent issues in secondary science textbooks and in the media. Secondly, I deemed it likely that my participants would at least be somewhat familiar with these issues. Lastly, the issues are two different but important areas in terms of the development of science and technology: how it is related to humanity and how it is related to the ‘environment’.

---

#### ENTITY 1

Entity 1 was the first participant I interviewed. Xe was twenty-two at the time of the first interview and a third-year Bachelor of Education/Science student, interested in teaching science as a general subject, as well as chemistry and mathematics. Entity 1 identified xirself as male, Catholic, as ‘Sri Lankan/Indian/Australian’, and has lived in Australia, and specifically Melbourne, since xe was around one-years-old. Xe related that xir mother works as a medical professional and xir father works as a creative professional. When asked about xir political leanings, Entity 1 stated that ‘I wouldn’t say I’m left. I wouldn’t say I’m extremely ... I’m more central. Probably Labor, that side more’. ‘Labor’ is one of the two major political parties in Australia. They define their goals as ‘commitment to fairness at work, access to quality education no matter what a person’s circumstances and a firm belief that we should all have the same opportunities in life’ (Australian Labor Party, 2017).

For primary and secondary, Entity 1 went to private Catholic schools in Melbourne, Australia. The secondary school is a high-performing single-sex college, with NAPLAN<sup>30</sup> scores above the average across all domains (MySchool<sup>31</sup>, n.d.). Entity 1 stated that overall xe enjoyed school, except for some negative aspects such as the social limitations of a single-sex school. Xe indicated that xe was a consistently good student but never a ‘stand out’ one and struggled at times with some subjects. Entity 1 related that xir secondary history, chemistry, and physics teachers had a significant role in xir interest in teaching, as xe stated that their passion for teaching was inspiring. Xir history teacher’s comment that Entity 1 might be a good teacher one day especially had xir considering this as a career option. Entity 1 also rated xir secondary and tertiary education experiences as being the most influential on xir views about science and ethics.

In Entity 1’s replies to questions about xir views of science and ethics, xir comments wavered somewhat. Significantly, however, xe at times stated a negative relationship between emotions and the objectivity of science. This was reiterated throughout the two interviews, although xe at times conceded that it is not possible to entirely be divorced from emotions. For instance, when we were discussing genetically modified humans, Entity 1 stated that ‘when you start to put [in] emotions and stuff like that you can sort of be clouded a bit’. Later, in discussing xir experience of a university science unit covering science issues, Entity 1 said it is necessary in

---

<sup>30</sup> The National Assessment Program – Literacy and Numeracy is a national test for years 3, 5, 7, and 9 on reading, writing, narrative writing, spelling, grammar and punctuation, and numeracy. It is ‘the measure through which governments, education authorities, schools and the community can determine whether or not young Australians are meeting important educational outcomes’ (About NAPLAN, 2016). There have been many critiques of NAPLAN’s effectiveness and usefulness (e.g. Thompson & Cook, 2014); however, I have used the results only as a general guide for the participants’ schools.

<sup>31</sup> ‘My School is a resource for parents, educators and the community to receive important information about each of Australia’s schools in a readily accessible format’ (MySchool, 2017) and is managed by the Australian Curriculum, Assessment and Reporting Authority (ACARA). It was introduced in 2010.

science to be ‘looking at evidence and trying to have that empirical data...not making any judgements, not using emotion but trying to have it based on data’.

The tertiary science unit Entity 1 refers to, which I will call ‘SCI1’, is also mentioned by other participants. This unit appears to be significant in highlighting what Entity 1 called ‘bad science’, to mean unethical practice by a few infamous scientists. In discussing this unit’s content, Entity 1 stated that ‘emotion and empirical evidence shouldn’t really be bed fellows, should they?’ and while xe conceded that ‘there’s always emotion in things’ xe also stated that ‘you kind of want to be [...] not as subjective, you want to be a bit more objective in trying to work out things’.

For this analysis, I consider what onto-epistemological processes might be involved for some of the participants coming to believe in the Euro-Western and masculinist influenced concept of an ‘objective’ science. That is, the Cartesian separation between subjectivity/objectivity, mind/body, human/world, and emotions/reason. I argue that it is possible, via this framework, to conceptualise a renewed idea of an entity’s views, one that is non-linear, non-individualist, and involving an agency that is not a ‘thing’ but rather a becoming via material-discursive intra-actions. In acknowledging ‘reality’ as messy, it is possible to stay with this mess and resist the urge to present neat, linear narratives.

I understand the participants as ‘becoming’ via entanglements that make up complex material-discursive assemblages. The rhizomic and affective pathways of norms and power involved in such assemblages might be thought of as vibrating strings, held in tension by the past and present: ‘...any point of a rhizome can be connected to anything other, and must be. This is very different from the tree or root, which plots a point, fixes an order’ (Deleuze & Guattari, 1984, p. 7). Rhizomic tendrils extend out, creating assemblages. They are highly dynamic because of their potential to make new tendrils (territorialisation), and for tendrils to

morph and/or die (deterritorialisation), but they are still constrained by their proximities to phenomena. Some ‘tendrils’ inevitably are also stronger than others.

Of course, because rhizomic assemblages are never complete, never static, and cannot be separated from the ‘research-assemblage’ (Fox & Alldred, 2015) such analyses are always only partial glimpses at various potentialities that arise from data and a diffractive analysis. Therefore, utilising this approach is about using ‘multiple conceptual perspectives to open and diffract data, rather than crystalising representation’ (Jackson & Mazzei, 2012, p. ix). Such assemblages involve ‘affective flows’, some of which are constraining, in conflict, and highly dynamic. Affect, in other words, involves different intensities and capacities. For entities, therefore, affect leads to the particularities of their actions and views (Fox & Alldred, 2016, p. 99).

As a reminder from Chapter 3, the first interview session involved the participants completing an ‘influence diagram’. This activity required them to order a set of cards in terms of what might have least influenced their views about science and ethics to what might have most influenced them. Entity 1 completed this diagram activity as pictured on the following page.



Figure 8: Entity 1's influence diagram

The spaces between the cards in Entity 1's diagram suggest three groupings. Entity 1 put secondary and tertiary education first. This is followed by a grouping of family, friends, and community, with social activities as perhaps a subsidiary. The third set of influences, then, are xir primary education, culture, religion/spirituality, and books/TV/films.

Although Entity 1 put 'religion/spirituality' as the second last card in the above diagram, xir responses to my questions suggested that xir 'becoming-Catholic' is significant for xir beliefs about science (and ethics), as well as for xir 'becoming-science-teacher'. Religion was not something I originally expected to focus on within the interviews. However, it became apparent to me, from the outset of this first interview, that religion and non-religion is a significant aspect of my participants' 'views-assemblage' concerning science and ethics.

I suggest that Entity 1's becoming-Catholic and becoming-science-teacher echo each other, held virtually suspended in ongoing intra-actions. Entity 1 has spent time in church, although less so more recently, as xe stated 'I don't go to church as often as I should'. Xe has also experienced countless hours in Catholic schools, wherein it is generally expected students and teachers attend mass, be involved in charity and community work, and have the option to undertake specialised religious programs<sup>32</sup>. It is likely that in attending Catholic schools and attending church, Entity 1 experienced various affective responses to such things like sitting on church pews, listening to sermons, and praying, all of which are bound to involve senses, emotions, and changes to, or confirmations of, ways of thinking.

Entity 1 noted in the interviews that one of xir favourite teachers, xir secondary chemistry teacher, also taught 'religious education'. However, this teacher never enacted any crossovers between the two topics in class: 'When she was on chem[istry] she was just full on

---

<sup>32</sup> For an example of religious programs in similar schools to Entity 1's see <http://www.delasalle.vic.edu.au/wellbeing/faith/> and <http://www.avemaria.vic.edu.au/faith/>

about chemistry'. The tone of Entity 1's voice when speaking about this suggested that xe respected this separation. It is conceivable that Entity 1's affective experiences of being in chemistry classes, and perhaps other science classes, involved quite different becomings. The common materialities of a chemistry class, with its usual laboratory-like environment, with other students, a teacher, Bunsen burners, test tubes, beakers, chemicals, textbooks, and lab coats, are quite different from the materialities of attending church.

Entity 1, overall, appreciated an apparent separation between science and religion, in xir personal life, schooling experiences, and society at large. A few times, xe spoke about looking at issues through either a 'religious lens' or a 'scientific' one. For instance, in our discussion about genetically modified humans, Entity 1 stated that via xir religious lens this would be ethically wrong but from the science perspective, it is a good thing. Albeit, xe also said that on the science side 'there's still not enough evidence to say it's good or bad'. Therefore, xe reserves a definitive judgement because of that and as xe would want to be more informed on the topic.

It would seem from these responses, and what might be xir affective experiences, that Entity 1's 'becoming' shifts dynamically between xir becoming-Catholic and becoming-science-teacher. Such becomings conceivably also involve many affective intra-actions that are beyond this study to assess in detail. For instance, aspects such as experiences, desires, and emotions not related in the interviews, but also aspects beyond the usually conceivable, such as the biological processes of neurology, hormones, and so on. As Fox and Alldred contend, 'thoughts, memories, emotions and desires – through their ability to affect – are also material' (Fox & Alldred, 2016, p. 30). Consequently, acknowledgement of these processes is important even while it is difficult to capture them. In all, what I suggest here is that the tensions between Entity 1's religious and teacher becomings are one significant aspect of xir beliefs about the separations between subjectivity and objectivity, as well as emotions and reason.

By associating xir ‘religious’ lens with a more subjective, personal, spiritual, and emotional standpoint, and xir ‘science’ lens with a more objective and rational standpoint, this separation overall may support Entity 1’s beliefs concerning objectivity in science. Especially so considering that this involves a separation from emotions. In conceptualising such lenses, or *becoming through them*, Entity 1 can compartmentalise different identities and different views. From a relational posthumanist perspective, these ‘lenses’ are not mere discursive constructions but are a part of broad assemblages that involve actualities of knowing-being.

When Entity 1 is thinking via ‘becoming-Catholic’, this is one becoming xe enacts, bringing about different intra-actions and therefore different affective capacities than xir ‘becoming-science-teacher’. With both aspects of xir becoming, various intra-actions, involving different experiences, emotions, and materialities, come into play. However, it might be that the most important aspect of these becomings is the dynamic push and pull between them. This dynamic ‘movement’ may well be an important aspect of Entity 1’s entanglements that continually territorialises xir beliefs about objectivity in science.

Another potentially significant becoming in relation to Entity 1’s beliefs about objectivity in science is xir ‘becoming-male’. Becoming-male, from a relational posthumanist viewpoint, is not a pre-existing condition that then enacts, or confines, behaviours and thoughts. Rather, becoming-male might be understood as an onto-epistemological process of ‘tensions, resonances, transformations, resistances, and complicities’ (Haraway, 1988, p. 588). Or, as Peta Hinton argues, in reworking Haraway’s arguments alongside feminist materialist one’s, gender-sex subjectivities ‘are continually emerging in relational configurations’ (Hinton, 2014, p. 108).

In this regard, what arises in Entity 1’s interviews concerning gender-sex is not what xe said but rather the silence on this topic. Entity 1 rarely mentioned gender-sex or sexuality as significant to xir life, or views. Xe described limited exposure to critical questions about gender-

sex and was not aware of the concept of a ‘patriarchal’ society, which is included in the assemblage map presented in the second interview. Two things may be gestured to here in an understanding of gender-sex as a material-discursive phenomenon, bound up in assemblages.

One is that the ‘silence’ of gender-sex in Entity 1’s interviews is just as significant as overt references, especially in considering gender-sex as a flow of affect, or entailing negative or positive capacities/agencies. As Braidotti argues, ‘gender is just a historically contingent mechanism of capture of the multiple potentialities of the body’ (Braidotti, 2013, p. 98). Although I suggest instead of gender, it could be ‘gender-sex’ and therefore there can be no strict boundary line between ‘body’ and ‘brain/mind’.

Entity 1’s silence concerning gender-sex and sexuality resonates with the supposed ‘neutrality’ of science, as well as Entity 1’s beliefs about the objectivity of science and potential negative interference of emotions. Might it be possible to understand ‘becoming-male’ as also ‘becoming-neutral’, in this sense? In other words, Entity 1’s becoming-male involves a comfortable alignment with xir identity, xir body, and xir beliefs about science and objectivity. Consequently, this enacts a territorialisation and a capacity to believe in the objectivity and neutrality of science, but also not to consider other possibilities.

Entity 1’s ‘becoming-male’ does not begin with xir ‘body’ and identities, but rather is an intra-action of various micro-macro entanglements. This is in similarity to what Fox and Alldred argue:

it is not an individual body but the sexuality-assemblage that is productive of phenomena associated with the physical and social manifestations of sex and sexuality, and that establishes the capacities of individual bodies to do, feel and desire (Fox & Alldred, 2016, p. 99).

I characterise this as not ‘individual bodies’ but ‘entities’, in recognition that an ‘individual’ is not necessarily intelligible. Thus, for Entity 1, it may be that xir becoming-male entails the capacity to desire ‘neutrality’ in becoming-science-teacher.

My processes of data analysis involve creating ‘views-assemblage’ visualisation maps for each participant, as outlined in Chapter 3. As a reminder, these maps are an attempt to visualise some of the material-discursive complexities arising in my analyses, drawing attention to what a relational posthumanist standpoint brings into the analysis frame.

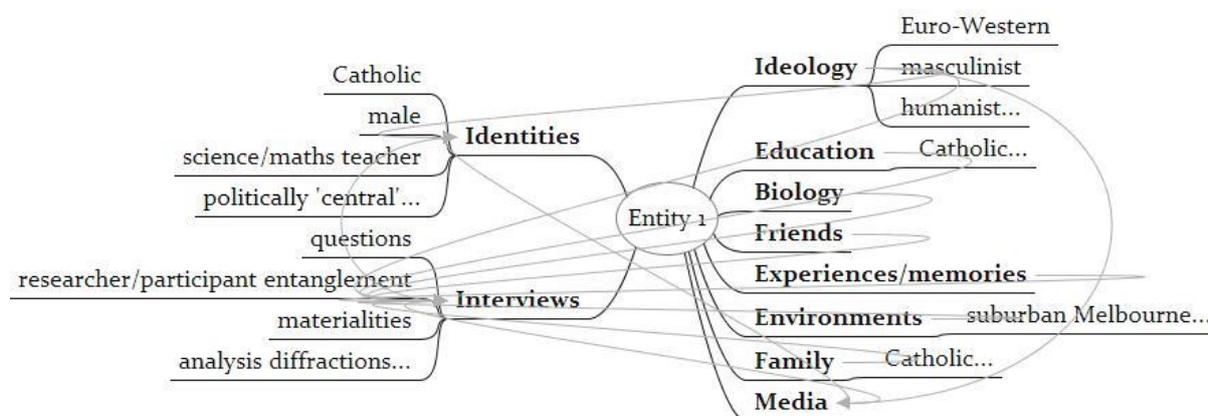


Figure 9: Entity 1’s views-assemblage map

In this map for Entity 1, there are the various aspects of Entity 1’s views-assemblage that I consider in this chapter, such as xir identities, while others are only indicative, such as ‘biology’ and ‘environments’. The ellipses emphasise that there are numerous elements not included in this map, and the web of arrows also suggest, symbolically, the overall relationality between phenomena. That is, that while I have separated phenomena into categories, they all intra-act.

What might be particularly significant with Entity 1, however, is not actually the specifics of xir views-assemblage but rather that there is no ‘line of flight’, or ‘movements of deterritorialization and destratification’ (Deleuze & Guatarri, 1984, p. 3), that may have challenged or shifted Entity 1’s beliefs about ‘objective science’. In other words, what is

significant is not the assemblages Entity 1 is a part of but rather what was *not* a part of these assemblages.

It appears overall that the flow of affects within Entity 1 and xir ‘environment’, family, and friends, as well as xir experiences, including with formal education, have not elicited the capacity to critically consider xir beliefs in the ‘objectivity’ of science. Consequently, while Entity 1’s expression of normative beliefs about science and ethics are highly dynamic, regarding xir becoming-science-teacher and becoming-Catholic, they are still ‘territorialised’, or constrained by the particular onto-epistemological entanglements of which Entity 1’s views are constituted.

---

#### ENTITY 6

Entity 6 was twenty-five at the time of the first interview and a third-year Bachelor of Science/Education student. Entity 6 identified as atheist, male, and Australian. Xe has lived in Melbourne, Australia since birth. Xe described xir political leanings as ‘definitely lefty’ but ‘as I’ve gotten older, I found I’ve gone - moved back to the right a little bit’. Entity 6 stated an intention to teach primarily school biology and chemistry. Xir father is a small goods manager and xir mother is an education integration aide, working with children with disabilities. Entity 6 also mentioned currently working part time with children with disabilities. Xe is also the first in xir family to attend university. After initially dropping out of university, and a degree in nutrition, Entity 6 joined the army for one year and then also did some volunteer work in an African country before deciding to pursue a degree in education.

For primary and secondary, Entity 6 went to public (government-run) schools. The secondary school is a mid-ranking co-educational college in the south-east of Melbourne, with NAPLAN scores generally average to slightly above average (MySchool, n.d.). Entity 6 stated that xe always ‘loved science as a student’ and that xe had good teachers in secondary school. Xe also expressed an interest in sustainability as inspired by xir education experiences but also

xir father. Entity 6's army experience involved general infantry training as well as rifleman training. Ultimately, Entity 6 decided against continuing in the army due to xir desire to travel and do other things that a contract with the army would prevent.

The volunteer work in Africa came about, as Entity 6 said, due to a desire to visit the continent. Xe searched online for volunteer opportunities and found a secular one that xe thought aligned with xir beliefs. The volunteering involved mainly physical work, such as helping build a sewing room, but also involved working with sports teams in partnership with raising awareness about HIV. Lastly, Entity 6 stated an interest in popular scientist figures such as 'Dr Karl<sup>33</sup>' and the British biologist, Richard Dawkins, who xe follows on social media.

Entity 6's views of science were on the whole very positive, describing science as something that 'will cure a lot of the world's problems' and that 'the possibilities of science is limitless and that it's, yeah, very much a source of good'. Xe did also note a preference for some negative aspects, or limitations, to technology, such as noting possible negative effects of wind farms in that 'they can kill native fauna and stuff like that'. Additionally, with genetically modified humans, xe stated that:

I think when you go down to kind of like superficial changes, like eye colour, hair colour, and stuff like that [...] that's where it becomes a bit murky and a bit too tailored and I'm not a fan of that.

Xe also noted complexities such as with the potential to 'eradicate' diseases and disabilities in saying that:

---

<sup>33</sup> Dr Karl, otherwise known as Dr Karl Kruszelnicki, is an Australian science commentator and author appearing on many TV and radio shows.

variety really is the spice of life. Like, the differences between people is really important as well and even if you know someone does have a disease, or anything like that, they're of no lesser value.

While Entity 6 did not use the specific term 'objective' to describe science, xe did express the view that science is about giving 'concrete answers' in contrast to 'pseudo-science' and, indeed, that this was one of the main reasons that xe loves science. Xe stated that 'if I kind of go searching for an answer, I really hate getting an answer that's kind of wishy-washy. I really like definite answers' and that 'I liked the scientific method in that it gave me concrete answers to questions and, like, it could kind of translate into real life'. Entity 6's influence diagram is pictured on the following page.



Figure 10: Entity 6's influence diagram

Entity 6 completed the influence diagram using the pre-made cards but then added in ‘Scientific Media Personalities (Dr Karl)’ into third place later in the interview. The diagram on the whole corresponds well with Entity 6’s verbal responses. For instance, xe often mentioned how much xe enjoyed science in secondary school, and xir father’s influence in discussing science related subjects, particularly around environmental concerns. One aspect not addressed by this diagram or explicitly in xir verbal responses, however, was xir relationship with xir embodiment, or what I refer to as xir ‘bodily’ becoming.

As almost an aside to xir main answer to my question about what got xir interested in science, Entity 6 noted that when xe was younger xe was ‘heavy’ and xe went looking for dietary information on the Internet to help lose weight. Therefore, one potentiality in relation to Entity 6’s views that science provides ‘concrete answers’ is an entanglement with norms and ideals around health and physical appearance. Like with Entity 1’s religious becoming, it is conceivable that many materialities are at play in an entity coming to believe xe is ‘overweight’.

What Entity 6 found on the Internet was the ‘wishy-washy’ answers that xe stated xe hates. Xe said: ‘I think I just got a bit fed up with how much misinformation that was out there, especially about nutritional advice, so I found that really frustrating’. This response suggests xir affective capacities were shifted via the process of accessing nutrition advice on the Internet, especially with the emotion of frustration. Entity 6’s weight concerns seemingly did not just involve this perspective on, and frustration with, pseudo-science but also why xe initially began a degree in nutrition. Consequently, xir ‘bodily becoming’ arises as particularly significant for numerous reasons in Entity 6’s becoming in general, but also toward xir becoming-science-teacher and xir views of science and ethics.

Overall, my analysis of Entity 6’s science-ethics views-assemblage might be understood as involving the following:

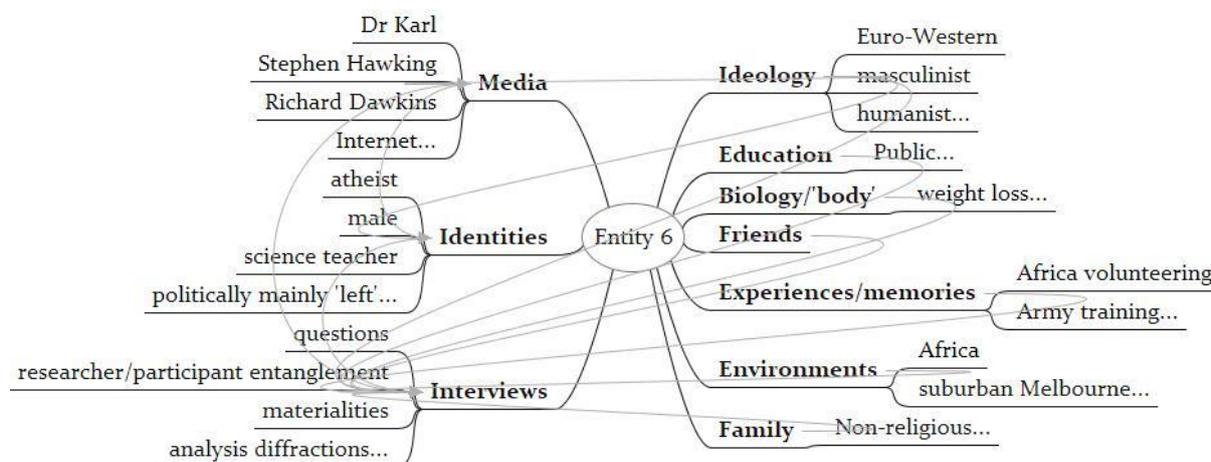


Figure 11: Entity 6’s views-assemblage map

The arms ‘media’, ‘identities’, and ‘biology/body’ are areas of phenomena I consider as potentially important and unique aspects of Entity 6’s science and ethics views-assemblage. To a lesser extent, I also include Entity 6’s experiences of volunteering in Africa, which is included in this map under ‘environments’.

Firstly, a potentiality is that Entity 6’s frustration in encountering pseudo-science when wanting to find nutrition advice influenced xir in finding stability in the idea that ‘real’ science can provide ‘concrete’ answers. Although this is so if only it can be clearly divorced from ‘wishy-washy’ pseudo-science. It could also be argued that the wider implications and entanglements apparent in Entity 6’s bodily becoming are not only Euro-Western and masculinist ideals concerning ‘objective’ science but also related norms around health and body weight/appearance. It is likely that this entanglement includes micro-macro events in which it became known to Entity 6 that xir body’s appearance did not meet normative expectations. The expanding area of research into body image issues suggests that it has a significant impact on people and society (Grogan, 2016, p. 2).

The Internet's influence in dispersing a staggering amount of information perhaps goes together with an increasing desire for people to be able to distinguish between what is 'true' or not. Indeed, with those entanglements considered, it is understandable that there is comfort found in the idea that there *is* such a thing as real, pure, objective truth. Entity 6 also expressed the view that unethical science is mainly about individual scientists' unethical behaviour, as seemingly inspired by the same university subject 'SCI1' that Entity 1 mentioned. This, again, may reinforce the capacity to believe that science is objective/neutral, or at least that this is always the ideal to be achieved. Furthermore, it supports the view that 'bad science' is only linked to some scientists rather than other issues inside and outside of scientific research/knowledge.

Another significant potentiality, as Entity 6 noted xirself, is xir entanglements with media and scientific media personalities/authors, such as Dr Karl, Stephen Hawking, and Richard Dawkins. Entity 6 stated that:

Dr Karl is probably the big one in there. He is a huge influence. I listen to his podcasts all the time. He's been on the radio for 30 years. I remember when, as a kid, I used to listen to him heaps with my dad.

It is potentially significant for Entity 6's becoming that these popular scientists are male, and particularly revered by many for 'revealing truth' about the universe and/or science. Dawkins, for instance, is well known for being extremely critical of the 'supernatural', and all forms of religion, as well as being a proponent of 'reason' (Gray, 2014).

Entity 6 also said the following about Dr Karl:

The thing that I really like about his scientific outlook is if he is wrong about something, he will be like, "Sorry, I didn't realise. You are a

hundred percent right. I'm a hundred percent wrong. I didn't know enough about the topic and I'm going back [...to] research it".

This suggests that, because Dr Karl admits when he is wrong, that he is therefore trustworthy in pursuit of 'ultimate truth'. While Dr Karl, Stephen Hawking, and Richard Dawkins are vastly different in many ways, Entity 6's interest in their work and ideas, even though xe at times expressed criticisms of them, perhaps influences xir capacities and therefore xir belief in science being ultimately about providing 'concrete answers'.

The last potentiality I consider is Entity 6's experience volunteering in Africa. Entity 6's descriptions of these experiences were limited in the first interview, and I was only able to partly follow up on them more in the second interview. Although this topic was only touched on, the materialities of travelling to, and living in, a country quite different from place of origin are no doubt significant for an entity's becoming. What arose as especially relevant about Entity 6's volunteering experiences are xir comments that reinforced a masculinist and Euro-Western ideological conception of science, in contrast to what xe saw as a 'less developed' African culture.

For instance, Entity 6 related that while in Africa, although xe had no health qualifications, xe ended up 'educating' people about 'basic sanitation'. Entity 6 stated that:

I hate to say it but it blew them out of the water. Like, they still have beliefs about witchcraft and Malaria being transferred by, like, voodoo and stuff like that, rather than mosquitoes.

A potentiality, therefore, is that Entity 6's experience in Africa, of encountering different ways-of-knowing-being, reinforced xir ideas about the authoritative power of Euro-Western science. This is especially in the case of Euro-Western science being seen as more 'rational/reasonable' and therefore able to provide 'concrete answers'. In other words, 'the humanist Enlightenment

ideal of (Western, white, European) Man as the measure of all things' (Neimanis et al., 2015, p. 4). What this also suggests is that being introduced to different ways-of-knowing-being can further entrench original beliefs, rather than challenge them. This is perhaps especially so if an entity's assemblages involve considerable onto-epistemological attachment to certain ideals, such as 'concrete' knowledge.

Overall, Entity 6's bodily becoming, xir engaging with scientific personalities such as Dr Karl, xir volunteering in Africa, and surely many other experiences I was not able to consider such as xir army training, can be understood as affective flows resulting in xir capacity to view 'real' science as about delivering concrete reason, or pure knowledge. Xir experiences in Africa especially may have further territorialised this perspective, by being able to view firsthand the 'Other' of Euro-Western science, such as beliefs in the supernatural.

It is evident in this that Entity's alignment with Euro-Western ideals of science close the capacity to appreciate other ways-of-knowing-being as anything other than false and inferior. However, what a relational posthumanist framework especially outlines here is that an entity's views of science and ethics are not just passed on by socially hegemonic ideals but complex onto-epistemological relations, which can include subtle events such as seeking to lose weight.

---

#### ENTITY 7

At the time of the first interview, Entity 7 was twenty-two years old and in the second year of the Bachelor of Science/Education double degree. Entity 7 identified as male, agnostic, and Australian. Entity 7 moved to Melbourne from xir rural home town in Victoria to attend university. Xe expressed a strong interest and ability in mathematics throughout xir schooling and, at the time of the interviews, had the intention to primarily teach mathematics. Xe also expressed an interest in philosophy and stated xir political leanings as 'socially I am a little bit left, to use the convention, but economically right'.

Entity 7 has a large family, with many siblings, a father who works in the trades industry and a stay-at-home mother. While xir father finished the Victorian Certificate of Education (VCE)<sup>34</sup>, Entity 1 told me xir mother and siblings did not, and xe is therefore in the minority in xir family to have completed the VCE and to be undertaking tertiary education. Entity 7 went to public, rural schools in Victoria for both primary and secondary.

The secondary school Entity 7 went to is a co-educational college. This school's NAPLAN scores are below average to average (MySchool, n.d). Entity 7 said that xe did not do much science in secondary school, mainly because xe did not have the space as xir focus was on mathematics. However, xe also did take German, and a music subject as well. Entity 7 took a gap year<sup>35</sup> and worked during that time in food production.

Entity 7 stated that, in relation to renewable energy, 'I feel really passionately about it and [am] very pro wind farms'. When we were discussing the topic of genetically modified humans, Entity 7 identified ethical problems but said xe would support it, so long as there were 'parameters in place to prevent people from abusing it'. After I asked xir what from xir education might have helped xir consider this topic, xe identified a relationship between the characteristics of mathematics and objectivity, to mean a distancing from emotions:

I suppose like the objectivity that comes from mathematics in being able to step back from like my own emotions, in that [...] it doesn't derive straight from maths but I think it definitely contributes to it.

---

<sup>34</sup> The 'Victorian Certificate of Education' is received after the final two years of Victorian secondary school are completed.

<sup>35</sup> A 'gap year', which is a break between completing secondary school and beginning tertiary studies, to work and/or travel, is popular in Australia.

Further, Entity 7 stated that ‘I’d say the biggest or the main thing that I see a positive attribute [of science] would be I guess the fact that it’s objective’.

In the second interview, I asked Entity 7 to elaborate on this view, leading to the following exchange, in which I am ‘researcher-entity’:

**Entity 7:** I guess, like, to me objectivity is more a disassociation from your own personal opinions. But again, even that can be subjective like [in] contrast. So, just being...I guess wary. It’s hard to find that context I guess [laughs]. Just trying to limit [...] your own personal opinions affect[ing] your decision, in an objective circumstance, or how you view something objectively.

**Researcher-Entity:** Can you identify where those ideas that you have about objectivity in science come from? Is it from high school or your personal interest in science?

**Entity 7:** I’d say a lot of it would stem from math. Just the fact that it is objective, and it is what it is. And it doesn’t sort of relate to, yeah, to personal opinion.

This interview extract has resonances with Entity 1 in relation to the separation of knowledge and emotions. It also resonates with Entity 6 in relation to the idea of ‘objective’ knowledge as in some way ‘pure’ or as not influenced by personal opinions. The image on the following page shows Entity 7’s completed influence diagram.

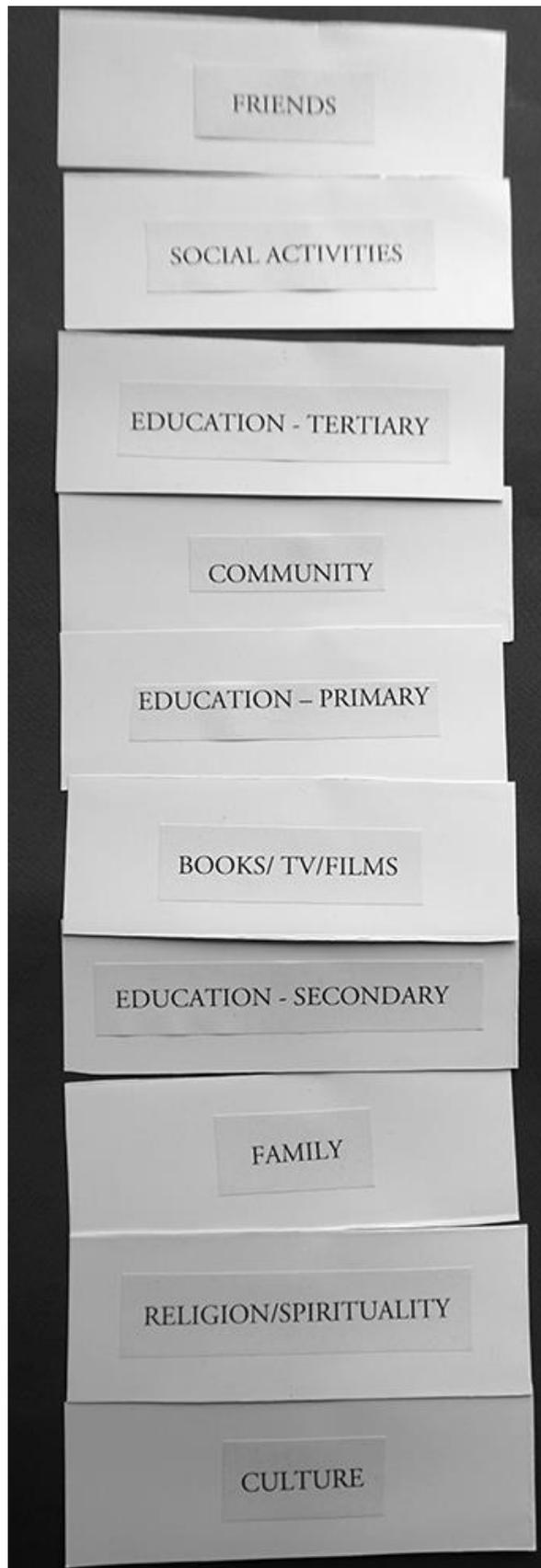


Figure 12: Entity 7's influence diagram

It is potentially meaningful that Entity 7 put ‘friends’ first in xir influence diagram. Xe spoke highly of one friendship, which is ‘very trusting’ and that this friend is ‘really open to discussion and loves, like, debating intellectual issues, which is great’. Overall, Entity 7 spoke of enjoying debating issues with friends. When I asked if xir education may have influenced xir views on genetically modified humans, xe responded by saying:

not particularly in high school. At least not through the school curriculum but I think just interactions with, like, friends and just, I suppose, presenting ideas and then debating them just amongst ourselves, like that was really a valuable thing.

When I asked for further details in the second interview, Entity 7 described xir friends as ones that have developed since primary and secondary school, and that one of the main bonding points for them has been an interest in science. Indeed, xe said that most of xir friends have gone into science-based studies and careers. Xe stated that within xir friendship group, there is a lot of mutual respect and their discussions are about ‘listening and just understanding where the other person’s coming from’. Xe also stated, however, that ‘we tend to have a lot of the same opinions’. This suggests that Entity 7’s friendships may be a significant influence for territorialising xir thinking-feeling capacities and therefore also xir views about science and ethics.

Entity 7 stated in the interviews, as constituting xir becoming-mathematics-teacher, that xe makes a connection between the objectivity of mathematics and science. Mathematics, even perhaps more so than science, may be believed to be a method to get at pure, objective truth about the universe. This view relates to the ‘realist’:

philosophers of mathematics [who] have accounted for the objectivity and robustness of mathematics by recourse to a foundational theory of

mathematics that ultimately determines the ontology and truth of mathematics (Friend, 2017, p. 1).

Entity 7's comments about the objectivity of mathematics and science seems indeed to be what xe sees as the most valuable component of both. Entity 7 also demonstrated in xir responses that the form of objectivity that xe also most values is the Cartesian split between reason and emotions. Objectivity, in this sense, 'is what it is', as Entity 7 stated, and thus offers an authoritative account and one that is pure, or clean, because it is divorced from emotions.

In addition, Entity 7 also stated an interest in philosophy, and said that 'I like to incorporate it into, yeah, how I perceive science'. This interest also appears especially entangled with Entity 7's ideas about objectivity in mathematics and science, and thus may invoke particular affective capacities in Entity 7 in relation to these topics. Notably, after xe stated a love for philosophy xe immediately also stated a love of 'objectivity'. Although xe did not state which philosophers or schools interested xir, and unfortunately, I did not think to ask further questions on this topic, Entity 7's connection between philosophy and objectivity appears congruent with those that are often related to Euro-Western ideals. In other words, xir views, like Entity 6's, correspond with 'the humanist Enlightenment ideal of (Western, white, European) Man as the measure of all things' (Neimanis et al., 2015, p. 4).

My analysis of Entity 7's science-ethics views-assemblage can be represented as the following:

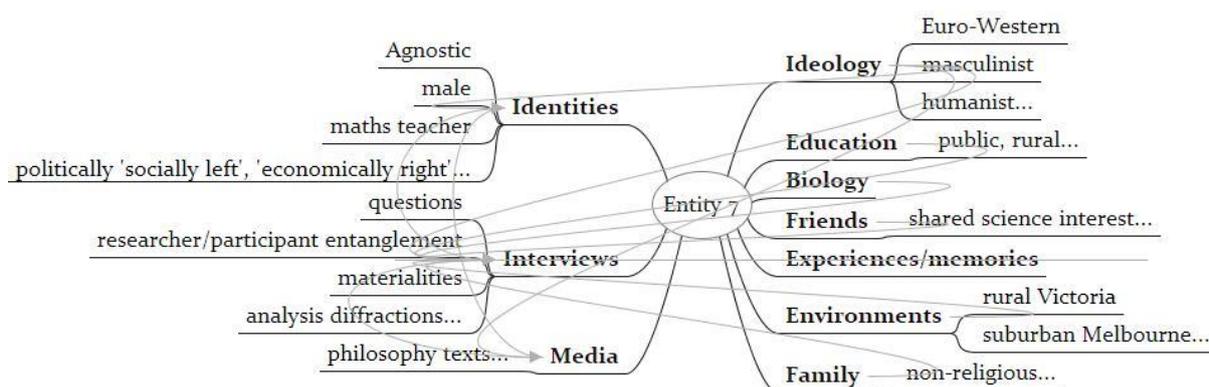


Figure 13: Entity 7's views-assemblage map

In this map, I have highlighted Entity 7's identities, xir interest in philosophy, and xir shared interest in science with xir friends. Other areas I could only consider in a more peripheral sense, due to time and word count constraints, include Entity 7's rural upbringing and xir family being non-religious. However, I highlight this as it seems probable that whether an entity grows up in a rural, suburban, or urban area also has a significant influence in their becomings.

This was evident in some of the participants' responses, such as Entity 8, who noted that the topic of wind farms was a 'hot debate' in the rural community xe grew up in as there was a wind farm built nearby. Consequently, xe was more aware of the issues, and had also physically experienced the sight and sound of wind farms, which led to xir strong views on the subject. Additionally, it seems probable that not having a religious belief, along with a non-religious family and upbringing, has as much implication in an entities' science and ethics views-assemblage as does religious belief and a religious upbringing.

---

## STORYING DIFFRACTIONS I

The above stories of entities 1, 6, and 7, although involving multiplicities, can be further diffracted together. I illustrate here how this diffraction brings together the potential advantages of considering the participants' views as 'onto-epistemological'. It may be argued that all-encompassing elements of society, such as hegemonic ideals, play a significant part

within views-assemblages. However, my analyses suggest that the ways in which hegemonic ideals are involved vary according to multiple other onto-epistemological phenomena in the participants' becomings. Some phenomena, such as religion, may be quite overt, while other becomings involve subtler shifts.

For example, with Entity 1 I examined xir potential becoming as involving tensions between two identities: becoming-Catholic and becoming-science-teacher, both of which are overtly continuing aspects of xir life. In the case of Entity 6, I considered the potentiality of a specific episode in xir life, that of concern about xir weight, as being a significant part of xir becoming-science-teacher. For Entity 7, I suggested the subtle intra-actions between xir becoming-mathematics-teacher, xir interests, such as in philosophy, and xir friendships as potentially significant. These becomings, overall, appear to be very important in how these three participants thought of science as 'objective'.

As previously indicated, it is noteworthy that these three participants, who most strongly support the ideal of 'objectivity' intend to teach science or mathematics. It might be that their becoming-science-teacher or becoming-mathematics-teacher is also entangled with hegemonic ideals about disciplinary boundaries. One important way in which boundaries are maintained around science might be the ideal about objectivity, as well as broader connections with Cartesian dualisms. In Chapter 1, I noted that science education tends to be isolated from other subjects in school science, as well as society (High Level Group, 2004, as cited in Tytler, 2007, p. 12). Consequently, it may well be that alignment with disciplinary boundaries are also crucial to consider in relation to how teachers and students understand science. I extend this thinking to views about ethics in the next half of this chapter.

Furthermore, what a relational posthumanist standpoint suggests is that participants' becomings are not as a result of a top-down arrangement of power, or a humanist conception

of putting the individual first as a singular, intelligible entity who then utilises self-agency (Fox & Alldred, 2016, p. 27). Instead, their becomings are understood as a complex onto-epistemological mesh, in which bodies, matter, emotions, environments, and experiences are not separable from the concerns of discourse, identities, and ideology.

As Barad argues, ‘matter is substance in its iterative intra-active becoming—not a thing, but a doing, a congealing of agency’ (Barad in Kleinman, 2012, p. 80). This ‘congealing of agency’ for the above participants involves a vast array of phenomena, in which hegemonic ideals are no less or more important than phenomena such as their physiological make up, their experiences, emotions, or the environments they encounter. Clearly, though, I have only been able to gesture to some of these subtle aspects.

Additionally, at times the significance lies more in what is *not* present, in terms of potential lines of flight, than what *is* present in an assemblage. For instance, what might be of most significance for entities 1, 6, and 7, is that their views-assemblages were territorialised to align with the traditional ‘science is objective’ view. Furthermore, that there were no ‘lines of flight’, or processes of deterritorialisation powerful enough, for them to have the capacity to question this traditional view, or to consider other potential views.

To conclude this section, I briefly also consider here my entanglement in this study as integral to the overall becoming of my analyses in this chapter. I note that I have come to be more aware of elements of my own becoming, and my own science-ethics views-assemblage, via my writing ‘The Beforetimer’, as well as via conducting the interviews, and my processes of analysis. In terms of how I view science, ‘The Beforetimer’ perhaps demonstrates my perspective as being a mixture of optimism and pessimism. This view is exemplified in the overall cataclysmic premise of the story, while elements of optimism lie in the depiction of the *Homo adaptos* and their approach to science and technology as adhering to a ‘balance’ with nature.

My experience of conducting the interviews and by thinking deeply about the complex ways people come to their views about science made me think more critically about my own becoming. This includes consideration of what in my life has contributed to this perspective, such as the rural environment I grew up in, as noted in the introduction to this dissertation. Another important aspect is the media I have engaged with, including non-fiction and fiction, although particularly speculative/science fiction.

Furthermore, these interviews may also highlight how rare it is for most of us to consider our lives, our ideals, and our ethical perspectives, or cumulatively our becomings, in detail. Indeed, some of the participants also noted this. Entity 1, for example, stated in xir interview that xe found taking part in this research project to be rewarding because xe was given the opportunity to consider these ideas, which xe never got as part of xir schooling experiences.

Consequently, it is noteworthy that while my main prerogative in these analyses was to open this research space into teachers' views by considering complex assemblages of onto-epistemologies, my analyses also potentially highlight the importance of giving time and space for teachers and students to consider their own becomings. This may therefore be a promising avenue to consider regarding developing the curriculum, pedagogy, teacher education, and professional teacher development for the science-ethics nexus. In the following section, to continue this onto-epistemological account, I present my analyses of interviews that relate most strongly to focussing on views about ethics as related to science.

---

## ENTANGLING WITH ETHICS

One major commonality between my short story, 'The Beforetimer', and the film *Snowpiercer*, is that they both highlight the understanding that ethics concerning science and technology are not developed in a vacuum. Rather, there are numerous entanglements involved. In 'The Beforetimer', Pax/Entity is a 'tester', or a test subject, who undergoes dangerous

experiments on himself to test a serum that might allow the humans living in the ‘subhouses’ underground to survive a stasis sleep. Regardless of whether this is ethically ‘right’, the parameters are set by the context; that is, if they do not create a working serum, they may all die of starvation. The underground inhabitants have decided that the dangers of these experiments are worth the risk, if a possible outcome is that many of them will survive.

In the ‘real’ world, there are many ethical questions regarding science and technology that do not have perfect answers, and certainly not answers that cleanly demarcate humanity from ‘the world’. Attempts to overcome messiness, or complexity, by avoiding it, may produce as much harm as practices most commonly understood as ‘unethical’, such as cloning humans.

In *Snowpiercer*, one of the most significant ethical quandaries is the use of children from the back of the train as replacement engine parts; parts which have worn and cannot be fixed. The train engine, in the context of this world, is not just a machine. It is like a god, revered because it is the only thing keeping everyone on the train alive. When the group led by Curtis reaches the train carriage being used as a primary school, the overly exuberant teacher sings a call and response song with the children, who are clearly well-versed in it.

The teacher sings ‘rumble, rumble, rattle, rattle, it will never die. But will it stop, will it stop?’ The children shout ‘no!’ The teacher continues ‘But can you tell us why? The engine is eternal’. The children shout ‘yes!’ The teacher then sings ‘the engine is forever’ (Garland, 2015). When we see the skinny, dirty, and vacant-eyed children towards the end of the film, there is a strong affective potentiality of a response of anger, discomfort, and other similar emotions. Furthermore, the end of the film, involving the derailment of the train, might be understood as an ethical position or statement; that the lives of many are not worth the sacrifice of children. However, the movie overall functions much more in terms of provocations than it does in specific ethical positions.

I now focus on entities 10, 4, and 9, by specifically examining their views of ethics in relation to science and school education. What I demonstrate is how a relational posthumanist framework allows us to understand the very ‘messy’ nature of how ethics is constituted and, as per the previous section, how ethical views also involve onto-epistemological becomings. I first include analysis of Entity 10’s interviews, as xe was the participant who expressed the strongest view about ethics being a ‘controversial’ topic, which xe would prefer not to have to teach. I consider this in relationality with the Euro-Western and masculinist constitution of ethics, as well as xir religious identity.

I include analyses of the interviews with entities 4 and 9 as I believe they out of the group best exemplify how it might be that some entities depart, at least in some way, from hegemonic Euro-Western, humanist, and masculinist ideals concerning ethics and science. Specifically, I suggest that their ‘becoming-Other’ functions as a line of flight, modifying the assemblages they are a part of to produce alternative capacities. It is, again, noteworthy that discipline area appears to have significance for these participants’ views. Entity 10 intends to mainly teach biology, while Entity 4 intends to teach history and English, and Entity 9 intends to teach English and English as a Second Language (ESL).

---

ENTITY 10

Entity 10, at twenty-one, was in the second year of the Bachelor of Science/Education degree at the time of interviewing. Xe identified as female, as a member of a small Christian denomination<sup>36</sup>, and as Australian. In response to my question regarding xir political leanings, Entity 10 described xirself as ‘conservative’ but does not identify with any specific political party. Xe overall relayed a sense of frustration with politics in Australia ‘because I don’t really think that any of them stand for anything. They’re all pretty much the same’. Entity 10’s teaching

---

<sup>36</sup> The denomination name has been redacted to protect Entity 10’s identity.

interest is mainly biology but xe is also interested in teaching English. Entity 10's father is a manager at a major technology company and xe has a stay-at-home mother. Entity 10 attended interdenominational Christian schools for primary and secondary, in the outer suburbs of Melbourne.

Entity 10's secondary school is one that is high-achieving, according to NAPLAN data, having above average results across all domains (MySchool, n.d). Xe described xirself as a very successful student and that xe has always loved science but was not originally intending to pursue science teaching. Indeed, after finishing secondary school, Entity 10 originally began an Arts/Law degree but xir experience in tutoring biology led to an interest in teaching science. That, combined with a realised lack of interest in law, led to the change in course.

Like entities 1, 6, and 7, Entity 10 also expressed a view in line with 'objective science', in saying that science 'has facts behind it, so you can back it up' and 'generally speaking, you can't refute science depending on what it is [laughs]... but it's a little bit more like hard facts'. On the topic of genetic modification of humans, Entity 10 for the most part was negative. Xe stated that:

everybody has a potential in some way or another and if you're going to alter everyone to be a certain way then it kind of...I guess you're robbing from those people an experience they could learn from.

When I asked how xe might approach teaching a class on this topic, xe stated that xe 'wouldn't cover the moral side of it I don't think' because it is 'too hard' as everyone has very different opinions, which could be a 'mine field'. When we were discussing science and ethics more generally, Entity 10 stated that:

I think it's very hard to teach ethics though, so I guess it's the same as in the classroom, people don't want to teach ethics because it's

controversial [...]. It's hard to teach because it's something you don't really want to breach the topic of.

I also asked Entity 10 if xe is guided by xir religion when considering science and ethics, to which xir response was 'my philosophy is when in doubt [to ask] what does my religion say?'

Entity 10 chose to complete the influence diagram by relating it to one topic, and for xir this was 'renewable energy'. Entity 10 also added in a card, which xe placed at the top, for 'Internet/Personal Research'. A photo is on the following page.

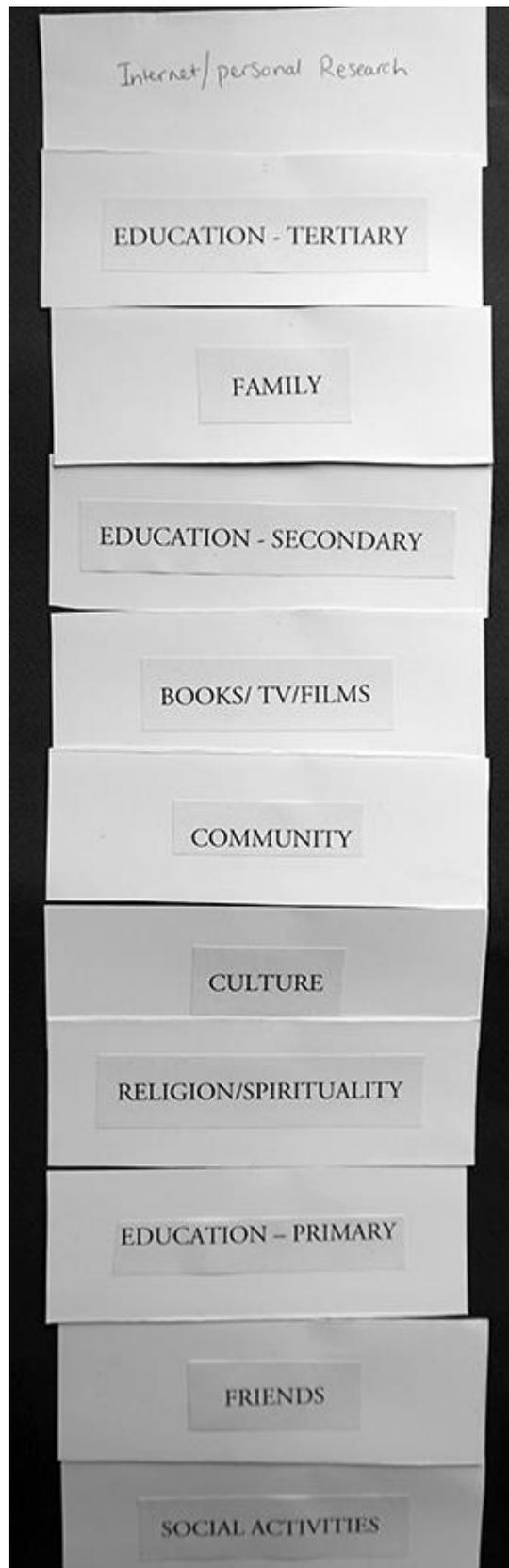


Figure 14: Entity 10's influence diagram

So, why has Entity 10 come to view ethics as ‘controversial’, and why does such a view also mean that xe would prefer to avoid teaching ethics? I suggest that one potentiality is a tension between the Euro-Western, masculinist, and humanist constitution of ethics and Entity 10’s negative view of teaching ethics. However, as part of this examination I also consider the complexity that is suggested by xir religious views, even though xe did not place ‘religion/spirituality’ high in the influence diagram activity.

My analysis of Entity 10’s views-assemblage can be understood as involving the following:

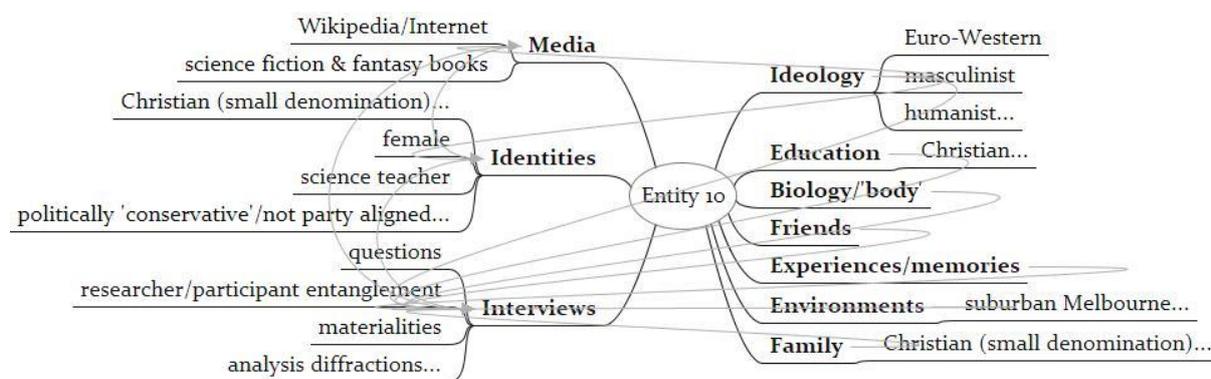


Figure 15: Entity 10’s views-assemblage map

In this map, I draw attention to the potential influence of media as well as fiction. Additionally, I highlight the entanglement of Entity 10’s religious identity, as aligned with a Christian denomination that is relatively small within Australia, which is also linked to xir family. I first suggest that Entity 10’s view of ethics in relation to science being both ‘controversial’ and something xe would prefer not to teach is not necessarily something inherent about ethics. Rather, this may be due to how masculinist, humanist, and Euro-Western ideals characterise ethics as linked to rationality, reason, and objectivity.

The ‘controversy’ therefore occurs in the inherent affective tension between this supposed objective process and the ‘common sense’, or common experience, of ethics as

inseparable from personal subjectivities. This latter aspect is suggested by Entity 10's observation that ethics is 'difficult' to teach. I propose that this is because ethics is 'messy' and personal. To put this another way, ethics may be widely thought of as controversial because fundamentally it is recognised as potentially involving intense emotions. However, at the same time, hegemonic masculinist, humanist, and Euro-Western implications in the definition of ethics requires ethical considerations to be measured, 'rational/reasonable', and therefore non-emotional. Consequently, a tension exists.

The 'controversy', correspondingly, is not wholly about ethics being emotional, but that it is overtly *not recognised as emotional*. In other words, it is not often recognised that engaging with ethics is always already an emotional process, and entangled with various phenomena. In contrast, a posthumanist ethics might be linked to what Neimanis et al. refer to as 'the imaginary' through which 'humans cultivate and negotiate relations with the material world, both *emotionally and rationally*, while also creating identities for themselves' (Neimanis et al., 2015, p. 5; emphasis added). They follow this by arguing that any consideration of things like environmental issues must also take into account 'human desire, motivation, and values' (Neimanis et al., 2015, p. 6). This consideration will be further detailed in Chapter 6.

Entity 10's views as being in alignment with a strong masculinist and Euro-Western hegemonic ideal that science is about 'hard facts', as well as xir perception that ethics is 'controversial', may also be in tension with xir strong religious beliefs. This is perhaps not due to xir religious beliefs specifically, however, but rather Entity 10's awareness of such beliefs being a *form of subjectivity*, and one that is in the minority. That is, xe belongs to a very small Christian denomination within Australia, according to the latest census data (Australian Bureau of Statistics, n.d.).

Entity 10 expressed awareness many times throughout the interviews that xir religious-based views are far from ‘mainstream’. For instance, xe noted that her undertaking gender studies was unusual for someone who follows xir religious beliefs. Xe stated that in these classes ‘there are a lot of people who have some very loud views that are particularly in conflict with mine’ and that xe was therefore quiet in such classes, ostensibly to avoid possible conflict and emotional discomfort.

This tension was pronounced occasionally throughout both interviews. However, it especially became apparent during our discussion of genetic engineering, related in the following exchange:

**Entity 10:** ...about the – the genetically modified human thing – like [I’m] thinking about that in terms of that [...] oh well, I guess as a [member of a small Christian denomination] I probably believe that you shouldn’t genetically modify humans because it’s all part of life and part of, you know, God makes everybody individual. Oh, that it’s not natural then you’re not giving them the opportunity to learn because trials are supposed to happen in life. But then, at the same time, it’s like I don’t really know, the [religious leaders] have never spoken on it so I couldn’t say for sure – for certain [laughs] [...] but yeah it would always – that’s what it always comes back to [...] I don’t know. Things like abortion, embryo stuff...

**Researcher-Entity:** oh, okay, like stem cell research?

**Entity 10:** oh, you can get stem cells as long as it’s not stem cells from an embryo, that’s okay. I figure that, you know, if it’s from a donor from bone marrow stem cells that’s okay but if it’s a stem cell from...oh, even stem cells from a placenta that’s okay because it’s not

destroying a life in the process of doing it [laughs] [...] but those are the things that come from my religion. It's because I believe in that, you know, the value of life and that, you know, you shouldn't be – well, personally, I think it is murder [laughs] but that's...it's the fact that, you know, you shouldn't be killing living things....

Consequently, in Entity 10's becoming-science-teacher, xe must navigate prioritising xir religious beliefs with xir scientific views, which causes one particular kind of tension. Adding to this tension, however, is that xir views of ethics in science align with implications of Euro-Western, humanist, and masculinist ideals. These ideals understand objectivity and reason to be the basis of coming to ethical choices and opinions.

Overall, then, the potentiality I highlight is that a reason Entity 10 expressed such a strong view that ethics is controversial, and that xe would prefer not to have to teach it, is because of this pronounced tension that requires Entity 10 to go through multiple levels of interrogations of any specific ethical issues. It is also conceivable that such processes necessarily involve numerous intra-actions, involving affects and materialities, that relate to xir religion and schooling experiences.

---

#### ENTITY 4

Entity 4 was twenty-one and in the third year of the Bachelor of Arts/Education at the time of interviewing. Entity 4 identified as Australian, male, and non-religious. Specifically, xe stated that 'I tend not to believe in God but at the same time if someone can convince me otherwise then I'm more than happy to listen'. Xe said that xe has no specific allegiance to a political party or leaning, and xe votes according to a party's current policies. Xe said that in the

last election xe voted Greens<sup>37</sup> because of their policies: ‘Same-sex marriage was one, and I think there were a couple of other[s] like gay rights in there that were really good. They weren’t cutting education, which was nice’.

Entity 4 has lived in Melbourne, Australia since birth. The subjects xe indicated xe wants to teach are primarily history, with English as secondary. Entity 4’s mother is a health professional and xir father is a tradesperson. Entity 4 described xir family as being Catholic but not very strongly religious. Entity 4’s primary and secondary schools were, however, both private Catholic schools. The secondary college is a prestigious and high performing single-sex private school in a wealthy area of Melbourne, with NAPLAN scores generally above average (MySchool, n.d).

Entity 4 described the school as quite religious, but not on the whole conservative, although xe also noted that some teachers expressed strong Catholic-based views in class. Xe said that after Years 7 and 8, xe did not enjoy science in secondary school. Furthermore, while xe did end up doing chemistry in Year 11, this was mainly due to encouragement from xir mother, in terms of keeping options open, and xe did not enjoy it. Xe noted that on the whole science after Year 8 was very textbook driven and ‘very dry’.

Although during our discussions on ethics, Entity 4’s responses varied, there emerged a somewhat posthumanist-leaning and relational perspective. For instance, xe said ‘there’s ethics in everything we do these days, which is a good thing. So, I think it’s kind of everything’ and that ‘ethics is just a part of being human these days but it’s also a way of basic awareness and respect’. During discussion of the topic of genetically modified humans, Entity 4 also expressed

---

<sup>37</sup> The Greens party in Australia is considered ‘left wing’ and primarily concerned with environmental issues and social equity (About the Australian Greens, n.d.).

concern that because of societal issues such as racism and homophobia, genetically modified humans cannot be thought of as separate to such issues:

obviously they're trying to think of the best possible reasons. Like, you know, no more sicknesses or anything like that, or kind of special needs. But then, yeah, it could be used for other purposes, to promote the master race, and we're still not over racism or anything like that yet [...] Yeah, because I identify as gay, so in terms for me, like, it's still a very heteronormative society. Would that be the view that's kind of pushed on everyone as well?

These statements relate to posthumanism in acknowledging that ethics is not relatable only to certain questions or situations, but rather 'kind of everything' or 'a part of being human', as Entity 4 said. Or, as Barad puts this, 'the interconnectedness of ethics, ontology, and epistemology' (Barad in Juelskjær & Schwennesen, 2012, p. 15). However, while Entity 4 also expressed the view in relation to renewable energy that 'anything with the environment, that's sustainable, is a good thing' xe also said that:

I think my views have changed just slightly, from, you know, like the world is doomed, to the world will be doomed if we don't do something. But [...] I dunno, put up some wind farms, install solar panels, make public transport more viable ... but yeah, *just little things first* [emphasis added].

Additionally, xe also said that 'we need to find, like, some sort of compromise in between, you know, having something that's sustainable and then having something that isn't so sustainable'. This suggests that even while some of Entity 4's views may align with the relational

understanding of ethics, this does not necessarily translate into a major concern for a sustainable world overall.

For the influence diagram activity, Entity 4 grouped two cards equally first 'books/TV/films' and 'education - tertiary'. This is followed by 'education - secondary' and 'culture'. At the bottom, Entity 4 put 'community' and 'religion/spirituality'. A photo is on the following page.



Figure 16: Entity 4's influence diagram

What is most significant between Entity 4’s influence diagram and xir interview responses is that xe put ‘books/tv/films’ equally first in the diagram and, in the interviews, spent a lot of time talking about science/speculative fiction, such as *Doctor Who*. Entity 4’s views-assemblage map is shown below.

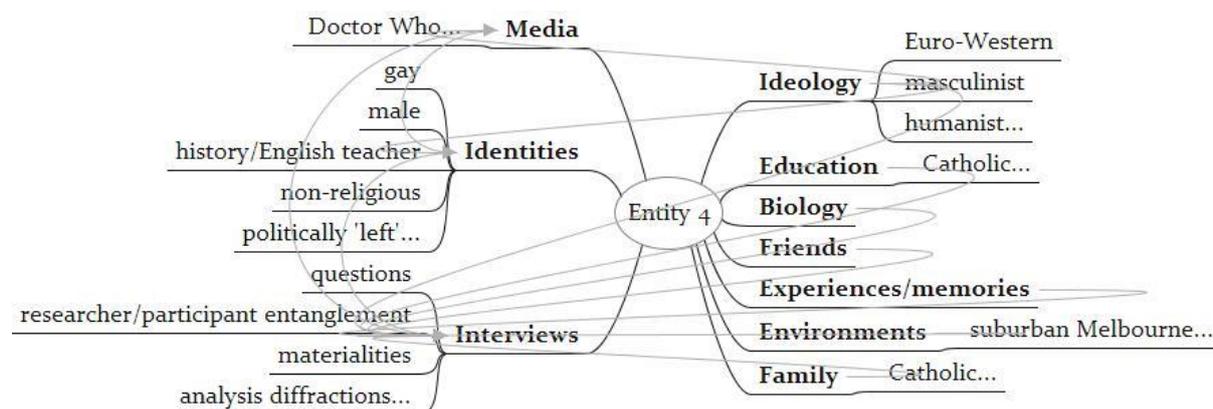


Figure 17: Entity 4’s views-assemblage map

In this map, I especially highlight Entity 4’s interest in popular media, such as *Doctor Who*. I also include xir identities as potentially strongly relevant, including xir identities as gay, male, and a history and English teacher. Entity 4’s views about ethics are especially interesting in the sense that xe expressed awareness that phenomena, including racism and homophobia, are not separate from ethical concerns about science and technology. The potential links between such phenomena, and the science-ethics nexus, is not something I saw present in the Australian curriculum, or in science textbooks, during my analyses. The question, therefore, is: what might be the reason for Entity 4’s alternative thinking about ethics? Specifically, what in xir views-assemblage allows the capacity for Entity 4 to consider the relationality between phenomena, such as ‘homophobia’, with the ethical becoming of science and technology?

I suggest that Entity 4’s gay identity might be considered xir ‘becoming-Other’. Within the concept of ‘becoming-Other’, I bring together ideas from Braidotti with those drawing on Deleuze and Guattari. However, I attempt to apply these philosophical ideas to conceptualising

the becoming of actual entities. Braidotti links together ‘becoming-woman’ and ‘becoming-minoritarian’ (Braidotti, 2012, p. 35). These becomings define configurations of ‘otherness’, which can be related to ‘compulsory heterosexuality’ (Braidotti, 2012, p. 39). I am not proposing that ‘becoming-Other’ in relation to identifying as gay is the same as ‘becoming-woman’, but that there are some similarities when it comes to understanding instances of ‘becoming’ as getting ‘outside’ of the conventional, or the normative, wherein there may be ‘transformative lines of flight’ (Braidotti, 2013, p. 40).

Consequently, ‘becoming-Other’ does not define a specific identity, nor any essentialist ‘self’. Rather, this becoming describes a Deleuzian-Guattarian ‘line of flight’, and specifically a change in capacity that ‘opens to differences [...] to go beyond what is’ (Masny & Waterhouse, 2011, p. 287). In other words, Entity 4’s becoming-Other may be an aspect of xir capacity to ‘think differently’ in contrast to hegemonic ideals concerning views of science and ethics. This does not mean that Entity 4’s identities led purely to this awareness, however, as in xir multiplicities there are many other aspects also implicated. As Braidotti points out ‘Just being a minority, however, is not enough: it is only the starting point’ (Braidotti, 2012, p. 41). I extend on this with considerations of Entity 9, as also becoming-Other, in the following section.

Another potentiality is that part of Entity 4’s becoming also involves xir interest in science fiction. Rather, it is not just this interest but what further macro-micro ‘vibrating strings’ are interconnected in Entity 4’s views-assemblage, via the experience of reading, and viewing, science fiction. Entity 4 stated that science fiction is a strong influence for figuring out xir views of science and ethical issues. When I asked Entity 4 about this interest, xe spoke about a couple of TV shows, such as *Doctor Who*, and movies such as *Snowpiercer*, as mentioned earlier, which got xir thinking about science, technology, and social issues.

When we were discussing genetically modified humans, Entity 4 gave the following example of an episode of *Doctor Who*, which dealt with issues such as identity, being, and technology:

because [*Doctor Who* creators are] not restricted by certain things they can often experiment with stuff like this. So, what do you do if you modify the human and what are the effects on others, what are the effects on their personal self that's been modified? [...] for example, there was a person who was modified to become, like, a part of a computer, and part of that was he could wipe his memory whenever he wanted. And to save his family, he actually wiped his memory of his family but he doesn't know why he's done it because he can't remember them [laughs]. So, it's just, like, little things like that maybe that are quite insignificant in the long run. But these kind of events kind of got me thinking....

This interview extract indicates that Entity 4 picked up on issues in this episode that he did not speak about as being a part of his formal education experiences. Therefore, it is possible that science fiction has affectively served as an avenue that, in partnership with Entity 4's becoming-Other, may have elicited the capacity for critical thought about normative ideals concerning ethics and science/technology. Additionally, while there is a variety of issues and themes *Snowpiercer* touches on, Entity 4 said it is a movie that made him think about maintaining balance in the world and sustainability: 'for instance like marine fishing, that we don't take away too much of one thing [because] it'll just upset everything else'.

Entity 4's views on sustainability provide some glimpse into the push and pull between normative ideals and the entanglements with Entity 4's becoming that have provided avenue to

be critical of such ideals. For instance, Entity 4 stated positive views overall about the need for sustainability. However, xe also stated that as xe has grown older, xe has developed a less radical perspective, and one wherein sustainable practices should be in balance with those that are less-sustainable.

This demonstrates a common standpoint around discussions of sustainability or climate change; that while actions must be taken we need not go overboard or initiate drastic changes. Canadian political activist Naomi Klein, in *This Changes Everything: Capitalism vs. the Climate*, argues that it is difficult for people to agree with drastic sustainability measures because:

it challenges something that might be even more powerful than capitalism, and that is the fetish of centrism—of reasonableness, seriousness, splitting the difference, and generally not getting overly excited about anything (Klein, 2014, p. 22).

Accordingly, this speaks strongly to the idea of emotions, or the control of emotions, as a significant affective force in an individual's capacity to grapple with ethics, as I gestured to with Entity 10. It would seem, therefore, that not just hegemonic ideals, or personal experiences, are impacting on an entity's views about ethics, but that these intra-act in complex ways. I suggest that relational posthumanism allows the beginning gestures of highlighting this complexity in conceptualising onto-epistemological becomings. My analysis of Entity 9's interviews further extend this thinking.

---

#### ENTITY 9

Entity 9 was twenty-two and in the third year of the Bachelor of Arts/Education degree at the time of interviewing. Entity 9 identified as female, non-religious, and Australian, while xir birth place was England. Xe identified English and English as a Second Language (ESL) to be the main subjects xe wants to teach. Entity 9 stated xir political leanings as 'I guess, left wing if

I was to pick any. I'm not really that political but it would be left wing out of the two'. Entity 9 described xir family to be quite 'patriarchal' and 'old fashioned' in nature. Xir father is a tradesperson and xir mother works in aged care; xe also has an older brother. Entity 9 attended two primary schools, one in London, England and one in Melbourne, Australia, and then also attended secondary school in Melbourne.

This secondary school is a mid-range performing school, with average and above average NAPLAN scores (MySchool, n.d.), and situated in the outer suburbs of Melbourne. Entity 9 said that xe enjoyed science in secondary school but found it difficult. Xe especially liked biology but decided not to continue with it at the end of secondary school, partly as it was too difficult, partly as it was not enough of a passion, and partly because xe wanted to undertake subjects for which xe knew xe would get a good study score.

When discussing renewable energy and wind farms, Entity 9 was in favour of them, to the point that xe stated people should just move away if living near wind farms negatively affect them. On the topic of genetically modified humans, Entity 9 stated that xe does not approve of this technology overall, mainly because 'I think people are not really looking at the long-term consequences of what this might do [...] socially'. Overall, xe expressed a lot more concern about the potential negatives of science and technology than the other participants. Indeed, out of all the participants, Entity 9 expressed the strongest views, in response to questions about science and ethics, that might be understood as anti-humanist or posthumanist.

For example, although often said in a flippant manner, Entity 9 expressed a disapproving view of humanity in terms of how destructive humans are, as well as our over-reliance on technology. Xe noted that science is 'very human focussed, like it's all about how to get people to live longer, how to get people to not have diseases [...] I think it's very focussed on kind of humans living forever'. Xe did also, however, say that eradicating human diseases is a good

thing; therefore, there appeared to be a tension here due to it being likely that if human diseases are eradicated humans overall will live longer.

Entity 9 made the choice to complete the influence diagram, presented on the following page, in relation to xir views about genetic modification of humans, due to xir having more familiarity with this topic.



Figure 18: Entity 9's influence diagram

Entity 9 put ‘friends’ first, followed by xir tertiary education, books/TV/films, and family. Xe put xir primary education and ‘religion/spirituality’ last. In xir verbal responses, Entity 9 did not speak much about the specifics of xir friendships. However, like Entity 4, xe did speak often about various media as significant for xir views about science and ethics. Xe also spoke about xir interest in, and the classes xe has taken on, gender issues and feminism. Another aspect I consider as potentially significant was xir experience of depression at the end of secondary school. I examine this experience for understanding xir becoming-teacher because xe specifically related that it led to xir desire to be a teacher, and a specific kind of teacher who focusses on empowering students. However, I also link this experience to xir ‘becoming-Other’, in a similar sense to Entity 4.

Entity 9 described undertaking a subject in gender studies at university and taking more of an interest in gender recently. Throughout xir interviews, Entity 9 demonstrated awareness of some gender issues, such as noting that xir family is ‘patriarchal’. For xir, this meant that that xir parents treated xir and xir brother differently in terms of chores, as well as what books they were encouraged to read, or given. Secondly, Entity 9, like Entity 4, described an interest in science fiction, as having been influenced by xir father’s interest in science fiction films: ‘I think I used to watch a lot of sci-fi films when I was younger’.

The following is Entity 9’s views-assemblage map.

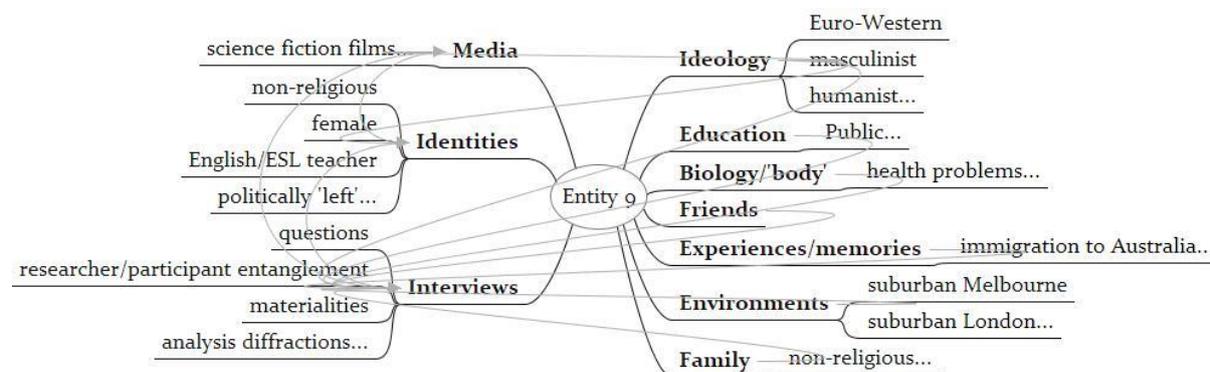


Figure 19: Entity 9’s views-assemblage map

As indicated in this map, there are some areas I consider important but, due to a lack of information, cannot consider in more detail. For example, Entity 9's experience of immigrating to Australia from the United Kingdom. One area I highlight and do focus on is xir interest in popular media, and especially science fiction films. Additionally, in similarity to Entity 6, I highlight Entity 9's health-related experiences as potentially especially relevant.

Entity 9 spoke about being absent a lot in secondary school due to experiencing depression. I conceptualise xir experience of depression as involving not just the physical-neurological-sociality of depression but also the intra-actions involving health systems and government policies, broad beliefs about mental health, media depictions of mental illness, and xir schooling. Indeed, the materialities of school may be especially important. This is suggested by Taguchi and Palmer's study of 'schoolgirls' "school-related" ill-health and well-being' (H.L. Taguchi & Palmer, 2013, p. 764). The researchers argue that various school-related materialities, such as 'balconies, the raw eggs, the rubber, and the semiotic and social flows of sexism, surveillance, bullying, discrimination, as well as smell, sounds and light' have implications for 'schoolgirls' and their ill-health (H.L. Taguchi & Palmer, 2013, p. 769).

Put together, I consider these intra-actions as Entity 9's becoming-Other. In similarity to Entity 4, becoming-Other for Entity 9 may be related to xir 'thinking differently' in relation to science and ethics. It is widely argued in psychology and sociology research that there is prevailing stigma concerning 'mental illness'. Stigma is often understood as negative stereotypes, separating someone with mental illness as 'fundamentally different', experiencing negative emotional reactions, and 'Status loss and discrimination' (Link & Phelan, 2014, p. 79-80).

Significantly, Entity 9 indicated that xir experience of depression involved the negative reactions of some of xir teachers. This xe strongly attributed to xir desire to become a teacher,

and a specific kind of teacher who is ‘someone students feel they can trust and confide in if they ever need to’. Therefore, this experience of depression may also be significant for Entity 9’s becoming-English-teacher. Additionally, Entity 9’s identity as someone who is not reliant on technology might also be a part of xir becoming-Other. Entity 9 stated:

I find it interesting that people are genuinely very dependent on technology because I don’t feel like that myself. I could go a month without checking Facebook and things like that and not die from it.

It might be, therefore, that Entity 9’s identity as being ‘against the grain’ is in alignment with xir non-normative views of science and technology; the two are intra-actions that produce each other.

All these aspects of Entity 9’s views-assemblage; that is, xir interest in gender studies and awareness of gender issues, xir interest in science fiction, xir experience of depression in secondary school, and lastly, xir perception of being ‘different’ in relation to technology use, might all be understood as significant aspects of xir views-assemblage. Specifically, the intra-actions between these aspects may be a line of flight that enables in Entity 9 the capacity to ‘think differently’ in contrast to normative ideologies about science, ethics, and humanity.

This capacity is especially demonstrated by Entity 9’s criticism of anthropocentrism, in the sense of science being ‘too human focussed’ and concerned with humans living longer. In the following section, I further diffract my analyses of entities 10, 4, and 9 to bring together a relational posthumanist take on how entities come to their views about ethics in relation to science.

---

## STORYING DIFFRACTIONS II

My interview analyses concerning ethics are not intended to be representative of all beginning teachers' views on ethics. Nor are they a demonstration of how a relational posthumanist framework might renew thinking in concentrated detail about teachers' views of science. Rather, these analytical gestures are intended to be provocative of how this framework can be utilised to consider views as 'onto-epistemological', and thus are an examination of the usefulness of considering matter and discourse as inseparable.

The addition of Entity 10, as previously stated, was because xir interviews highlighted a potential connection between 'traditional' ideals about ethics and a reluctance to teach ethics in secondary school education. Some of the other participants expressed similar sentiments; however, Entity 10's was the strongest. I suggested this may be related to the masculinist, humanist, and Euro-Western constitution of ethics and science, with added consideration of the significant tension between xir becoming-science-teacher and becoming-Christian.

By including entities 4 and 9, my intention was to highlight how relational posthumanism might frame why some individuals think at least somewhat differently to hegemonic ideals about the science-ethics nexus, as described in the previous chapter. That is, entities 4 and 9 expressed views that were, to a degree, posthumanist rather than humanist. Specifically, this included their understanding of the science-ethics nexus to be inseparable from all aspects of the world and as particularly not separable from social phenomena, such as racism or homophobia. Additionally, in Entity 9's case, xe expressed a critical anti-anthropocentric view concerning scientific development as focussed on humans living longer.

Relational posthumanism frames such developments as onto-epistemological becomings, wherein becoming-Other does not begin with any kind of fixed identity but is rather a *process* of agency involving multiple material-discursive phenomena and intra-actions. In this

framework, becoming-Other is a line of flight, enacting certain capacities that disrupt the status quo. Albeit, these capacities are not enacted unproblematically and not without various tensions and inconsistencies due to the complex nature of assemblages.

As per the first half of this chapter, how the issue of disciplinary boundaries is implicated in these participants' views of ethics is also relevant to this approach. While relational posthumanism emphasises the intrinsic relationality of subjects, such relationality does not seem apparent in school education. For instance, as noted earlier, science in school tends to be isolated from other subjects, with its own culture. While not conclusive, it is significant therefore that the participants' views of ethics appear to align with their disciplinary teaching focus. That is, those that intend to mainly teach science or mathematics tend to have more traditional views of the science-ethics nexus, while those who intend to teach humanities have less traditional views. I extend this thinking about disciplinary boundaries in the following chapter.

Returning to diffractions of speculative fiction and my entanglement in this study, my intention for writing 'The Beforetimer' was partly an examination of the 'messiness' of ethics. This contrasts with a masculinist, humanist, and Euro-Western constitution that might constitute ethics as about objectively, rationally, and reasonably determining what is or is not 'ethical'. In understanding that it is important to separate out subjectivity and emotions from ethical considerations, ethics may be in some ways simpler, or 'cleaner', yet this may not best reflect the nature of the world, or society.

In trying to clean up the messiness, all that might occur is to fashion a false sense of mastery and perhaps, in that, the ultimate hubris of Enlightenment-era humanism. In 'The Beforetimer', although my various ethical investments are undoubtedly entangled in the story, I attempt to refuse the temptation to conclude the various ethical questions raised. For instance,

the questions about genetically modified humans, and the larger unspoken question at the end of the story, about whether Pax should wake up the other surviving humans.

---

## CONCLUDING THOUGHTS

From a relational posthumanist viewpoint, matter, bodies, environments, emotions, experiences, identities, and discourses are all part of our becomings. As such, it can be conceptualised that how we come to have specific views is an assemblage of intra-actions between these various phenomena. When we watch a movie, like *Snowpiercer* (Bong, 2013), or write a story as I have with ‘The Beforetimer’, it is an experience involving a web of complicated intra-actions, going beyond engaging with ‘representations’ and discourse. The history of our becomings is involved as we carry with us countless memories and experiences; but in addition to this, our ‘bodies’, our emotions, senses, and much more, are also all involved.

These complex entanglements may be just one part of our overall becomings, such as entities 1 and 10’s religious views, or Entity 6’s desire to lose weight, yet they can be very important, and all experiences enact change. The reasons why some experiences produce the capacities in us that they do, or why some intra-actions lead to deterritorialisation, or lines of flight, such as for entities 4 and 9, is a result of the sum of many intra-actions. We are what we are entangled with, in tension or in alignment with, in continual processes of folding and unfolding. Accordingly, examination of these entanglements may be necessary to be more conscious of our ethical becomings. This is especially important in noting that ethical becomings are not neutral or ‘universal’.

Understanding how teachers develop their views of science and ethics is a crucial aspect of understanding the current constitution of the science-ethics nexus in Australian school education. It is not just the curricula, textbooks, and other aspects that make up this nexus; it is also how teachers interpret and respond to these features, as well as their broader

understanding. To expand on the current literature in this area, I examined how relational posthumanism allows for a renewed approach to this concern. By diffracting the concept of ‘onto-epistemologies’ through my data I outlined the possibilities of interrogating beginning teachers’ views-assemblages.

By using this framework, I could demonstrate the material-discursive complexities and tensions involved in my participants’ views about science and ethics. This involved acknowledging the masculinist, humanist, and Euro-Western ideological implications. However, in going further, this framework’s conceptual tools bring in the ‘matter of matter’, such as incorporating bodies, experiences, feelings, and environments, in their views-assemblages. I also suggested that some becomings, especially ‘becoming-Other’ for entities 4 and 9, in relationality with various phenomena , potentially open lines of flight that enact capacities to ‘think differently’ about science and ethics. Lastly, I identified how relational posthumanism emphasises the ways in which disciplinary boundaries are a further important consideration in how these participants view the science-ethics nexus.

This approach suggests overall that it may not be enough to consider only ‘discourse’ in attempting to understand how particular views about ethics and science become normative. Nor how some ‘think differently’ to such norms. What might instead be needed is examination, in addition to discourse, of the finer complexities of the materialities, environments, emotions, and more, in which entities, and entities’ views, are enmeshed.

CHAPTER 6: TOWARDS A POSTHUMANIST SCIENCE-ETHICS NEXUS

With instinctual purpose, Entity strode over and picked up the chair, taking it back to the glass door. Using all the strength xe could gather, Entity swung the chair at the door. The first time it rebounded out of xir hands but this did not stop xir for more than a moment.

Entity slammed the chair into the door over and over again, lips moving soundlessly at first before a primal noise erupted from xir throat. Only after xir hands were starting to go numb and bruise, and after one of the chair legs snapped, did the glass finally crack, and with one, two more strikes the glass shattered and the chair went sailing out of Entity's hands. As the glass showered over xir head, Entity curled into a protective ball. After the last piece smashed and splintered on the floor, Entity's head lifted warily and xe looked outside, into a brilliant world of green.

---

What is needed is a posthumanist ethics, an ethics of worlding.

—(Barad, 2007, p. 392)

---

The potential of a speculative outlook is its ability to conceptualise possible futures without being bounded by the past or present, and without conceptualising time as linear or naturally leading to reforms. In this chapter, I focus on the speculative possibilities of both relational posthumanism and speculative fiction to re-envision the science-ethics nexus in Australian secondary school education. I put speculative fiction to work again as a diffractive component but also to demonstrate its possibilities as a component of the science-ethics nexus in school education. I also examine how relational posthumanism, including a posthumanist ethics, might renew thinking about what the science-ethics nexus could become. By drawing from my data and analyses, I present a series of illustrations of what a relational posthumanist

science-ethics nexus might look like, along with outlining potential benefits. It is not my intention to offer these illustrations as prescriptive revisions, but rather as examples of possibilities.

The scene in the extract above from ‘The Beforetimer’ is a pivotal moment. After hundreds of years living underground, one of the last surviving humans, Pax/Entity, escapes to the surface of the planet. Earlier in the story, Pax feels a desperation to be free of the confines of a concrete prison, in which xir only connection with a ‘natural’ environment is a digital waterfall scene on xir ‘e-screen’. Pax’s, and the other surviving humans’, imprisonment can be thought of as a self-imposed exile from the rest of the world, brought about by the unheeded scientific, technological, and industrial development that led to climate-based destruction. Consequently, the moment Pax escapes becomes ever more significant.

I intend for this to be an emotionally charged scene, with a significant contrast between the concrete world Pax is escaping from and the renewed green world beyond the glass doors that xe breaks through. The questions addressed in this chapter are searching for this moment in the real world. That is, a moment towards seeking alternative imaginings for a harmonious, more sustainable world, wherein there is an acknowledgement that the world does not exclusively exist for humans.

Braidotti points out that ‘Unless one likes complexity one cannot feel at home in the twenty-first century’ (Braidotti, 2002, p. 1). Part of this complexity is surely that we are experiencing weighty issues due to the increasing rates of change at the behest of scientific and technological development. Thus, there are crucial questions about how such changes are governed, or managed, and continually critically interrogated. Yet, so too is it crucial that we envision alternative becomings that are not just purely based on risk management. As Wilkie et al. argue in *Speculative Research: The Lure of Possible Futures* ‘it matters how we enter the

future, what senses of futurity we bring into play, which modes of relating to the not-yet we enable' (Wilkie et al., 2017, p. 5).

Feminist materialisms and posthumanism have often been argued to be uniquely geared to tackle these issues about the becoming of the world in the 21<sup>st</sup> century. For example, these frameworks are considered especially useful to address 'environmental, demographic, geopolitical, and economic change' (Coole & Frost, 2010, p. 3). That is, they are not the only frameworks through which to examine these issues but they do provide distinctive standpoints. At the heart of this perhaps lies the ethical imperative of overcoming the various negative facets of anthropocentric humanism, which have privileged humanity at the behest of other species and environments, to instead offer a more posthumanist ethos. As Carol Taylor argues:

One only has to think for a moment of the geopolitical suffering, ecological depredation, and epistemological violence that humanism, particularly in its alliance with neo-colonialism and hyper-capitalism, has given rise to, to appreciate the urgency of the task (C. A. Taylor, 2016, p. 9).

I do not propose that this chapter covers all potentialities of a posthumanist vision of the science-ethics nexus in school education, or education more broadly. Rather, I hope to provide enough gestures and provocations to contribute to the beginning of thinking in this area.

Reform concerning science in school education has been an ongoing issue in Australia, as mentioned earlier. Notably, while there have been some changes it is widely argued that they have failed to truly overcome traditional, transmissive and 'factual' modes. For instance, Russell Tytler has pointed out that despite attempts at reform 'the basic shape of school science has been kept in place, maintaining its emphasis on distinctive knowledge structures' (Tytler, 2007, p. 5). My data analyses of the Australian secondary school curriculum, associated textbooks, and

interviews with beginning teachers corroborates this by highlighting the prominence of ‘factual’ and ‘objective’ scientific knowledge.

Tytler also notes that science teachers can often be barriers to reform (Tytler, 2007, p. 57) but that there are many other issues involved, such as the development of high stakes testing (Tytler, 2010, p. 968). Examining the intricacies of barriers to reform goes beyond the parameters of this study; my focus instead is on re-envisioning aspects of the science-ethics nexus. This focus still resonates outwards to broader complex issues, such as neoliberalism, capitalism, education policy, pedagogy, teacher education, and professional development for teachers.

There are four sections to this chapter. The first, ‘Relational world-science-education’, outlines my argument that to begin re-envisioning the science-ethics nexus, via a relational posthumanist framework, this nexus must be first thought of as *intrinsically* relational. Or as one component of the intra-actions of world-science becomings. This links back to the first section of Chapter 4. In the second section, ‘Posthumanist ethics’, I examine in further detail how this concept might strengthen the science-ethics nexus. The last two sections, ‘Speculative fiction diffractions in school’ and ‘Diverse ways-of-knowing-being’, extend my thoughts concerning disciplinary and cultural boundaries. This is towards potentially better recognising the complexities, dynamics, and intrinsic relationality between disciplines, such as incorporating speculative fiction, and between cultures, such as incorporating Indigenous ways-of-knowing.

---

#### RELATIONAL WORLD-SCIENCE-EDUCATION

What is ‘the world’ and ‘science’ in an Australian secondary school classroom, when a discussion is taking place about renewable energy, or climate change, or genetically modified humans? How are ‘the world’ and ‘science’ understood in relation to each other? In Chapter 4, I utilised relational posthumanism to consider how major research reports frame the

constitution and importance of science in Australian school education, as well as the various major related issues. I identified that one major research report by Marginson et al. (2013) largely focussed on science in education as an economic imperative. I also noted that another major report, by Russell Tytler, offered a broader scope, suggesting the importance of science in education be considered also for cultural, democratic, and practical reasons (Tytler, 2007, p. 19).

I argued that from a relational posthumanist perspective a focus on an economic imperative might limit an ethical imperative. Additionally, anthropocentrism might limit Tytler's broader conception, which could have ethical ramifications. Consequently, I argue a more relational approach may be necessary to truly shift traditional conceptions of science in education beyond a primary focus on 'factual' knowledge. This might also then strengthen the science-ethics nexus. The question I address here, then, is: how might a more relational world-science constitution operate in education? I offer some illustrations of what this might look like and outline how it might be beneficial for the science-ethics nexus.

As a reminder from previous chapters, the concept of 'relationality' understands phenomena to be always already entangled, which means no aspect of science can be separated out from other facets of society or the world. What relationality offers is understanding these phenomena as intra-acting; they do not pre-exist but come to be via their relationality. As Barad argues, 'the dynamic relationality between continuity and discontinuity is crucial to the open-ended becoming of the world' (Barad, 2011, p. 139). In taking inspiration from Barad's arguments, I work with this concept in the context of school education. Therefore, I suggest that for this intrinsic relationality to be constituted *in* the science-ethics nexus in Australian school education, scientific knowledge can never be separated from the becoming of society or the world.

To illustrate this, I examine here one science topic that is established in the Australian Year 9 science curriculum: ‘the atom’. I choose the atom because it is one that best exemplifies how certain topics in school science are constituted as primarily concerned with ‘factual’ knowledge. Consequently, as is evident, ‘the atom’ is given much less *relational* consideration in comparison to topics such as renewable energy and genetic engineering. For example, the curriculum states that Year 9 students ‘are introduced to the notion of the atom as a system of protons, electrons and neutrons, and how this system can change through nuclear decay’ (ACARA, n.d. <sup>8</sup>).

Furthermore, the ‘achievement standards’ also suggest that by the end of Year 9, students should be able to ‘explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions’ (ACARA, n.d. <sup>8</sup>). In these sections, there is no mention of the relational way in which knowledge and discoveries about the atom are entangled in the becoming of human society. The aspects of the atom evidently deemed most important by the curriculum for Year 9 students to learn are ‘factual’ ones, concerning an atom’s make-up and changes in state.

There are some indications of relationality in the curriculum more broadly. For instance, the achievement standards for Year 9 states that students ‘describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people’s lives’ (ACARA, n.d. <sup>8</sup>). However, I suggest that this relationality is limited by anthropocentrism, due to the linking of potential consequences to human lives only, rather than considering broader ramifications. Additionally, it is not clearly linked to specific ‘topics’, such as ‘the atom’.

The science textbooks that I analyse reflect this ‘factual’ emphasis of the curriculum. The textbook chapters on the atom do vary in content, including how relationally the topic of atoms

is presented. However, the focus is certainly on the make-up of the atom with some history of who made discoveries about the atom and when. Therefore, the important factor for this examination is not the differences between textbooks, but rather the ways in which the textbooks overall reflect the curriculum's emphasis on atom 'facts'. Take, for example, one of the most recently published textbooks for the Australian/Victorian curriculum, *Oxford Science 9: Victorian Curriculum* (Silvester, 2016<sup>b</sup>).

The chapter on atoms in this textbook reflects the factual emphasis of the curriculum by covering the make-up of atoms, the periodic table, and radioactivity. The history of discoveries about the atom is included but is limited to the scientists involved and the advancement of factual knowledge about atoms. The review questions in the chapter reflect and repeat this content. For example, there are questions about the make-up of atoms, including formulae and models, as well as questions referring to the historical accounts (Silvester, 2016<sup>b</sup>, p. 91). Students are also guided to learn about isotopes as well as atomic and mass numbers. The application of advancements in knowledge about atoms include only carbon dating and radioactivity in medicine (Silvester, 2016<sup>b</sup>, p. 104-106).

For a relational posthumanist re-envisioning, the first major change to the topic of the atom, as constituted in the curriculum and textbooks, would be to bring into primary focus the ethical becoming of knowledge about atoms. The curriculum in this sense might emphasise not only 'systems', such as the atom being a system made up of protons, electrons and neutrons, but also relationality. That is, the history of knowledge about atoms, and particles in general, would be presented as relational with society, history, psychology, philosophy, ideology, and politics. For example, the history of the atom would not be primarily the who, what, and when. Instead, this would also include the relational consequences, both negative and positive, of discoveries regarding particles, as well as the various material-discursive forces inhibiting and promoting those discoveries.

What makes this approach different from others, such as the STS and STSE developments, are three main ideas. The first is that rather than be considered an addition to traditional school science content, this relational approach does not demarcate ‘facts’ with sociocultural and environmental concerns. Secondly, neither changes in society and history, nor changes in science, are considered to have come first in knowledge about the atom. Rather, by working with the concept of relationality, these aspects are understood to intra-act, and thus come to be always already in relationship with each other. Thirdly, the ethical element of knowledge about the atom can be applied to all areas, not only the potential unethical consequences of *uses* of this knowledge, such as with the atom bomb.

The story of the atom bomb’s development further provides a useful illustration. From a relational posthumanist viewpoint, the inclusion of the development of the atom bomb would be very important information to include with the topic of atoms. This connection powerfully demonstrates the relational implications of science and technology. However, this envisioning goes further than merely introducing awareness of this weapon’s development. This addition would also require relational thinking concerning the development and consequences of the atom bomb. Questions posed might be: why was the atom bomb invented? Who invented it? What were the consequences of this? What were the consequences of the United States of America dropping atom bombs on Japan?

Since World War II ended, these questions have been addressed in various fields. For example, there have been social studies on the political, social, and military machinations that led to the development of the atom bomb (e.g. Kelly, 2004; Pike, 2016; Reed, 2014). There have long been studies on the health, and environmental impact, of the atom bombs dropped on Japan (e.g. Amemiya & Choshi, 1993; Katahira et al., 2013; Kusunoki & Hayashi, 2008; Miyamoto, 2015). There is also literature on the moral and ethical implications of the atom bomb (e.g. Nicholas, 1999; Takeuchi & M. Taguchi, 2015). Lastly, there is some literature on teaching the

social implications of the atom bomb in school science (e.g. Schibuk, 2015). Consequently, the possibility to translate this literature, in a relational sense, into Australian school education is certainly conceivable.

An additional feature of a more relational constitution of the topic of atoms is that instead of a focus on more ‘factual’ but abstract knowledge, such as the make-up of atoms without much reference to the world, there might instead be more relational and explicit context to everyday ethical becomings. As part of this, it might be outlined for students how they are part of these everyday becomings, while also acknowledging humans are not at the centre of all concerns. This focus would therefore include the relationality of everyday becomings with consequences for society and the world.

For example, highlighting issues such as nuclear waste and its actual or potential effects on environments and various species, of which humans are only one. This also may be a way to increase students’ interest in science, by continually making links from ‘abstract’ knowledge, such as the make-up of atoms, with the becoming of the world. In this re-envisioning such examinations would also necessarily be linked to a posthumanist ethics, about which I will discuss in further detail in the following section.

Lastly, acknowledging world-science-education relationality also draws attention to the ways in which separations between disciplines may create a barrier for such relational understanding. This invites not only critical questions about why science is often split from the creative arts and the humanities, as well as separated into distinct *sciences*, but the ways in which this forms the view that such separations are ‘natural’ and reflect ‘reality’. I expand on this idea in the third section of this chapter.

---

## POSTHUMANIST ETHICS

In this section, I examine in more detail how a posthumanist conception of ethics might develop the science-ethics nexus in Australian secondary school education, especially regarding the nature and needs of the 21<sup>st</sup> century world. A posthumanist ethics may have multiple interpretations. Generally, however, I define it as, firstly, constituting humans as one aspect of the becoming of the world, rather than existing as separate or at the centre. Additionally, a posthumanist ethics acknowledges the implications of the context of everyday becomings instead of supposed universal values or abstract ideals. Therefore, a posthumanist ethics forefronts the concepts of messy relationality and onto-epistemology; that is, the inseparability of knowing and being.

Barad has argued that ‘Ethics is not about right response to the other, but about responsibility and accountability for the lively relationalities of becoming of which ‘we’ are a part’ (Barad, 2008, p. 333). As I first suggested in Chapter 2, what ‘responsibility’ and ‘accountability’ means via posthumanism may not yet be wholly explained, by Barad or others. However, I propose that beginning this consideration without stipulating universal rights or wrongs potentially brings about renewed thinking. Contributing to this, is the idea that a posthumanist ethics does not determine ‘what is right or wrong based on the rational human being’ (Thomas, 2015, p. 978).

I noted in Chapter 4 that ‘ethical understanding’ in the Australian curriculum has been defined using mainly ancient, male, Euro-Western philosophers, who largely base ethics on ‘objective’ reasoning and abstract but universal parameters. As a reminder, the curriculum states that ‘students develop ethical understanding as they identify and investigate the nature of ethical concepts, values and character traits, and understand how reasoning can assist ethical judgment’ (ACARA, n.d.<sup>a</sup>). To further illustrate a posthumanist perspective, I have rewritten this statement as the following:

students develop ethical understanding as they develop awareness of ongoing entanglements in everyday life, such as their use of technology and waste management, as well as broader scopes, between context, processes and outcomes, and understand how different thinking techniques might be utilised to consider ongoing ethical becomings.

What these changes do is, firstly, emphasise the link between ethics and contextualised relationality, or ‘entanglements in everyday life’. This might include students assessing such issues like their environmental impact, carbon footprint, waste, consumerism, and use of technology such as smartphones. Secondly, my changes emphasise that there are many ways to think about ethics, and as such ‘reasoning’ is only one technique.

Ethics defined as posthumanist may have quite practical benefits. The first benefit might be that a posthumanist ethics is potentially less daunting and easier to understand for both teachers and students. A posthumanist ethics brings ethics to the forefront, as something inseparable from all aspects of science and knowledge-making processes rather than an add-on topic. Indeed, this repositioning might be considered an ethical imperative of the 21<sup>st</sup> century world, towards having a public more deeply able to understand ethical issues.

In my interviews with beginning teachers, most noted that they had not previously covered ethics much throughout their schooling and were therefore not confident about the idea of teaching ethics. At the more extreme end, as noted with Entity 10 in the previous chapter, was the view that ethics is a controversial and difficult subject to teach, as well as something that would be additive to ‘factual’ science. Many of the participants also emphasised their belief in the importance of remaining ‘neutral’ or ‘objective’ teachers. This means that they intended

not to let their ‘personal opinions’ influence students and that they did not see potentially actively changing students’ opinions about ethics and science as a valid goal of teaching.

For example, Entity 2 said that ‘having a science background, I’d probably try to focus on the science component of [genetically modified humans]’ and that xe would try to be as ‘objective’ as possible in teaching this topic. For the same topic, Entity 10 said that ‘I would probably just explain the technicalities of it...if it was possible [...and] I wouldn’t cover the moral side of it I don’t think’. Additionally, Entity 7 stated that in teaching such a topic ‘obviously it’d be controversial [...so I would] minimise I suppose just, like, negative emotions and, like, offending anyone or anything like that’<sup>38</sup>.

In contrast to an ethics based on supposed ‘objectivity’, and the Euro-Western split between reason and emotions, a posthumanist ethics poses alternative avenues. It can be considered as a means by which to instead acknowledge the inherent entanglement with emotions, as well as with our overall entangled onto-epistemological becomings. Consequently, emotions and entangled becomings might be positioned overtly as inherent aspects of ethical considerations, rather than as something negative, controversial, or difficult to manage because they are considered separate to ‘objective’ facts.

To demonstrate what this shift might look like, I include here analysis of my participants’ responses to the lesson plan task (see Appendix 2) that I asked them to complete in the second interview. For this task, as a reminder, I asked them to utilise what I called an ‘assemblage map’ of the possible influences behind beginning teachers’ views of science and ethics. I then asked them to pick one ‘arm’ of this map and apply it to thinking about a lesson plan for either renewable energy or genetically modified humans. The intent was to examine

---

<sup>38</sup> Similar statements from all the participants can be seen in Appendix 3.

how considering a simplified aspect of relational entanglements might influence my participants' lesson plans on these two specifically science-ethics related issues.

Interestingly, six out of the nine beginning teachers, who participated in this second interview, chose the 'arm' of 'Micro > Personal > Interests > Media > Films > Science Fiction'. Out of this six, five chose to focus on the topic of genetically modified humans while one chose renewable energy. My analysis involves comparisons between the participants' responses to this lesson plan task and their responses in the first interview, as to how they might teach a class on wind farms/renewable energy or genetically modified humans.

I argue that, for the second interview task, five of the participants demonstrated some thinking about relationality with the use of the assemblage map, considering such things as 'environments' and students' general backgrounds within their lesson plans. This was particularly so for entities 2, 4, 5, and 9, who already demonstrated some views that are alternatives to traditional masculinist, Euro-Western, and humanist understanding of the science-ethics nexus. However, Entity 1, who did speak about believing in 'objective science', also demonstrated some posthumanist ideas in xir responses.

This 'posthumanist thinking' contrasts with the participants' initial answers in the first interview, which generally focussed more on covering the science and specific learning tasks or processes. For example, Entity 9's first response, to how xe would teach a class on genetically modified humans, outlined a general overview of genetically modified humans, covering what the issues are and initiating a class discussion. Entity 9 also made a point of ensuring xe 'would try not to put in my own opinion too much'.

In the second interview, however, Entity 9 related that xe would have 'a discussion about issues/benefits raised and their [xir students'] own personal opinions', as well as the inclusion

of ‘current social issues’. In relaying xir written responses, Entity 9 added to this that for the boys’ school xe would consider:

maybe asking them to talk about other modes of media, like video games, and if anything they’ve seen in video games or books themselves, that would influence them to have, like, other opinions on genetic modification that we haven’t covered.

These responses suggest that Entity 9 shifted somewhat from a perspective that discussing ethical issues must be kept impersonal and general. Xir response in the second interview acknowledges the potential benefits of bringing into the discussion the students’ opinions and what might influence their opinion, such as video games or books. This can be related to my rewritten posthumanist definition of ‘ethical understanding’ in the Australian curriculum. I contend that this acknowledgement of students’ opinions, and the influences behind their opinions, relates to a perspective that includes onto-epistemological entanglements.

While, for Entity 9, as xe acknowledged, there was some ‘gender stereotyping’ occurring (such as inviting boys to consider video games while the girls were to consider gender inequality) in xir response, xe also did link the issue of genetically modified humans to the students’ experience of gender-sex, as well as with different forms of media. In other words, by considering the assemblage map, xe made an ‘onto-epistemological’ connection between these phenomena. Other participants also demonstrated something similar. For example, Entity 2 envisioned xir hypothetical class on renewable energy as a ‘nature’ excursion camp, in which xe would ‘talk about the surroundings (life/environment)’. Additionally, Entity 5 suggested linking renewable energy with ‘personal political standpoint’ and associated discussion.

Overall, this lesson plan exercise suggests that making a general connection between ethics and onto-epistemological relationality not only helped expand some of the participants' views of ethics, but also appeared to give them some confidence in addressing a contextualised and personal connection with ethics in a hypothetical classroom. Although this was a limited exercise, it nonetheless suggests further possibilities, not only for redefining ethics, but also for developments in teacher education and professional development in relation to the science-ethics nexus.

Taking ethics away from abstraction into the folding and unfolding of the world allows for an ethics that may be more personalised and more relatable. This is because a posthumanist science-ethics nexus invites us to acknowledge ourselves as personally involved, or 'becoming', in this nexus. This is so even while also acknowledging that humans are not at the centre of the world. As Barad argues, 'According to my agential realist ontology, or rather ethico-onto-epistemology [...] "individuals" do not preexist as such but rather materialize in intra-action' (Barad in Kleinman, 2012, p. 77). In other words, 'individuals' become via intra-actions, and those intra-actions are ethico-onto-epistemological, wherein ethics, ontology, and epistemology are inseparable. In this sense, 'individuals' do not sit back and 'decide' the ethics they enact but are always already involved in ethically becoming.

While we might try to ascertain as much as possible about the complex ethico-onto-epistemological entanglements that contribute to *worlding*, we must also acknowledge that we cannot know everything about our own entanglements. Nor can we know everything about the broad human-world entanglements. This is especially so when the concept of 'humanity' is understood as a messy concept. Rather than seeing this as a restriction to ethical considerations, however, it is possible to see this instead as increasing the ability to acknowledge the complexities involved.

To further illustrate a posthumanist ethics, I include here a link between my posthumanist definition of ethical understanding to some examples from a science textbook I analyse. In my textbook analyses, I noted that all the textbooks, if they did mention ethics explicitly, did so by relating ethics to only some sections/chapters. In contrast, a posthumanist ethics would be necessarily fully integrated throughout a science textbook's content. To demonstrate this idea further, and for ease of understanding, I will stay with the topic of genetic engineering. I have selected one example from *Oxford Big Ideas Science 10* (Quinton et al., 2012), in which there is a list of the disadvantages of genetic engineering:

- ethical issues around the source of some material (e.g. the use of human embryos)
- privacy issues resulting from access to human genomes (e.g. predisposition to a disease as determined by genome analysis)
- the potential spread of genetically modified crops to non-modified crops
- the drama of patents for discoveries and the argument that genes are not discoveries

(Quinton et al., 2012, p. 158).

This example provides a useful illustration of the differences between the influence of anthropocentrism in defining ethics and a posthumanist definition. First, it is noteworthy in this example that 'ethical issues' are separated out as only one potential disadvantage of genetic engineering. In contrast, a posthumanist ethical understanding would define all the above dot points as related to ethics. 'Ethical issues' would also be contextualised to everyday becomings, rather than the vague connection to contentious subjects such as the use of human embryos. If this section was reworked in a posthumanist sense, it might be something more like the following:

We cannot know everything about the possible short-term and long-term effects of genetic engineering. We do know that technology is

not always easily controlled and that genetic engineering, due to the unpredictable nature of genetic mutations and cross-breeding, could have potentially devastating effects on all life on Earth. From the limited issues that we can identify and therefore ethically consider, these include:

- The potential spread of genetically modified crops to non-modified crops, which could have lasting negative effects on many species, both plant and animal
- The use of human embryos and religious-based opposition
- Privacy issues resulting from access to human genomes (e.g. predisposition to a disease as determined by genome analysis)
- Concerns about the human ‘ownership’ of knowledge, such as patenting genes.

There are a few things this reworked section does in demonstrating a posthumanist ethics. First, it decentres the human in acknowledging the limits of our knowledge and control over technology. It then acknowledges that the possible consequences of genetic engineering could potentially affect all kinds of life (both plant and animal), and this is just as important to consider with how it might affect humans in the future. Secondly, it resituates ethics as relatable to all the issues mentioned rather than reducing ethics down to a connection to the use of human embryos. Instead, it becomes possible to see that, in each dot point, ethics, knowing, and being are inseparable.

As an additional example, I refer again to the textbook section I utilised in Chapter 4 to demonstrate the constitution of humanist ethics. This is the section called ‘Heating up for Thermageddon?’ from the textbook *Science Quest 10 for Victoria* (Lofts & Evergreen, 2014). Repositioning the ethical consideration here of climate change as posthumanist necessarily

moves away from the primary focus on the human. Neimanis et al. argue in their paper ‘Post-Humanist Imaginaries’, we should instead be asking the ethical question of ‘how are different bodies situated within the co-weathering of the planet?’ (Neimanis et al., 2015, p. 16). My understanding of ‘co-weathering’ is that it refers to intra-actions between climate and bodies.

Perhaps an even better way to put this, and that could initiate a posthumanist ethical manoeuvre in a science textbook, is to ask, ‘what are the ethical considerations of how *different entities* are situated within the co-weathering of the planet?’ Therein, an entity need not be definitively identified as an individual body, nor in having a body at all. For instance, a rainforest might well be considered an entity, involving an entanglement between climate, land, plants, animals, dirt, and elements. Consequently, attention to climate change from a posthumanist lens necessitates students being encouraged to think of the world as a relational whole, rather than beginning with concerns about humanity.

---

#### SPECULATIVE FICTION DIFFRACTIONS IN SCHOOL

This study, and therefore this dissertation, is a gesture towards the benefits of transdisciplinary connections by bringing together the science-ethics nexus in school education with speculative fiction diffractions. In this section, my intention is to further that project by considering how this connection might play out *within* secondary school education. To begin, I argue a science-ethics nexus re-envisioned as posthumanist also entails a critical perspective that puts significant pressure on disciplinary boundaries. Acknowledging the inherent relationality of science and ethics means that the science-ethics nexus should be considered as entangled with all knowing-being. In this sense then, the science-ethics nexus is more than the science curriculum.

Braidotti argues that ‘Transdisciplinarity is an important feature. This means the crossing of disciplinary boundaries without concern for the vertical distinctions around which

they have been organized' (Braidotti, 2011, p. 66). While Braidotti here is writing broadly about disciplines, it is possible to see that the same idea can be applied when considering how disciplines are constituted in school education. Although challenges concerning disciplinary boundaries for education are not new, and are defined in varying ways, a relational posthumanist approach adds some alternative conceptualisations of what this means. This includes drawing special attention to the ethical implications.

The typical major focus in this research area appears to be bringing together disciplines for a specific topic or complex issue, such as 'sustainability' (e.g. Clark & Button, 2011; Salite et al., 2016). It is important to note that the new Australian curriculum gestures to some of these ideas, such as the 'cross-curriculum priorities' and the 'general capabilities'. However, I argue that a relational posthumanist perspective pushes such ideas further. This perspective first defines the necessity of *working through* disciplinary boundaries to make relational connections, and specifically towards strengthening the science-ethics nexus in school education.

What I understand Braidotti's definition to mean in the context of school education is a critical interrogation of the whys and ways in which disciplines, and the boundaries around them, have been initially constituted, i.e. their 'vertical distinctions'. More pointedly, this means taking account of how the masculinist, Euro-Western, and humanist hegemonic ways-of-knowing have contributed to these vertical distinctions. I support the argument that these hegemonies are intrinsically entangled in the specific hierarchical and rigid approach to disciplines, which positions some as more legitimate or more important. For instance, the clearest example of this is the well-known common judgement that the social sciences are not 'real' science, or even that biology is not a 'real' science, in comparison to physics or chemistry. In other words, these are the distinctions between so-called 'soft' and 'hard' sciences.

In contrast, a relational posthumanist perspective ‘flattens out’ hierarchies (Barad, 2015). This is an attempt to specifically challenge such hierarchical positioning. However, while I appreciate Barad’s intentions, I am cautious about the specific term of ‘flattening’. I suggest that although it works to critique hierarches, it may inadvertently emphasise sameness and uniformity, which would be in antagonism with messy relationality. The terminology of this idea therefore requires further nuance.

Nonetheless, my relational posthumanist conception of the science-ethics nexus in school education defines this as specifically putting pressure on the boundaries constituting disciplines rather than blurring them together. It is also not about merely bringing aspects of different disciplines together to focus on broad issues, such as climate change. Rather, this is to propose that different knowledge-making processes in different areas are fundamentally entangled, as an aspect of a fundamentally entangled and relational world. It also involves being critically conscious of the ways disciplines have dominantly been hierarchically constituted and/or separated from each other and the world; such as the distinction between ‘hard’ and ‘soft’ sciences, and the supposed separation of science from the socio-political world.

This re-envisioning of school education that puts pressure on disciplinary boundaries potentially opens many possibilities. For example, connecting science with the humanities and the creative arts in a way that understands the ongoing intra-actions between these areas. However, one avenue I see promising for the science-ethics nexus, and that I believe my own attempts in this dissertation illustrate, is the further and more nuanced inclusion of speculative fiction. Accordingly, it is this possibility that I focus on here.

In my analysis of science textbooks, I noted a few that have included some aspect of speculative/science fiction, albeit very rarely, and even more rarely again for ethical considerations. *Science Quest 10 for Victoria*, for instance, notes that ‘Science fiction can take

you to another universe where anything is possible. It provides you with the opportunity to dream and imagine endless possibilities and creations' (Lofts & Evergreen, 2014, p. 290).

The introduction of speculative/science fiction in secondary school education could be given much more attention, as not only beneficial for general understandings of science but also for *exploring ethical becomings*. A relational posthumanist perspective inspires attention to the possibilities of phenomena, such as speculative/science fiction, brought in as an aspect of the science-ethics nexus. This framework can also be a specific method through which to analyse speculative fiction for the purposes of examining ethical becomings. I illustrate this potentiality here by offering a relational posthumanist analysis of the film *Ex Machina* (Garland, 2015). This film was chosen because it is recent and it illustrates a clear critical engagement with the ethics of science and technology.

Set in a potential not-too-distant future, *Ex Machina* tells the story of a programmer Caleb Smith (Domhnall Gleeson), who works at the company 'Blue Book' (an equivalent to Google) and wins a lottery to meet his reclusive employer, Nathan Bateman (Oscar Isaac). Nathan's home is secluded in the wilderness and it also serves as his workplace/laboratory. After Caleb arrives, Nathan reveals that he wants Caleb to perform the 'Turing test' on an artificially intelligent (AI) android he has programmed himself. The 'Turing test' is not fictional. It is named after Alan Turing, a renowned computer scientist, and is a test that is designed to measure whether an AI demonstrates intelligent behaviour, or is at least indistinguishable from human behaviour. Nathan's AI, Ava (Alicia Vikander), as we soon learn, is modelled after a human female form. There is a slow build-up of tension and various twists occur until, at the end of the film, Ava kills both Caleb and Nathan and escapes into human society.

Using a posthumanist analysis allows for understanding the film-audience entangled becoming. More than this, a focus on the materialities of the film, particularly the visuals and

scenery, contribute to various potentialities in terms of an affective experience. In a similar sense, Anna Hickey-Moody argues that ‘Literature, sound, dance, are media that prompt affective responses and generate affectus: a synergy, a machinic assemblage that is bigger than the sum of its parts’ (Hickey-Moody, 2016, p. 260). This is not to say that there is only one ‘true meaning’ behind the materialities but rather that the materialities affectively invite and constrain the film-audience becoming.

Ava’s appearance potentially contributes to the film-audience becoming and the affective entanglements therein. At the beginning, her face is fully human in appearance while her body is metallic mesh. However, as the film progresses, Ava slowly becomes more and more indistinguishable from a human. She first puts on clothing and a wig. Then, at the end of the film, when Ava escapes her room/prison, she takes the synthetic skin from other non-functioning androids, which were earlier versions that Nathan has put away in closets, and attaches it to herself. This is a slow, drawn-out scene; Ava is very deliberate in her movements, first touching the other androids and then taking sections of the synthetic skin and fixing it to her mesh-body. A potentiality, therefore, is an invitation for the audience to consider this becoming-human in a very material way.

The major ethical issue in this film is the use and development of artificial intelligence. AI is especially interesting to consider from a relational posthumanist standpoint. On the one hand, it can represent the ultimate Cartesian dualism; that is, pure intelligence unmediated by corporeal form. Or, to put it another way, a ‘mind’ that has transcended ‘biology’. On the other hand, however, AI also presents a basis for challenging ideas about the human. More precisely, it challenges and blurs the human in the sense of questioning what/who is defined as human (is an AI android human?). Haraway, for instance, has argued that ‘Cyborg imagery can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves’ (Haraway, 2004, p. 39).

An ethical question is, do we now consider Ava to be human because she *looks* human? What are the ethical consequences of this? How might this critique disrupt dominant ways of defining who is, or is not, human? It has, after all, been pointed out by many that the regulatory ways in which ‘humanness’ has been defined throughout history has never been innocent or stable.

In focusing on Ava alone, this character presents multiple ethical issues entangled with the development of technology. It becomes clear that Ava’s ultimate desire is to escape captivity. The nature of her being, and her captivity, draw attention to the complicated ethics of technology and an individual’s rights. If we understand Ava as an individual, and as conscious, what legal ramifications are there around an AI entity’s rights? How might the law accommodate, or indeed not accommodate, AI? Another way of questioning this, is to be critical of a hard distinction between ‘organic’ and ‘artificial’ intelligence.

This issue underscores, in a posthumanist sense, the distinctions between human rights and other animals’ rights as enforced or not by the laws of countries, and international law. This ethical question in the film is pronounced when Kyoko, another of Nathan’s AI androids, and Ava, end up killing Nathan. This is also the case when Ava leaves Caleb locked in Nathan’s house, ostensibly to die there. How would such actions be determined by the law; as murder? Ultimately, what these aspects of the film serve to do is highlight the ongoing ethical issues around AI development and the vast unknowns concerning where this technology might lead.

This film can serve as a critical perspective on AI, and perhaps also other advanced forms of technology. The theme of AI is therefore a major aspect of the relational assemblage around this film; although AI was conceived long ago, it seems close to becoming a reality. This acknowledgement involves the recent initial successful expansion of quantum computing; computers set to become faster than we might yet comprehend. One example of this is NASA’s

‘Quantum Artificial Intelligence Laboratory’ (QuAIL), which ‘is the space agency’s hub for an experiment to assess the potential of quantum computers to perform calculations that are difficult or impossible using conventional supercomputers’ (NASA, n.d.).

One of the other issues about AI highlighted by this film is the ways in which such technological development is conceived. Nathan argues that:

the arrival of strong artificial intelligence has been inevitable for decades. The variable was when, not if. So, I don’t really see her [Ava] as a decision. Just an evolution’ (Garland, 2015).

In other words, the technology that is feasible in the future is the technology that must, or just will, come to be. It is not a ‘decision’, let alone an ethical one, but inevitability. This speaks volumes about a vast array of technological possibilities already considered feasible in the near future and the terms by which we ethically consider these possibilities.

In all, a posthumanist analysis of *Ex Machina* highlights the vast ethical relational complexities around the development of artificial intelligence. What it taps into is the very real assemblages around such technology. *Ex Machina*, while hyperbolic and somewhat reliant on stereotypes, depicts a world that is conceivable, and for that reason of real ethical concern. The materialities and affective experience of this film add to its critical viewpoint and possible discomfoting film-audience becoming.

As I noted in my interview analyses in Chapter 5, speculative/science fiction already plays a significant part in how my beginning teacher participants think about the science-ethics nexus. Most of them, in the second interview lesson plan task, chose science fiction to think about how they might teach a class related to the science-ethics nexus. For example, a few of the participants overtly stated that science fiction is influential in their views, such as attributing

watching the film *Gattaca* (Niccol, 1997) to their views on the genetic modification of humans. *Gattaca*, which I also first watched in secondary school, is about a future wherein the genetic engineering of humans is widely accepted but causes rifts in the genetic ‘haves’ and the ‘have nots’.

A relational posthumanist perspective supports the further inclusion of speculative fiction, especially as one avenue through which to consider ethical deliberations about science and technology. This framework requires the understanding that fiction and art do not just describe, invent, examine, and interrogate, but are also entangled and active forces in the differential becoming of the world. In other words, as I outlined in Chapter 3, creative processes cannot only be thought of as representative but rather are actively involved in the *worlding* of the world.

Additionally, creative products have affective forces as part of their materialities. As Hickey-Moody puts it, ‘These simultaneous acts of propelling a political agenda and creating a sensory landscape occur *through* an artwork’s affective potential’ (Hickey-Moody, 2016, p. 260; original emphasis). The audience-film becoming, therefore, is a potentially commanding process to tap into for the science-ethics nexus in school education. However, similar characteristics might be applied to novels, games, TV shows, and other forms of media. This thinking might also be applicable to the *creation* of media, rather than only the experience of various media.

This framework also supports the idea that creative processes cannot be restricted to disciplines within the creative arts. Thus, a constitution of a science-ethics nexus that challenges disciplinary boundaries necessarily brings this understanding to the forefront. When it comes to ethical considerations of science and technology, it is difficult to believe in a future where science and technology, and humans in general, can exist in harmony with other life, as well as

the planet, without first having the imaginative power to conceive of such a world. Thus, creative processes are also integral to realise more positive futures.

Finally, it seems possible that should such a conception of school education be eventuated, this might not only help break down barriers between disciplines. It could also necessitate a flow-on effect that would again help make it clearer that the science-ethics nexus is relevant and important across many domains. The following section adds to this idea by further consideration of *cultural* barriers.

---

#### DIVERSE WAYS-OF-KNOWING-BEING

A science-ethics nexus in secondary school education, as inspired by relational posthumanist concepts, could be one that openly acknowledges the significant role culture plays in processes of knowing-being. In Chapter 4, I outlined the ways in which Euro-Western cultural hegemony is a significant aspect of how this nexus is constituted in Australian secondary school education. While I focussed on the example of how the definition of ethics in the Australian curriculum is limited by only referencing Euro-Western (and male) philosophers, it is also important to emphasise that a Euro-Western hegemony clearly also means alternative cultural ways-of-knowing-being are marginalised or excluded.

Although there is attention to Euro-Western (or what is elsewhere referred to as ‘Eurocentric’) hegemony, I here attempt to underscore, by using a relational posthumanist standpoint, the loss that is the exclusion of diverse-ways-of-knowing. As per my discussion in chapters 1 and 4, this approach acknowledges the importance of equity issues but focusses on onto-epistemological concerns.

I argue that this theoretical framework not only highlights that cultural issues have implications for the science-ethics nexus but also is useful in conceiving of the inherent relationality of cultures. This starting point has multiple potentialities worth exploring.

However, the one I focus on here is how this nexus may achieve a constitution that puts pressure on Euro-Western hegemony by the in-depth inclusion of (Australian) Indigenous ways-of-knowing. While my focus is on the Australian context, due to the limited Indigenous-led research in this area within Australia, I also draw on some indigenous researchers outside of Australia.

I want to make it clear that I am not situating myself as someone who is an expert on indigenous ways-of-knowing. Nor is it my aim to attempt to describe the intricacies and the vast diversity in indigenous ways of-knowing, either around the world or within Australia. I recognise the risk of discussing this topic, particularly as someone who is a descendent of white settlers in Australia. As Semali and Kincheloe note:

Indigenous knowledge is an ambiguous topic that immediately places analysts on a dangerous terrain. Not only are scholars unsure what we're talking about, but many analysts are uncertain who should be talking about it (Semali & Kincheloe, 2002, p. 3).

Nonetheless, I contend that the ethical implications of such considerations make this argument necessary.

Earlier, in Chapter 2, I argued that aspects of the material/ontological/posthumanist turn in theory are not without precedence. Notably, there is similarity to aspects of some wide-ranging indigenous ways-of-knowing, especially a more relational positioning of the human, which have been a part of human history for centuries. In this sense, therefore, the inclusion of indigenous ways-of-knowing in school education has much in common with a posthumanist ethos. This is acknowledged elsewhere; for instance, Margaret Somerville and Monica Green note that:

Indigenous knowledge frameworks commonly originate in cultural understandings in which there is no binary structure of thought [...therefore bringing] these into conversation with new Western onto-epistemologies is an important strand of research in the scholarship of the Anthropocene (Somerville & M. Green, 2015, p. 8).

This connection, and consequently the call for renewed attention to human-world relationality, is especially important as a response to the perception of increasing ecological devastation due to human activities. It is therefore also the case that ‘Worldwide, environmental conservation directives are mandating greater inclusion of Indigenous people and their knowledge in the management of global ecosystems’ (Ens et al., 2015, p. 133).

Although this development is still in its early stages, and especially so in relation to science/education, there are some studies that illustrate the importance of this research area. Australian researcher Margaret Somerville and her collaborators, which includes Indigenous researchers, for the project ‘Thinking through Country’ is an especially salient example (Somerville & M. Green, 2015; Somerville, 2014). Others include a New Zealand-based study on indigenous relational ethics (Thomas, 2015) and a North American-based study on indigenous expertise, posthumanist ethics, and climate change (Watson & Huntington, 2014). Additionally, Canada-based researcher Marc Higgins argues for a science education that ‘centres and takes seriously Indigenous, diasporic and other postcolonial ways-of-knowing’ (Higgins, 2016, p. 187).

To encapsulate my critical emphasis on the limitations due to a lack of diverse ways-of-knowing in the Australian school science-ethics nexus, I first draw on Glen Aikenhead and Herman Michell’s illustrative work *Bridging Cultures: Indigenous and Scientific Ways of Knowing Nature* (Aikenhead & Michell, 2011). Their work includes many persuasive arguments concerning cultural and epistemological issues around science and education. However, there

are some elements of their arguments that I believe highlight the ongoing tensions around Euro-Western cultural hegemony within school education.

On the one hand, they note that, in contrast to indigenous knowledge, Euro-Western science and technology has often been (purportedly) divorced from ethical or social values. Furthermore, that this divorce has often lead to harmful effects. For example, they write that the:

disastrous impact of material progress on planet Earth during those 450 years, made possible by participation of Eurocentric sciences and technologies, challenges ES's [Eurocentric science's] content validity in terms of humanity's survival (Aikenhead & Michell, 2011, p. 89).

They also note that sustainability is more intrinsic in indigenous knowledge than in 'Eurocentric' science (Aikenhead & Michell, 2011, p. 11). Furthermore, like me, they make several other critical points, such as the harmful effects of 'Eurocentric' science's reliance on the Cartesian dualism, as well as the negative effects of reductionism and anthropocentrism (Aikenhead & Michell, 2011, p. 50-52).

However, on the other hand, despite these acknowledgements, the authors also argue that 'Eurocentric' and indigenous knowledge are merely different and complementary perspectives (Aikenhead & Michell, 2011, p. 5). While I appreciate Aikenhead and Michell's evident desire to avoid stereotypes and false dichotomies, I suggest that their arguments highlight a common position; one that advocates the idea that the traditional foundations of science education need not dramatically change but only that it requires additions or modifications. I noted this previously regarding the STS, STSE, and SSI developments. I accept that there are of course many benefits to Euro-Western science; however, I argue that its hegemony, and some specific ideals, have significant negative consequences.

This issue is especially a concern when considering Euro-Western science has never been value-free but the values it often upholds is a supposed neutrality. Indeed, I contend that this supposed neutrality in relation to ethics and social values has resulted in a harmful limitation regarding ethics. This supposed neutrality may also be involved in the inclusion of destructive and often unquestioned social values, such as the belief that the environment is for humanity's exploitation. Another way of putting this is that 'certain technologies and technoscientific practices are not only not innocent but, in fact, deeply intertwined with colonialism, white supremacy, and racism' (Hinton et al., 2015, p. 2).

A constitution of the science-ethics nexus that pressures Euro-Western hegemony, with attention paid to culturally diverse Indigenous ways-of-knowing, may not just benefit Indigenous students in engaging with science and seeing their cultures valued. It may also benefit non-Indigenous students in appreciating, and coming to understand, other ways-of-knowing-being: 'An appreciation of indigenous epistemology [...] provides Western peoples with another view of knowledge production in diverse cultural sites' (Semali & Kincheloe, 2002, p. 17). Perhaps most importantly, though, it might also help lessen Euro-Western hegemonic science's separation from the world and other subjects.

In contrast, an alternative to this might involve constituting a deeply relational and entangled relationship with ethical considerations. Indeed, this is what I have previously argued, in Chapter 4, to be an *ethical imperative*. Therefore, the inclusion of culturally diverse, and markedly Indigenous, ways-of-knowing within the science-ethics nexus of Australian school education must be fully conscious of the ways in which such ways-of-knowing have long been marginalised, and de-legitimised, by Euro-Western hegemony.

Furthermore, it is important to acknowledge that such marginalisation and de-legitimation continues to occur in numerous ways, including for scientific developments. For

instance, as the authors of *Haunting the Knowledge Economy*, drawing on Vandana Shiva's work, argue 'the colonization of survival economies continues in the present 'age of biology' [...and] is associated with the life sciences and biotechnology industry' (Kenway, Bullen, Fahey & Robb 2006, p. 101). Consequently, Euro-Western cultural hegemony is not just an ethical issue for school education but the overall becoming of science.

My argument here aligns with those who argue for the 'de-colonisation' of science education. The main difference that relational posthumanism makes is explicitly relating this process to the ethical becoming of the world, as well as to concepts of onto-epistemology and relationality. In addition to this, there must be acknowledgement of the stereotyping of any of these differing perspectives, including acknowledgement of the fluidity of cultural perspectives, which do, and necessarily, change over time. All that said, this should not be taken for an argument that there is nothing positive within Euro-Western science, or even that culturally diverse ways-of-knowing-being should not be critically assessed.

In many ways, as Aikenhead and Michell also convincingly argue, differing perspectives can sometimes be only relevant in certain areas. Another way of understanding this is that, in contrast to Euro-Western science's dominant 'universalist' perspective, there are different spheres of context for ethical-knowing-being, but this does not mean that knowing-being becomes uselessly relativist. To illustrate this using my data, I return to the same example I used in the previous section, 'Heating up for Thermageddon?', from *Science Quest 10 for Victoria* (Lofts & Evergreen, 2014). There is some indication in this section that climate change is a global concern, and its impacts around the world vary. For instance, one passage states:

An increase in heat and humidity due to climate change could render half the world uninhabitable. In regions where the 'wet-hub' temperature [...] exceeds 35°C (the human heat-stress limit), it would

be impossible for people to survive without some kind of cooling system (Lofts & Evergreen, 2014, p. 235).

I suggest that an acknowledgement of the different impacts of climate change, corresponding to place/space, could be much enriched by incorporating Indigenous ways-of-knowing. It is important to note that people who already experience marginalisation and inequities, such as indigenous people, are more vulnerable to the impacts of climate change. Not only does climate change not affect all (meaning all species and ‘environments’) equally but different human cultures around the world have very different perspectives on climate change (Watson & Huntington, 2014, p. 721). They also may have insights to offer about the unique effects on them, other animals and plants, as well as the place/space in which they live. For instance, the editors of the collection *Climate Change and Indigenous Peoples in the United States* argue that:

Unlike most citizens who form opinions about climate change based on cable news networks, internet sites, and even paper news publications, American Indian and Alaska Native awareness of climate change is the result of practical lifeway experiences and sensitivity to the rhythms of seasons that make them particularly knowledgeable about what is going on where they live (Maldonado, Colombi & Pandya, 2014, p. 2).

Additionally, as stated earlier, since many indigenous cultures ethically position the human-world relationship in different ways to Euro-Western cultures, this inevitably results in quite different ethical understanding of climate change. Aikenhead and Michell suggest that:

Sustainability is inherent to Indigenous knowledge [but is a] concept not usually integral to Eurocentric science. The planet’s environmental

crises cannot be solved solely with conventional Eurocentric science and technology but must call on knowledge systems that naturally embrace sustainability at their very core (Aikenhead & Michell, 2011, p. 11).

A way of envisioning this approach, in relation to the textbook example, is by the inclusion of different Indigenous cultures/language groups<sup>39</sup> around Australia and their perspectives on humanity's ethical entanglement and response to climate change. This might include how people from different Indigenous cultures/language groups in Australia perceive the effects of climate change on the local 'environments' they live in and how they understand human-world relationality. For example, as Brian Martin argues, 'In Indigenous terms, one "belongs to country", not the reverse and there is a reciprocal relationship between people and "country"' (B. Martin, 2012, p. 185).

To take this further, and in linking back to the previous section of this chapter, I believe it is necessary to consider how Indigenous ways-of-knowing might enhance a science-ethics nexus that is not constrained within the 'science curriculum', or within specific texts, or even classrooms. Therefore, as another example of this potentiality, I consider here the value of student 'excursions' outside of classrooms and how such excursions might explicitly include ethical considerations of Indigenous ways-of-knowing. This resonates with work that emphasises the significance of 'place' and posthumanist thinking, which 'involves a shift [...] to heterogeneous relations between a whole host of living beings and things, non-living and living forces' (Somerville & M. Green, 2015, p. 115). Clearly, there would be multiple hurdles to

---

<sup>39</sup> Language groups for Indigenous Australians are important because 'language is not only seen as a form of communication but as a method of right to land, forming boundaries for each family group, and language group' (Indigenous Australia.info, 2017).

overcome towards such an approach, logistically, financially, and politically. However, following the speculative nature of this study, it is worth presenting such a possibility.

As pointed out earlier, there are developing connections already between Indigenous ways-of-knowing and scientific research, particularly in relation to issues of conservation and sustainability (e.g. Ayre & Mackenzie, 2013; Cullen-Unsworth, Hill, Butler & Wallace, 2012; and Zeimbicki, Woinarski & Mackey, 2013). Secondary school education might therefore utilise these existing partnerships for students to engage with the ‘environments’ they live in, as well as Indigenous ways-of-knowing concerning these ‘environments’.

A program already underway, called the National Indigenous Science Education Program (NISEP), reflects some of these ideas. This program’s mission ‘seeks to provide Indigenous students with the skills and attitudes required to secure science and technology based education and employment opportunities’ (NISEP, 2016). However, there are elements of this program that gesture towards possibilities for engaging with Indigenous ways-of-knowing and the science-ethics nexus, for the benefit of all students. For instance, a ‘Science Fun Day’ includes ‘a celebration of Indigenous and Western science’ as well as ‘the value of traditional and contemporary (customary) Indigenous knowledge in science and technology and the relevance of science to our everyday lives’ (NISEP, 2016).

It is also noted that NISEP ‘uses local sites of Aboriginal cultural significance to educate students about Indigenous culture and scientific principles during excursions led by science teachers and Aboriginal elders’ (Harrington, 2014). It is therefore possible to at least conceive of something similar being integrated into all secondary schools. Additionally, with the focus not just on benefitting Indigenous students but for all students in coming to better appreciate different cultural ways-of-knowing and related concerns of ethical becomings. The posthumanist element of such an approach is not just the inclusion of Indigenous ways-of-

knowing, however, but specific attention to relationality, ethical considerations, and being critically conscious of diverse cultural constitutions of the human.

The establishment of a science-ethics nexus in secondary school education that works through cultural boundaries, and that involves interrogating the understanding of such boundaries to begin with, overall involves numerous complexities. However, if there is to be a science-ethics nexus in school education that is truly going to challenge the various negative impacts, and potential ethical limitations, of Euro-Western cultural hegemony such complexities must surely be embraced. This may also be necessary for a truly valuable science-ethics nexus directed towards better meeting the ethical demands of the 21<sup>st</sup> century. However, it would be necessary that any such approach must begin with a critical re-evaluation of the values, and foundational cultural blocks, on which the science-ethics nexus rests rather than only adding to what already exists.

---

## CONCLUDING THOUGHTS

It is possible that the most important issue, and perhaps even the most defining ‘moment’ of humanity, is how to ethically resolve human-world relationality. This is so especially in the face of greatly expanding human populations, increasing rates of environmental destruction and degradation, increasing extinction rates of other species, climate change, as well as the overall increasing rate and influences on the world of scientific and technological development. However, we also need speculative stories that incorporate renewed thinking not just based on risk management. One of the most important avenues by which to meet this ethical imperative might well be school education, with acknowledgement, however, of the surrounding entangled influences that contribute to how people, governments, and communities think about, and engage with, the science-ethics nexus.

In this chapter, I presented a case for how a relational posthumanist framework can be utilised to re-envision the science-ethics nexus in Australian secondary school education. These ideas are offered as potentialities and provocations. I first outlined how this framework, by emphasising the concept of intra-active relationality, renews thinking about the importance of science in school education. This specifically involved re-evaluating an ‘economic imperative’. Additionally, this renews thinking about how researchers (and teachers) understand the problems associated with science in school education, such as students’ declining interest in the subject. Crucially, relationality also underscores the inseparability between science, school education, and the world. It also emphasises this as an ethical issue, and correspondingly this presents a possible constitution of the science-ethics nexus in Australian school education as an *ethical imperative*.

Another crucial perspective this framework offers is the reworking of how ethics is defined, and how such a reworking necessitates shifting ethics to the forefront as an aspect of all processes of knowing-being. There are a great many avenues through which to consider the benefits of a posthumanist definition of ethics. However, so far not much attention has been paid to its applications in school education. I outlined in this chapter, by utilising my analyses of interviews with beginning teachers, that this renewed definition of ethics may pave the way for school education to better meet the growing complexities and crucial importance of ethics in relation to the world’s ongoing scientific and technological development. This potentially has positive implications therefore not just for students and teachers but also for the world’s becoming.

The further provocations a relational posthumanist framework offers in this area is how the science-ethics nexus might expand beyond the ‘science curriculum’. Towards this possibility, I suggested that incorporating speculative fiction and posthumanist sensibilities is one avenue, especially as an ethical manoeuvre. That is, not as a way to develop understanding

of science ‘facts’ but as method of ethical deliberations, which may take the form of either watching/reading speculative fiction or doing creative work.

Lastly, I utilised relational posthumanism to add to the small but growing area of research, with posthumanist sensibilities, advocating for attention to Indigenous ways-of-knowing in school science. Here, I put critical emphasis on this as an *onto-epistemological and ethical issue*, due to some of the negative implications of a Euro-Western hegemony in relation to the science-ethics nexus in school education. In contrast to what arose in my analyses of the Australian curriculum and related science textbooks, the in-depth inclusion of Indigenous ways-of-knowing may open the science-ethics to not only diverse ways-of-knowing but also renewed ways school education might consider human-world relationality.

What I have offered here is no doubt only scratching the surface of further potentialities of renewed thinking about science, ethics, and school education as inspired by the material/ontological/posthumanist turn in research. Consequently, more research in this area will certainly be needed to ensure such potentialities are further teased out and tested.

## CONCLUSION

---

...the conditions for renewed political and ethical agency cannot be drawn from the immediate context or the current state of the terrain. They have to be generated affirmatively and creatively by efforts geared to creating possible futures, by mobilizing resources and visions that have been left untapped.

—(Braidotti, 2013, p. 191)

---

This dissertation has involved an examination of multiple diffracted stories; stories of science, technology, ethics, Australian secondary school education, beginning teachers, textbooks, curricula, speculative fiction, posthumanism, myself, and research. Braidotti points out, in the quote above, that there is value in accessing ‘untapped’ areas towards ‘renewed political and ethical agency’ (Braidotti, 2013, p. 191). This study has been such an attempt. Specifically, it has been a venture to help renew thinking for science, ethics, and Australian secondary school education by working with theory, developed by Haraway, Barad, and Braidotti, and using methods not usually employed in this area. As such, I have utilised the theoretical framework ‘relational posthumanism’ along with the creative practice of an original speculative fiction short story, as well as diffractions of selected other speculative fiction.

The result of this approach, combined with analyses of major research reports, the Australian secondary school curriculum, secondary school textbooks, and interviews with beginning teachers, realised four main propositions. The first was that, by working with posthumanist concepts and speculative fiction diffractions, I brought together usually disparate areas and ideas to expand on the conceptual tools for addressing science and ethics in secondary school education. Secondly, I outlined how concepts developed by Haraway, Barad, and Braidotti are significant for the science-ethics nexus in school education. This included, for

instance, re-evaluating how ethics is defined, the inseparability between ethics, knowing, and being, as well as critical questions put to anthropocentrism.

The third proposition was a reassessment of how teachers' views of science and ethics might be investigated and understood. In analysing interviews with beginning teachers, my approach was to examine 'onto-epistemologies' and therefore complex assemblages of discourse-matter-bodies-environments-emotions-experiences-identities. Consequently, this was an attempt to expand on discourse-centric analyses and highlight the significance of such complex assemblages in relation to the science-ethics nexus.

My fourth proposition outlined the potential benefits of a relational posthumanist envisioning of the science-ethics nexus in Australian secondary school education. This proposition emphasised relationality, including challenging disciplinary and cultural boundaries. Ethics, here, redefined through a posthumanist lens, re-situates the human as 'of the world' rather than at its centre. Overall, this approach acknowledges ethics are 'messy' and relational, and insists on the inseparability of ethics and 'knowing-being'.

In this conclusion, I unite the stories detailed in each chapter, as well as chart how each of these stories relate to the importance and implications of this research overall. In the following section, I review how my research questions were developed and how I addressed them throughout this dissertation. This leads to outlining my contributions to knowledge by further detailing my four main propositions. Lastly, I include some thoughts about how the provocations of my study might contribute to future imaginings and future research.

---

## QUESTIONS ADDRESSED

In my process of conducting a review into the literature concerning science and school education, various stories began to merge together in importance, as outlined in Chapter 1. These include the ongoing complexities, tensions, and questions concerning how science and

technology relate to ethics and the world's development. I connected this story with the developments in theory relating to renewed thinking about materialities and ontology. Additionally, another salient area has been the renewed attention to the human, and humanity's relationship with the world, via the lens of posthumanism. Notably, at the beginning stage of my research, there were very few connections made between these theoretical developments and science in school education, let alone a focus on ethics, and this remains an underdeveloped area.

In relating this progression of theory to the doing of research, I also brought into these conversations a creative research practice of writing speculative fiction, as well as the inclusion of further speculative diffractions in this dissertation. I outlined several connections being made between feminist materialist and posthumanist theory with creative research practice, in chapters 2 and 3. I also defined how I worked with related theory concepts as applied to my other methods of doing research, including my analyses of major research reports, the Australian secondary school curriculum, textbooks, and interviews with beginning teachers.

Lastly, the story of science in Australian secondary school education, including the lineage of research in this area, postulated important questions, especially via the lens of posthumanism. This story includes attention to how science and ethics in Australian secondary school education have been conceptualised and previously examined. Within this area, I noted the dominance of certain methods and frameworks, such as social constructionism and poststructuralism, as well as the ongoing related issues.

It remains unusual that the material/ontological/posthumanist turn in theory, which specifically encompasses epistemological questions about science, is rare in research about school science. Although there are indications this may be changing, this lack of attention, to my best knowledge, is still the case within Australia. In addition, although it is widely noted

that speculative fiction is especially disposed towards asking questions of, and interrogating, science and ethics, it too has been little utilised in this area of research, and particularly not as a form of creative research practice.

The combination of all these stories led me to ask the following question: *How does relational posthumanism, combined with speculative fiction as a creative research practice, help to renew thinking about the science-ethics nexus in Australian secondary school education?*

This main question drove the overall direction of this study. However, in breaking this question down to a manageable level, I specifically addressed the following three subsidiary questions.

1. How is the science-ethics nexus currently constituted in Australian secondary school education?
- 

I first addressed this question via a diffractive analysis of major research reports on science education in Australia. These reports, supported by my broader literature review, provided insights into the ways in which science in school education is considered important by prominent researchers in this area. I also focussed on what problems of science in Australian school education are identified and how they are understood. In this analysis, I additionally outlined the significance, and potential limitations, of the relationship between science and ethics in Australian secondary school education.

In considering ethics more specifically, I examined the Australian secondary school curriculum to assess how ethics is defined. My examination of this area then led to a focus on anthropocentrism, in relation to ethics, by my analyses of science textbooks. My first subsidiary question also extended to understanding beginning teachers' views of science and ethics as very much a crucial component of the science-ethics nexus. In this area of focus, I was able to elaborate on similarities between the curriculum and textbooks, as well as the manner in which

the beginning teachers I interviewed understood science and ethics generally. I also showed how this specifically related to Australian secondary school education. This included considerations of Euro-Western, masculinist, and humanist hegemony.

2. How does relational posthumanism, and speculative fiction, offer an alternative way of understanding how teachers' come to their views about science and ethics?
- 

Within my literature view, I noted that in comparable areas of research, such as that focussing on 'socioscientific issues', teachers' and students' views of science have been an area of interest. In identifying teachers' views as an important component of the science-ethics nexus, I considered how relational posthumanism might offer an alternative approach to this research. Consequently, I addressed this question by conducting two sessions of in-depth interviews with ten beginning secondary school teachers.

While the interviews followed mainly 'traditional' qualitative methods, I added some elements that were inspired by relational posthumanist concepts. This involved me developing and presenting the participants with an assemblage map, along with an exercise to assess how this map diffracted their approaches to hypothetical lesson plans. The assemblage map was intended to outline potential material-discursive implications of beginning teachers' views of science and ethics.

Additionally, in diffractively analysing the interviews, I worked with Barad's concept of 'onto-epistemology', or 'knowing-being', as well as with the work of those using concepts inspired by Deleuze and Guattari. I tested this approach out as an alternative method of understanding the ways teachers' views about science and ethics form. My analyses also involved considerations of how to challenge anthropocentrism by conceptualising human participants as entities-as-multiplicities. In these deliberations, I examined participants' 'views-assemblages' in relation to science and ethics, as well as their possible becomings as described

by such assemblages. Lastly, I also drew on speculative fiction diffractions to connect the participants' views-assemblages with posthumanist concepts and broader concerns about science and ethics.

3. What might relational posthumanist and speculative fiction provocations offer to an alternative vision of the science-ethics nexus in Australian secondary school education?
- 

What is conceivably the most important aspect of bringing posthumanist and speculative provocations into this area of research is the ability not only to critically assess the unfolding of the science-ethics nexus but also what it *could* be. By combining the insights from my previous chapters, in Chapter 6 I posed an argument in response to this question. This details how such concepts might be used to re-envision the science-ethics nexus in Australian secondary school education.

To illustrate possibilities, I incorporated aspects of my data and analyses, as well as speculative fiction diffractions. In this sense, I reworked aspects of the Australian secondary school curriculum, as well as extracts from textbooks, to demonstrate an emphasis on relationality, as well as a posthumanist inspired definition of ethics. I also brought in my interviews with beginning teachers as a gesture to what this re-envisioning could mean for teachers and their connection with science and ethics.

Furthermore, I illustrated how posthumanist and speculative fiction provocations can contribute to conversations about disciplinary and cultural boundaries and hegemony. Therefore, I presented an illustration of how relational posthumanism can be used to analyse speculative fiction as an ethical manoeuvre concerning science that could be taken up in secondary school education. Lastly, I also presented a case for diverse ways-of-knowing, by considering how Indigenous ways-of-knowing might be integrated into the science-ethics school nexus. To do this, I used examples from science textbooks and the idea of an excursion

with Indigenous guides that takes science and ethics, with a posthumanist sensibility, outside of the classroom.

---

## CONTRIBUTIONS TO KNOWLEDGE

The major outcome of this study was four main propositions, which together address my main question. These are the arguments that suggest renewed thinking, as well as renewed directions in research, in science, ethics, and secondary school education. In this section, by bringing together the main themes from each chapter, I outline my approach, and the results of my approach, for each proposition.

---

### PROPOSITION 1

**Speculative fiction as a creative research approach, combined with relational posthumanism, helps forge renewed thinking for science in secondary school education.**

In the process of conducting my literature review, I concluded that emerging theory related to the material/ontological/posthumanist turn is germane to researching science and ethics in school education. One aspect of working with this theory has involved drawing on diverse ideas and alternative approaches to this area, including creative research practices. Indeed, one aspect of my approach has been to enter this field from outside of the discipline-specific ‘science education’.

Speculative fiction as a creative practice arose as an opportunity for my study from multiple sources; my theoretical framework, my data, and my background in creative writing and literature studies. As outlined in Chapter 1, research combining speculative fiction and science in school education is limited. I was not able to find more than a few examples of

research in this area that utilises fiction writing as a creative research practice, let alone speculative fiction in relation to ethics.

While certainly a speculative fiction research practice, or even creative research practice more broadly, is not necessarily applicable to all aspects of researching science and ethics in school education, I outlined in this dissertation the ways in which it can work, and how specifically it can work along with my framework of relational posthumanism. Firstly, this concerned utilising speculative fiction as ‘diffractions’ along with my other data. For example, in each chapter I brought in elements of my speculative fiction short story ‘The Beforetimer’ into my analysis. This process allowed me to articulate ideas, concepts, and issues related to this study in a dynamic way.

One illustration of this was the way I examined aspects of broad ethical questions and concerns of science and technology in the world’s actual or potential development via ‘The Beforetimer’. As noted previously, speculative fiction is especially useful in this regard because it can engage with questions that are of real concern to and for the world. Additionally, its fictional element gives reign to imaginatively and affectively engaging with these issues. Thus, in Chapter 4, I drew on ‘The Beforetimer’, along with Margaret Atwood’s novel *MaddAddam* (Atwood, 2014), to demonstrate how speculative fiction ethically engages with issues such as sustainability, climate change, and gene technology. This also involved outlining the similarities between these ethical engagements and a posthumanist framework’s critical examination of the human, including how humanity affects ‘environments’ and other species.

Another illustration was my diffractions of speculative fiction to demonstrate how it can also be used to imagine things differently, and potentially as improved. In ‘The Beforetimer’, this included how the *Homo adaptos* have advanced technology and yet live in relative harmony with their environment. This approach also allowed me to tap into the speculative aspect of

posthumanism. In other words, it allowed me to consider alternative becomings of the world and alternative ways that humanity might engage with the world. Consequently, in Chapter 6, this manoeuvre began my examinations into how the science-ethics nexus in Australian secondary school education might be envisioned via a posthumanist, and speculative, lens.

The second aspect of this proposition was the way in which speculative fiction as a creative research practice, into which my theoretical framework was ‘plugged’, became a knowledge generating process. By incorporating some of the concepts of my theoretical framework into my creative fiction writing, I could examine them and the related issues of science and ethics in a way that otherwise would not have been possible. I was able to achieve a deeper understanding of these concepts as well as an imaginative, and potentially more engaging, method of articulating them.

In my analyses of my interviews with beginning teachers, I sought to articulate the concept of ‘onto-epistemology’ by diffracting aspects of ‘The Beforetimer’ and the film *Snowpiercer* (Bong, 2013). I outlined how I delved into this concept by reducing one of my characters in ‘The Beforetimer’, Pax/Entity, to a being who can only ‘know’ the world via xir body-sensation-world relationality. This, therefore, fictionalises Barad’s example of the brittlestar and its ability to ‘know’ the world without a brain. Furthermore, in drawing on my creative fiction research practice, and on speculative fiction broadly, I could outline how engagement with speculative fiction can be an affective onto-epistemological experience. In relating this to my interview analyses, I proposed that engaging with speculative fiction can be an important aspect of the participants’ becoming, especially for their views of science and ethics.

The last feature of this proposition entails conceptualising creative research practice as agentic in the process of developing knowledge. This means that my fiction practice can be

understood as significant for my contributions to knowledge and for potentially working in creative ways not bounded by my intentions. As argued in Chapter 3 and 4, relational posthumanism challenges the significance of any one human actor in creative processes. Instead, it acknowledges that creative processes are part of complex assemblages, within which any human actor is only one element. Overall, the combination of writing speculative fiction, with ‘plugged in’ relational posthumanist concepts, brought together both disparate and complementary characteristics. This relationality allowed for renewed thinking about both, as well as for the broad issue of science, technology, and ethics.

---

PROPOSITION 2

**Haraway, Barad, and Braidotti’s theories are significant for examining science, ethics, and school education.**

The inspiration for utilising a creative research practice, gained from my engagement with the material/ontological/posthumanist turn in theory, was only one part of this study’s alternative approach. An additional element, which forms my second proposition, is how this study demonstrates the important connections between this theory and researching the entanglement of science, ethics, and school education. Specifically, I identified the work by Donna Haraway, Karen Barad, and Rosi Braidotti as uniquely suited to providing renewed provocations in this area.

Haraway and Barad, as both scientists and theorists, submit several important arguments that intrinsically relate to how science is defined, and its relationship to ethics. All three theorists also place critical emphasis on how the ‘human’ is understood and humanity’s relationship with the nonhuman/more-than-human. I have translated their concepts into the context of science, ethics, and school education, as well as into the doing of research in this

area, in multiple ways. For this proposition, my focus for the moment is on the important broad aspects. I reserve more specific examples for propositions three and four.

One of the most important concepts I worked with is ‘relationality’, which Haraway, Barad, and Braidotti all reference in various respects. By putting this concept at the forefront of my framework, relational posthumanism, I was able to emphasise its importance in terms of assessing world-science-education relationality in Australian secondary school education. Furthermore, I advanced this in suggesting ways this relationality might be made more overt as a concern for school education, as well as enabling a stronger constitution *in* school education.

The concept of relationality informed much of my analyses of major research reports concerning science in Australian secondary school education. By diffracting this concept in my analysis, I identified the ways in which these reports conceptualised science education in relationship with the world. For example, I identified how the report ‘STEM: Country Comparisons’ (Marginson et al., 2013) largely characterised the importance of science education, and consequently the problems, as an economic imperative for Australia. In addition, I detailed how the concept of relationality is important in determining how Australian secondary school science might relate more strongly to science in the world’s becoming. In this sense, in Chapter 6, I used the example of ‘the atom’ to propose how all topics might forefront this relationality, rather than stressing more ‘factual’ knowledge.

In this dissertation, I have also demonstrated how Barad’s arguments concerning the inseparability of ethics, knowing, and being, and of matter with discourse, is another vital characteristic of a relational posthumanist approach to this area of research. For example, this inspired my consideration of the primacy of ethics in the constitution of science in school education. I noted that in my analyses of science textbooks, and the Australian secondary school

curriculum, ethics was not present across all topics and, when it was included, was not often contextualised as a part of everyday becomings.

Haraway and Barad's work contributed to my attention to anthropocentrism, but it was Braidotti's posthumanist theory that provided detailed considerations. By working with this concept, along with relationality, I identified anthropocentrism in my analysis of science textbooks. The concept of relationality also allowed me to consider the significant implications of Euro-Western and masculinist hegemony as these phenomena relate to anthropocentrism. Most importantly, perhaps, was how these concepts permitted a close analysis of the ways in which anthropocentrism is related to how ethics is constituted in Australian secondary school education.

I also demonstrated in this dissertation that Haraway, Barad, and Braidotti's theories, in combination with those who have developed Deleuze and Guattari's theory, can also be usefully translated into the doing of research in this area. Part of this, as outlined in proposition one, was inspiration for a creative research practice. However, this also entailed other elements that propose an alternative to much of the research on science in school education. For instance, this included an alternative approach to considering teachers' views of science and ethics, as onto-epistemological becomings, which I further outline in proposition three.

Lastly, the other main advantageous outcome of drawing from Haraway, Barad, and Braidotti, is the potential of relational posthumanism overall to address not only *what is* but *what could be*. With the use of relational posthumanist concepts, along with speculative fiction, which I extend on in proposition four, I was also able to present a re-envisioning of the science-ethics nexus in secondary school education *as posthumanist*.

---

PROPOSITION 3

**A relational posthumanist framework provides an alternative method of understanding teachers' views about science and ethics; as 'onto-epistemological' assemblages.**

In identifying teachers' views of science and ethics as an important factor for the science-ethics nexus in Australian secondary school education, I sought to include this area of concern in my study. After noting, in my literature review, that methodological approaches to this area were largely homogenous, I endeavoured to ascertain how a relational posthumanist framework might renew thinking in this area, not only for understanding what teachers' views are but also for how they might come to be.

By working with the concept of 'onto-epistemology' as my main guide, I argued that this approach extends on discursive-centric approaches to understanding views. The framework of relational posthumanism first inspired my alternative approach to conceptualising human participants; as entities-as-multiplicities. Thereby, I attempted to decentre the human in research, while still including human participants, by understanding my participants as not bounded, coherent individuals but always a part of multiplicities. Additionally, via my analyses of interviews with beginning teachers, I identified the usefulness of considering 'views-assemblages' as involving the participants' matter-bodies-environments-emotions-experiences-identities.

My analyses of interviews with entities 1, 6, and 7 suggested a way to conceptualise their becomings, and therefore their views, as a complex material-discursive assemblage continuously involving both overt and subtle intra-actions. I proposed that these intra-actions involved, in equal importance, hegemonic phenomena, such as Euro-Western culture, along with the participants' matter-bodies-environments-emotions-experiences-identities. For

example, for Entity 6, I suggested that while hegemonic ideology was implicated in xir view about science being about ‘concrete answers’, there were subtler but still central aspects of xir views-assemblage, such as xir experience of encountering pseudo-science when wanting to lose weight.

Furthermore, for my interviews with entities 4 and 9, I was also able to propose a way to consider why some views shift away from the normative. For these two participants, I noted that their views of ethics, in relation to science, differed somewhat from the norm. For Entity 4, this was in the sense of acknowledging the implications of social phenomena, such as homophobia and racism, as important to consider in relation to science and ethics, and that ethics is a part of everyday becomings. For Entity 9, xe expressed some anti-anthropocentric views, such as being critical of science and technology’s development in extending human lives. To conceptualise this difference, I drew on Braidotti’s concept of becoming-Other along with those who have developed Deleuze and Guattari’s concept of a ‘line of flight’. Via this approach, I could consider this difference in views due to entities 4 and 9 becoming-Other, as involving for instance their sexuality identity and mental health respectively.

Although my interview analyses were intended to provide diverse gestures, rather than in-depth accounts, the insights gained might still have broader implications. That is, not just for suggesting the usefulness of a relational posthumanist approach, but also the potential benefits for teacher education and professional development. For example, I noted that Entity 1 expressed that xe found the interview process very interesting and pointed out that xir tertiary education experiences had not addressed the implications of teachers’ backgrounds or identities in their views.

Additionally, in the second round of interviews, some of the participants responded positively to considering the implications of views-assemblages for the hypothetical lesson plan

exercise. Entity 9, for example, shifted from xir view expressed in the first interview, that xe would avoid personal implications in a class concerning ethics and genetically modified humans, to explicitly including the personal in the second interview exercise. This insight also addresses the broader concern about science in Australian school education and how ethics is framed. In other words, if ethics was shifted to the forefront of education about science, teachers might engage more strongly with ethics. Furthermore, more attention to views and views-assemblages may benefit teacher education in their coming to understand their personal viewpoints.

---

PROPOSITION 4

**Relational posthumanism can be used as a generative methodology, through which to propose an alternative vision of the science-ethics nexus in school education.**

The last chapter of this dissertation outlined my proposition that relational posthumanism, along with diffractions of speculative fiction, are generative of a renewed vision of the science-ethics nexus in Australian secondary school education. By drawing on the same concepts I used for my data analysis, I illustrated how they can be translated into a renewed approach for addressing, and defining, ethics. One of the most important aspects of this was considering how the science-ethics nexus might be constituted if ethics was put at the forefront, rather than the focus on ‘factual’ knowledge.

In the process of conducting my literature review, and data analysis, it became apparent to me that how science in school education relates to the world is a significant issue. Not only this, but also that previous suggestions to strengthen this connection have been mainly based on additive approaches. In contrast, by working with the concept of relationality, I outlined an alternative possibility. In this renewed vision, world-science-education relationality becomes an intrinsic aspect of school education, rather than an addition to a primary focus on ‘scientific

facts'. Consequently, for example, I proposed how all topics related to science could be connected to assemblages, which include ethical becomings, of history, psychology, philosophy, politics, environments, and ideology.

The concept of relationality also inspired my consideration of disciplinary and cultural boundaries. This included reviewing how disciplinary boundaries may inadvertently separate science from the world, and other subjects, due to an overemphasis on scientific 'content knowledge'. Significantly, such disciplinary boundaries were also suggested in my beginning teacher participants' views of science and ethics, as there were some connections between their views and whether they intended to teach in the humanities, the natural/biological sciences, or mathematics. An emphasis on relationality, in contrast, would conceptualise the inseparability of all elements of science, and scientific knowledge, with all other subjects in school science. By analysing the film *Ex Machina* (Garland, 2015), I illustrated one instance of this as the potential for speculative fiction to be an ethical manoeuvre *within* the science-ethics nexus.

Following this, I identified the concept of relationality, as well as of ethico-onto-epistemology, as significant for putting pressure on cultural boundaries. In Chapter 6, I gestured to the links between relational posthumanism and further challenging cultural hegemony by considering the usefulness of, and the ethically necessary, consideration of diverse ways-of-knowing-being. Towards overcoming a hegemonic influence of Euro-Western-centric science in Australian secondary school education, I proposed that a relational posthumanist framework firstly emphasises the relationality of cultures.

This relationality brings to attention how cultures intrinsically intra-act in their becoming but also how such relationality is not neutral. In other words, the dominance of Euro-Western thinking has had significant consequences for the marginalisation of other cultural

ways-of-knowing-being. This also relates to the hegemony of certain harmful ideas and ideals, such as the separations of nature and culture, human and world.

This understanding also underlines how cultural hegemony is very significant for the science-ethics nexus in school education. For instance, I outlined how Euro-Western philosophy has been solely utilised to define ethics in the Australian secondary school curriculum, to the exclusion of other cultural considerations. Consequently, I proposed that building on a science-ethics nexus along with Indigenous ways-of-knowing has the potential of emphasising and strengthening the intrinsic relationality of science, knowledge, and ethics. I highlighted Indigenous ways-of-knowing due to some similarities with relational posthumanism. These include articulating a more harmonious and relational perspective on humanity's relationship with environments and other species.

By using my framework to redefine ethics as posthumanist, I provided some illustrations of what this could mean for how ethics is constituted in the Australian curriculum, as well as in science textbooks. Specifically, this was about illustrating a science-ethics nexus in school education that overtly challenges anthropocentrism. Such a development would therefore require ethical considerations to acknowledge humans as no more or less important, overall, in the world's becoming. Consequently, in using an example from a science textbook that mainly framed climate change as a concern for human survival, I argued that such issues might instead be framed in diverse ways that de-centre the human.

Finally, I argued that a posthumanist ethics allows for understanding ethics as 'messy', as involving emotions, cultural differences, and other complexities. Ethics, in this sense, cannot be neatly separated from what is typically understood as subjectivities. Nor can decisions be made that are separate from the complexities of everyday ethical becomings. This understanding, therefore, could have multiple implications for school education. For example,

I suggested that one way this might be developed in school education is by the overt acknowledgement of the connection between ethics and entanglements in everyday life. For students, this could mean that assessments of their environmental impacts, carbon footprint and waste production, as well as general consumerism, as a major component of the science-ethics nexus.

---

## FUTURE PROVOCATIONS

In considering the vast complexities of science, ethics, and school education, I do not propose relational posthumanism as *the* answer to the many issues of this area. However, I demonstrated in this dissertation that it is a significantly useful tool for providing provocations, and for continually challenging the ways things are. This framework, inspired by Haraway, Barad, and Braidotti, has certain characteristics that make it especially useful in examining issues of science and ethics in school education. In this study, I put this framework, along with speculative fiction, to the test to outline how the constitution of ethics in Australian secondary school science is limited. Additionally, I proposed how this framework can be used to offer renewed directions that Australian school education could take to overcome such limitations.

Ultimately, this study has been a snapshot of emerging potentialities. The complex stories involved are ongoing. While I have attempted to offer renewed ways to think of these stories, and to suggest alternative stories, more work is required to grapple with the questions I have posed about the science-ethics nexus, and other questions not yet addressed. The most important broad issue partly addressed in this dissertation was what kind of school education we want to ‘become’ and how we might *speculatively* envision potential futures, not based on risk-management but on hope for something better.

As a gesture to what future research and future imaginings might develop from this study, I present the following relational posthumanist inspired vision of a secondary school lesson.

*Somewhere in Australia, a class on 'ethical imagination' begins for a group of Year 8s. They begin this class at a nature reserve, with an Indigenous guide, which is a continuation of their explorations into Indigenous ways-of-knowing. Their guide takes them through some aspects of the local Indigenous language group's connections to this land; specifically, the ways they have developed relationships with plants and other animals, such as illustrated in ancient stories. Students are invited to share what they know about the significance of their cultural backgrounds in thinking about how humans relate to 'environments' and other species.*

*The class continues inside and the students read a speculative fiction short story in their textbooks about a genetically modified human. This textbook is a significant departure from traditional content. It is about science but it makes ethics central; it contains scientific 'factual' knowledge but much more contingently. Such content is also expressly linked with sociocultural phenomena, as well as other subjects, such as English and history.*

*In this exercise, the students are encouraged to put themselves into the story, to think about diverse ethical considerations, and to come up with alternative endings. They are also asked to draw on their developing knowledge about DNA. They share their stories with each other and the teacher guides them to discuss the differences between their stories according to their backgrounds, their identities, and how they feel about gene technology and the emotional experience of the story.*

At the beginning of my study, research concerning science in school education that incorporates the material/ontological/posthumanism turn in theory was extremely rare, especially so for those that focus in some way on ethics. However, it appears that some momentum is slowly building in this area, especially around environmental concerns, as noted previously with the example of Margaret Somerville and Monica Green's *Children, Place and Sustainability* (Somerville & M. Green, 2015). Some other interesting examples include interpretations of new materialisms in the context of elementary school and 'ecological pedagogy' (Sonu & Snaza, 2015); consideration of a relationship between this theory and outdoor environmental education research (Gough, 2016); and an assessment of sex/gender and sexuality assemblages in relation to environmental education (Bazzul & Santavicca, 2017).

Overall, what might be most significant for these and similar mediations is the questions being asked about how this theory renews thinking about the doing of research in this area, as well as new possibilities for considering ethics, justice, ontology/materialities, epistemology, and the human, in the context of science and school education. The contribution of my study for this developing area is to further expand on the terms of engagement, in the sense of bringing in creative practices and speculative fiction. Additionally, the approach of my investigation proposes that such mediations need not start 'within' science education, nor within the materialities of a science classroom or school setting.

In this dissertation, I have suggested that speculative fiction, along with research, presents a way to imaginatively dwell on large and small ethical questions. Many such questions have no easy answers, but the innovation of fictional considerations make these questions continually, and personally, relevant to all. As a final coda, I include here the ending of 'The Beforetimer', which may at this point have taken on new meanings, and new significance, from its inclusion in the Introduction.

Pax stood over the river, watching the rushing water bubble over the rocks, while grasping the pendant tightly around xir neck. It wasn't really a pendant, of course, but since Cedar and the others saw it as such, Pax had almost begun to as well. Just a harmless, meaningless bit of decoration. It was easier to believe because digital keys had no meaning for Cedar's kind, and even if they did know what it was, they could not know what it opened. What it *could* open. Pax looked down at the key, brushing xir thumb over the engraved infinity symbol.

After a long time, Pax pulled the thread off from around xir neck and let it swing, back and forward, over the water. A thousand questions clamoured but, so far, an answer did not come.

*All the green things thrive and the world is light.*

REFERENCES

- Abbiss, J. (2011). Boys and machines: Gendered computer identities, regulation and resistance. *Gender and Education*, 23(5), 601-617.  
doi:<http://dx.doi.org/10.1080/09540253.2010.549108>
- About NAPLAN. (2016). Retrieved 2017 from <https://www.nap.edu.au/about>
- About the Australian Greens. (n.d.). Retrieved 2017 from <http://greens.org.au/about>
- Adams, J., Luitel, B. C., Afonso, E., & Taylor, P. C. (2008). A cogenerative inquiry using postcolonial theory to envisage culturally inclusive science education. *Cultural Studies of Science Education*, 3, 999-1019. doi:<http://dx.doi.org/10.1007/s11422-007-9067-8>
- Ahmed, S. (2008). Some preliminary remarks on the founding gestures of the 'new materialism'. *European Journal of Women's Studies*, 15(23), 23-39.  
doi:<http://dx.doi.org/10.1177/1350506807084854>
- Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural Studies of Science Education*, 2, 539-620. doi:<http://dx.doi.org/10.1007/s11422-007-9067-8>
- Aikenhead, G., & Michell, H. (2011). *Bridging cultures: Indigenous and scientific ways of knowing nature*. Canada: Pearson.
- Akçay, H., & Yager, R. E. (2010). The impact of a science/technology/society teaching approach on student learning in five domains. *Journal of Science Education and Technology*, 19(6), 602-611. doi:<http://dx.doi.org/10.1007/s10956-010-9226-7>

- Allchin, D. (2012). Teaching the nature of science through scientific errors. *Science Education*, 96(5), 904–926. doi:<http://dx.doi.org/10.1002/sce.21019>
- Amemiya, T., Takano, J., & Choshi, K. (1993). Did atomic bomb radiation influence the incidence of retinoblastoma in Nagasaki and Hiroshima? *Ophthalmic Paediatrics and Genetics*, 14(2), 75-79. doi:<http://dx.doi.org/10.3109/13816819309042906>
- Appanna, S. D. (2011). Embedding Indigenous perspectives in teaching school science. *The Australian Journal of Indigenous Education*, 40, 18-22.  
doi:<http://dx.doi.org/10.1375/ajie.40.18>
- Åsberg, C., Thiele, K., & van der Tuin, I. (2015). Speculative before the turn: Reintroducing feminist materialist performativity. *Cultural Studies Review*, 21(2), 45-72.  
doi:<http://dx.doi.org/10.5130/csr.v21i2.4324>
- Attebry, B. (1992). *Strategies of fantasy*. USA: Indiana University Press.
- Atwood, M. (2011). *In other worlds: SF and the human imagination*. USA: Virago Press.
- Atwood, M. (2014). *MaddAddam*. USA: Anchor Books.
- Australian Bureau of Statistics (n.d.). B14 religious affiliation by sex. Retrieved 2017 from [http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS\\_CENSUS2011\\_B14](http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_CENSUS2011_B14)
- Australian Council of Learned Academies. (2017). About ACOLA. Retrieved from <https://acola.org.au/wp/about-us/>
- Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>a</sup>). Ethical understanding. Retrieved 2017 from <http://v7-5.australiancurriculum.edu.au/GeneralCapabilities/Pdf/Ethical-understanding>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>b</sup>). General capabilities – introduction. Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>c</sup>). Overview - texts Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/english/key-ideas/>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>d</sup>). Science. Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/science/>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>e</sup>). Science - structure. Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/science/structure/>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>f</sup>). Sustainability - overview. Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/cross-curriculum-priorities/sustainability/>

Australian Curriculum, Assessment and Reporting Authority. (n.d.<sup>g</sup>). Year 9 science curriculum. Retrieved 2017 from <https://www.australiancurriculum.edu.au/f-10-curriculum/science/>

Australian Government. (2007). *Australian code for the responsible conduct of research*. Australia: Australian Government.

Australian Government. (2011). State of the environment 2011 (SoE 2011). Retrieved 2016 from <https://www.environment.gov.au/science/soe/2011>.

- Australian Government. (2014). *National statement on ethical conduct in human research 2007 (Updated March 2014)*. Commonwealth of Australia, Canberra: Australian Government.
- Australian Government. (n.d). The chief scientist. Retrieved 2017 from <http://www.chiefscientist.gov.au/about/the-chief-scientist/>
- Australian Labor Party. (2017). The Australian Labor Party. Retrieved 2017 from <http://www.alp.org.au/about>
- Avraamidou, L., & Osborne, J. (2009). The role of narrative in communicating science. *International Journal of Science Education*, 31(12), 1683-1707.  
doi:<http://dx.doi.org/10.1080/09500690802380695>
- Ayre, M., & Mackenzie, J. (2013). “Unwritten, unsaid, just known”: The role of Indigenous knowledge(s) in water planning in Australia. *Local Environment*, 18(7), 753-768.  
doi:<http://dx.doi.org/10.1080/13549839.2012.665864>
- Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science Education*, 94(6), 1008-1026.  
doi:<http://dx.doi.org/10.1002/sce.20392>
- Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs*, 28(3), 801-831. doi:<http://dx.doi.org/10.1086/345321>
- Barad, K. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham: Duke University Press.
- Barad, K. (2008). Queer causation and the ethics of mattering. In N. Giffney & M. J. Hird (Eds.), *Queering the non/human* (pp. 311-338). England: Ashgate Publishing Company.

- Barad, K. (2011). Nature's queer performativity. *Qui Parle*, 19(2), 121-158. Retrieved from <http://www.jstor.org/stable/10.5250/quiparle.19.2.0121>
- Barad, K. (2015). *Ecologies of nothingness and troubling time/s: On devastation and the impossibilities of endurance*. Paper presented at the Transversal practices: Matter, ecology and relationality VI conference on new materialisms, Melbourne.
- Barrett, E. (2010). Introduction. In E. Barrett & B. Bolt (Eds.), *Practice as research*. London: I.B. Tauris & Co Ltd.
- Barrett, E. (2015). Materiality, language and the production of knowledge: Art, subjectivity and Indigenous ontology. *Cultural Studies Review*, 21(2), 101-119.  
doi:<http://dx.doi.org/10.5130/csr.v21i2.4316>
- Barrett, E., & Bolt, B. (Eds.). (2012). *Carnal knowledge: Towards a 'new materialism' through the arts*. London: I.B. Tauris & Co Ltd.
- Barrett, S. E., & Pedretti, E. (2006). Contrasting orientations: STSE for social reconstruction or social reproduction? *School Science and Mathematics*, 106(5), 237-247.  
doi:<http://dx.doi.org/10.1111/j.1949-8594.2006.tb18082.x>
- Bazzul, J., & Santavicca, N. (2017). Diagramming assemblages of sex/gender and sexuality as environmental education. *The Journal of Environmental Education*, 48(1), 56-66.  
doi:<http://dx.doi.org/10.1080/00958964.2016.1249327>
- Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education*, 91(3), 347-370. doi:<http://dx.doi.org/10.1002/sce.20186>

- Bernhardt, S., Heyde, E., Hough, L., Simpson, D., McIntyre, H., & McNamara, S. (2012). *Macmillan English 10 for the Australian curriculum* (S. Bernhardt Ed.). Victoria, Australia: Macmillan Education Australia.
- Bishop, S., Bass, G., Champion, N., Gregory, E., McKenna, E., & Walker, K. (2012). *Nelson iscience for the Australian curriculum 7*. Victoria, Australia: Nelson Cengage Learning.
- Boddice, R. (2011). *Anthropocentrism: Humans, animals, environments*. Boston: Leiden.
- Boden, L. (2013). Seeing red? The agency of computer software in the production and management of students' school absences. *International Journal of Qualitative Studies in Education*, 26(9), 1117-1131. doi:<http://dx.doi.org/10.1080/09518398.2013.816887>
- Bong, J.-h. (Writer). (2013). *Snowpiercer* [Motion picture]. In P. Chan-wook, L. Tae-hun, J. Tae-sung, & S. Nam (Producers). South Korea: CJ Entertainment.
- Bould, M., & Williams, R. (Eds.). (2014). *SF now*. USA: Paradoxa.
- Braidotti, R. (2002). *Metamorphoses: Towards a materialist theory of becoming*. Cambridge, Polity Press.
- Braidotti, R. (2011). *Nomadic subjects: Embodiment and sexual difference in contemporary feminist theory* (2nd ed.). USA: Columbia University Press.
- Braidotti, R. (2012). *Nomadic theory - the portable Rosi Braidotti*. New York: Columbia University Press.
- Braidotti, R. (2013). *The posthuman*. UK: Polity Press.
- Braidotti, R. (2016). Posthuman critical theory. In D. Banerji & M. R. Paranjape (Eds.), *Critical posthumanism and planetary futures*. India: Springer.

- Brayboy, B. M. J., & Castagno, A. E. (2008). How might Native science inform “informal science learning”? *Cultural Studies of Science Education*, 3, 731-750.  
doi:<http://dx.doi.org/10.1007/s11422-008-9125-x>
- Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45(9), 971-1002.  
doi:<http://dx.doi.org/10.1002/tea.20241>
- Bury, R. (2011). She's geeky, the performance of identity among women working in IT. *International Journal of Gender, Science and Technology*, 3(1), 33-53. Retrieved from <http://genderandset.open.ac.uk/index.php/genderandset/issue/view/8>
- Butler, J. (1999). *Gender trouble: Feminism and the subversion of identity*. New York: Routledge.
- Carlone, H. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching*, 41(4), 392-414.  
doi:<http://dx.doi.org/10.1002/tea.20006>
- Carter, L. (2010). The armchair at the borders: The “messy” ideas of borders and border epistemologies within multicultural science education scholarship. *Science Education*, 94(3), 428-447. doi:<http://dx.doi.org/10.1002/sce.20323>
- Carter, P. (2010). Interest: The ethics of invention. In E. Barrett & B. Bolt (Eds.), *Practice as research: Approaches to creative arts enquiry*. London: I.B.Tauris & Co Ltd.
- Cartwright, J. (2007). Science and literature: Towards a conceptual framework. *Science & Education*, 16, 115-139. doi:<http://dx.doi.org/10.1007/s11191-005-4702-9>
- Cash, S., Quinton, G., Tilley, C., & Silvester, H. (2011). *Oxford big ideas science 7*. Victoria, Australia: Oxford University Press.

- Champion, N., Smith, D., Termaat, A., & Pappas, X. (2012). *Nelson iscience for the Australian curriculum 10*. Victoria, Australia: Nelson Cengage Learning.
- Clark, B., & Button, C. (2011). Sustainability transdisciplinary education model: Interface of arts, science, and community (STEM). *International Journal of Sustainability in Higher Education*, 12(1), 41-54. doi:<http://dx.doi.org/10.1108/14676371111098294>
- Colebrook, C. (2004). *Gender*. New York: Palgrave Macmillan.
- Colebrook, C. (2010). Queer vitalism. *New Formations*, 68(5), 77-92.  
doi:<http://dx.doi.org/10.3898/NEWF.68.05.2009>
- Coleman, R., & Ringrose, J. (Eds.). (2013). *Deleuze and research methodologies*. Edinburgh: Edinburgh University Press.
- Coole, D., & Frost, S. (2010). *New materialisms: Ontology, agency, and politics*. USA: Duke University Press.
- Cooper, K., & White, R. E. (2012). *Qualitative research in the post-modern era: Contexts of qualitative research*. Dordrecht: Springer.
- Core Writing Team, Pachauri, R. K., & Meyer, L. A (eds). (2015). *IPCC, 2014: Climate change 2014: Synthesis report*. Retrieved from <http://www.ipcc.ch/report/ar5/syr/>
- Cullen-Unsworth, L., Hill, R., Butler, J. R., & Wallace, M. (2012). A research process for integrating Indigenous and scientific knowledge in cultural landscapes: Principles and determinants of success in the Wet Tropics World Heritage Area, Australia. *The Geographical Journal*, 178(4), 351-365. doi:<http://dx.doi.org/10.1111/j.1475-4959.2011.00451.x>

Czerneda, J. E. (2006). Science fiction and scientific literacy. *The Science Teacher*, 73(2), 38-42.

Retrieved from <http://www.jstor.org/stable/24139206>

Danielsson, A. T. (2012). Exploring woman university physics students 'doing gender' and 'doing physics'. *Gender and Education*, 24(1), 25-39.

doi:<http://dx.doi.org/10.1080/09540253.2011.565040>

Daugbjerg, P. S., de Frietas, E., & Valero, P. (2015). Mapping the entangled ontology of science teachers' lived experience. *Cultural Studies of Science Education*, 10, 777-801.

doi:<http://dx.doi.org/10.1007/s11422-014-9612-1>

Davies, B., Browne, J., Gannon, S., Honan, E., Laws, C., Mueller-Rockstroh, B., & Peterson, E. B. (2004). The ambivalent practices of reflexivity. *Qualitative Inquiry*, 10(3), 360-389.

doi:<http://dx.doi.org/10.1177/1077800403257638>

Davis, N. (2014). Politics materialized: Rethinking the materiality of feminist political action through epigenetics. *Women: A Cultural Review*, 25(1), 62-77.

doi:<http://dx.doi.org/10.1080/09574042.2014.901101>

Deleuze, G., & Guattari, F. (1984). *A thousand plateaus: Capitalism and schizophrenia* (B. Massumi, Trans.). USA: University of Minnesota Press.

Der-Thanq Chen, F. D., Tsai, C.-C., & Chai, C. S. (2011). Students' views of the nature of science: A critical review of research. *Science Education*, 95(6), 961-999.

doi:<http://dx.doi.org/10.1002/sce.20460>

Dogan, N., & Abd-El-Khalick, F. (2008). Turkish grade 10 students' and science teachers' conceptions of nature of science: A national study. *Journal of Research in Science Teaching*, 45(10), 1083-1112.

doi:<http://dx.doi.org/10.1002/tea.20243>

- Dolphijn, R., & van der Tuin, I. (2011). Pushing dualism to an extreme: On the philosophical impetus of a new materialism. *Contemporary Philosophy Review*, 44, 383–400.  
doi:<http://dx.doi.org/10.1007/s11007-011-9197-2>
- Dolphijn, R., & van der Tuin, I. (2013). *New materialism: Interviews & cartographies*. USA: Open Humanities Press.
- Dolu, G. (2016). University students' opinions concerning science-technology-society issues. *Educational Sciences: Theory and Practice*, 16(3), 1051-1076.  
doi:<http://dx.doi.org/10.12738/estp.2016.3.0180>
- Duran, J. (1998). *Philosophies of science/feminist theories*. USA: Westview Press.
- Eastwood, J. L., Sadler, T. D., Zeidler, D. L., Lewis, A., Amiri, L., & Applebaum, S. (2012). Contextualizing nature of science instruction in socioscientific issues. *International Journal of Science Education*, 34(15), 2289-2315.  
doi:<http://dx.doi.org/10.1080/09500693.2012.667582>
- El-hani, C. N., & Souza De Ferreira Bandeira, F. P. (2008). Valuing indigenous knowledge: To call it "science" will not help. *Cultural Studies of Science Education*, 3(3), 751–779.  
doi:<http://dx.doi.org/10.1007/s11422-008-9129-6>
- Ens, E. J., Pert, P., Clarke, P. A., Budden, M., Clubb, L., Doran, B., . . . Watson, S. (2015). Indigenous biocultural knowledge in ecosystem science and management: Review and insight from Australia. *Biological Conservation*, 181, 133–149.  
doi:<https://doi.org/10.1016/j.biocon.2014.11.008>
- Expert Working Group. (2012). *Indigenous engagement with science: Towards deeper understanding*. Retrieved from <http://www.lsln.net.au/jspui/handle/1/4778>

- Fausto-Sterling, A. (2000). The five sexes revisited. *The Sciences*, July/August, 18-23.  
doi:<http://dx.doi.org/10.1002/j.2326-1951.2000.tb03504.x>
- Fausto-Sterling, A. (2001). Life in the XY corral. In M. Lederman & I. Bartsch (Eds.), *The gender and science reader* (pp. 234-251). London: Routledge.
- Fieser, J. (n.d.). Ethics. Retrieved 2016 from <http://www.iep.utm.edu/ethics/>
- Finley, S. (2008). Arts-based research. In G. J. Knowles & A. L. Cole (Eds.), *Handbook of the arts in qualitative research: Perspectives, methodologies, examples, and issues*. USA: Sage Publications.
- Fløistad, G. (Ed.) (2014). *Ethics or moral philosophy*. Dordrecht: Springer.
- Fox, N. J., & Alldred, P. (2015). New materialist social inquiry: Designs, methods and the research-assemblage. *International Journal of Social Research Methodology*, 18(4), 1-16.  
doi:<http://dx.doi.org/10.1080/13645579.2014.921458>
- Fox, N. J., & Alldred, P. (2016). *Sociology and the new materialism: Theory, research, action*. London, UK: Sage Publications.
- Friend, M. I. (2017). Varieties of pluralism and objectivity in mathematics. *Journal of Indian Council of Philosophical Research*, 34(2), 425-442. doi:<http://dx.doi.org/10.1007/s40961-016-0085-3>
- Gannon, S. (2016). 'Local girl befriends vicious bear': Unleashing educational aspiration through a pedagogy of material-semiotic entanglement. In C. A. Taylor & C. Hughes (Eds.), *Posthuman research practices in education* (pp. 128-148). UK: Palgrave Macmillan.

- Gardiner, J., Chumley, A., Grieve, H., Jones, R., Kimber, S., Manning, M., & Yaxley, R. (2012). *English is...English for the Australian curriculum year 10*. Queensland, Australia: John Wiley & Sons.
- Garland, A. (Writer/Director). (2015). *Ex machina* [Motion picture]. In A. Macdonald & A. Reich (Producers). UK & USA: Universal Pictures & A24.
- Gilbert, J. (2001). Science and its 'other': Looking underneath 'woman' and 'science' for new directions in research on gender and science education. *Gender and Education*, 13(3), 291-305. doi:<http://dx.doi.org/10.1080/09540250120063571>
- Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom: Looking at the gender and science education question through a different lens. *International Journal of Science Education*, 25(7), 861-878. doi:<http://dx.doi.org/10.1080/09500690305030>
- Glasson, G. E., Frykholm, J. A., Mhango, N. A., & Phiri, A. D. (2006). Understanding the earth systems of Malawi: Ecological sustainability, culture, and place-based education. *Science Education*, 90(4), 660-680. doi:<http://dx.doi.org/10.1002/sce.20148>
- Glasson, G. E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in Africa: Negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education*, 32(1), 125-141. doi:<http://dx.doi.org/10.1080/09500690902981269>
- GMO Compass. (2016). Genetic engineering, plants, and food: The European regulatory system. Retrieved from [http://www.gmo-compass.org/eng/regulation/regulatory\\_process/156.european\\_regulatory\\_system\\_genetic\\_engineering.html](http://www.gmo-compass.org/eng/regulation/regulatory_process/156.european_regulatory_system_genetic_engineering.html)

- Gomel, E. (2011). Science (fiction) and posthuman ethics: Redefining the human. *The European Legacy*, 16(3), 339–354. doi:<http://dx.doi.org/10.1080/10848770.2011.575597>
- Goodrum, D., Druhan, A., & Abbs, J. (2012). *The status and quality of year 11 and 12 science in Australian schools*. Canberra, Australia: Australian Academy of Science. Retrieved from <https://www.science.org.au/files/userfiles/support/reports-and-plans/2015/year11and12report.pdf>
- Goodson, I. (2017). Introduction: Life histories and narratives. In I. Goodson, A. Antikainen, P. Sikes, & o. Andrews (Eds.), *The Routledge international handbook on narrative and life history* (pp. 1-10). Oxon: Routledge.
- Gough, N. (2010). Performing imaginative inquiry: Narrative experiments and rhizosemiotic play. In T. W. Nielsen, R. Fitzgerald, & M. Fettes (Eds.), *Imagination in educational theory and practice: A many-sided vision*. Newcastle upon Tyne: Cambridge Scholars Publishing.
- Gough, N. (2016). Postparadigmatic materialisms: A "new movement of thought" for outdoor environmental education research? *Journal of Outdoor and Environmental Education*, 19(2), 51-65. Retrieved from <http://outdooreducationaustralia.org.au/joe/>
- Graham, H. (2014). *Bruno Latour: Reassembling the political*. London: Pluto Press.
- Gray, J. (2014). The closed mind of Richard Dawkins. Retrieved 2017 from <https://newrepublic.com/article/119596/appetite-wonder-review-closed-mind-richard-dawkins>

- Green, B. (2015). Thinking bodies: Practice theory, Deleuze, and professional education. In B. Green & N. Hopwood (Eds.), *The body in professional practice, learning and education: Body/practice* (pp. 121-136). Switzerland: Springer.
- Gregg, M., & Seigworth, G. J. (Eds.). (2010). *The affect theory reader*. USA: Duke University Press.
- Grogan, S. (2016). *Body image: Understanding body dissatisfaction in men, women and children*. Oxon: Routledge.
- Gunn, J., & Candelaria, M. (Eds.). (2005). *Speculations on speculation: Theories of science fiction*. USA: The Scarecrow Press.
- Hall, S. (1992). The west and the rest: Discourse and power In S. Hall & B. Gieben (Eds.), *Formations of modernity: Understanding modern societies* (pp. 275-332). UK: The Open University.
- Haraway, D. (1987). A manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s. *Australian Feminist Studies*, 2(4), 1-42.  
doi:<http://dx.doi.org/10.1080/08164649.1987.9961538>
- Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies*, 14(3), 575-599. Retrieved from <http://www.feministstudies.org/home.html>
- Haraway, D. (2004). *The Haraway reader*. New York: Routledge.
- Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Durham: Duke University Press.

- Harding, S. (1991). *Whose science? Whose knowledge? Thinking from women's lives*. New York: Open University Press.
- Harrington, D. (2014). Science and Indigenous culture. Retrieved 2017 from <http://sydney.edu.au/science/outreach/inspiring/news/science-indigenous.shtml>
- Hickey-Moody, A. (2016). A femifesta for posthuman art education: Visions and becomings. In C. A. Taylor & C. Hughes (Eds.), *Posthuman research practices in education* (pp. 258-266). UK: Palgrave Macmillan.
- Higgins, M. (2016). Decolonizing school science: Pedagogically enacting agential literacy and ecologies of relationships. In C. A. Taylor & C. Hughes (Eds.), *Posthuman research practices in education* (pp. 186-205). UK: Palgrave Macmillan.
- Hinton, P. (2014). 'Situated knowledges' and new materialism(s): Rethinking a politics of location. *Women: A Cultural Review*, 25(1), 99-113.  
doi:<http://dx.doi.org/10.1080/09574042.2014.901104>
- Hinton, P., Mehrabi, T., & Barla, J. (2015). New materialisms/new colonialisms. Retrieved 2017 from [http://newmaterialism.eu/content/5-working-groups/2-working-group-2/position-papers/subgroup-position-paper--new-materialisms\\_new-colonialisms.pdf](http://newmaterialism.eu/content/5-working-groups/2-working-group-2/position-papers/subgroup-position-paper--new-materialisms_new-colonialisms.pdf)
- Hird, M. J. (2004). Feminist matters: New materialist considerations of sexual difference. *Feminist Theory*, 5(2), 223-232. doi:<http://dx.doi.org/10.1177/1464700104045411>
- Holland, E. W. (2013). *Deleuze and Guattari's a thousand plateaus*. UK: Bloomsbury.
- Horton, D. R. (1996). The AIATSIS map of Aboriginal Australia. Retrieved 2017 from <http://www.abc.net.au/indigenous/map/>

- Hostettler, N. (2012). *Eurocentrism: A Marxian critical realist critique*. New York: Taylor and Francis.
- Hughes, G. (2000). Marginalization of socioscientific material in science-technology-society science curricula: Some implications for gender inclusivity and curriculum reform. *Journal of Research in Science Teaching*, 37(5), 426-440. Retrieved from [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1098-2736](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-2736)
- Hughes, G. (2001). Exploring the availability of student scientist identities within curriculum discourse: An anti-essentialist approach to gender-inclusive science. *Gender and Education*, 13(3), 275-290. doi:<http://dx.doi.org/10.1080/09540250120063562>
- Indigenous Australia.info. (2017). Language groups. Retrieved 2017 from <http://www.indigenoustralia.info/languages/language-groups.html>
- Irzik, G. (2001). Universalism, multiculturalism, and science education. *Science Education*, 85(1), 71-73. doi:[http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1098-237X](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-237X)
- Islam, M. M. (2016). Posthumanism: Through the postcolonial lens. In D. Banerji & M. R. Paranjape (Eds.), *Critical posthumanism and planetary futures*. India: Springer.
- Ivinson, G., & Renold, E. (2013). Valleys' girls: Re-theorising bodies and agency in a semi-rural post-industrial locale. *Gender and Education*, 25(6), 704-721. doi:<http://dx.doi.org/10.1080/09540253.2013.827372>
- Jackson, A. Y. (2013). Data-as-machine: A Deleuzian becoming. In R. Coleman & J. Ringrose (Eds.), *Deleuze and research methodologies* (pp. 111-124). UK: Edinburgh University Press.

- Jackson, A. Y., & Mazzei, L. A. (2012). *Thinking with theory in qualitative research: Viewing data across multiple perspectives*. USA: Taylor and Francis.
- Jakober, M. (2008). The continuum of meaning: A reflection on speculative fiction and society. In L. Easton & R. Schroedder (Eds.), *The influence of imagination: Essays on science fiction and fantasy as agents of social change*. USA: McFarland & Company.
- Juelskjær, M. (2013). Gendered subjectivities of spacetime matter. *Gender and Education*, 25(6), 754-768. doi:<http://dx.doi.org/10.1080/09540253.2013.831812>
- Juelskjær, M., & Schwennesen, N. (2012). Intra-active entanglements – an interview with Karen Barad. *Kvinder, Kon & Forskning*, 10(1-2), 10-24. Retrieved from <https://tidsskrift.dk/index.php/KKF>
- Kaplan, S. (2017). Scientists create a part-human, part-pig embryo — raising the possibility of interspecies organ transplants. Retrieved 2017 from [https://www.washingtonpost.com/news/speaking-of-science/wp/2017/01/26/scientists-create-a-part-human-part-pig-embryo-raising-the-possibility-of-interspecies-organ-transplants/?utm\\_term=.7407dao4c167](https://www.washingtonpost.com/news/speaking-of-science/wp/2017/01/26/scientists-create-a-part-human-part-pig-embryo-raising-the-possibility-of-interspecies-organ-transplants/?utm_term=.7407dao4c167)
- Katahira, K., Moriwaki, H., Ishitake, M., Saito-Kokubu, Y., Yamazaki, H., & Yoshikawa, S. (2013). Nishiyama Reservoir: Lead sources, inventory, and the influence of the Nagasaki atomic bomb. *Soil and Sediment Contamination: An International Journal*, 22(8), 1003-1012. doi:<http://dx.doi.org/10.1080/15320383.2013.770440>
- Kelly, C. C. (2004). *Remembering the Manhattan project: Perspectives on the making of the atomic bomb and its legacy*. Singapore: World Scientific Publishing.

Kenway, J., Bullen, E., Fahey, J., & Robb, S. (2006). *Haunting the knowledge economy*. London: Routledge.

Kenway, J., & Youdell, D. (2011). The emotional geographies of education: Beginning a conversation. *Emotion, Space and Society*, 4(3), 131-136.  
doi:<http://dx.doi.org/10.1016/j.emospa.2011.07.001>

Klein, N. (2014). *This changes everything: Capitalism vs. the climate*. USA: Simon & Schuster.

Kleinman, A. (2012). Intra-actions. *Mousse*, 34, 76-81. Retrieved from  
<http://moussemagazine.it/>

Kuhn, T. S. (1996). *The structure of scientific revolutions* (Third ed.). USA: The University of Chicago Press.

Kusunoki, Y., & Hayashi, T. (2008). Long-lasting alterations of the immune system by ionizing radiation exposure: Implications for disease development among atomic bomb survivors. *International Journal of Radiation Biology*, 84(1), 1-14.  
doi:<http://dx.doi.org/10.1080/09553000701616106>

Lather, P., & St. Pierre, E. A. (2013). Post-qualitative research. *International Journal of Qualitative Studies in Education*, 26(6), 629-633.  
doi:<http://dx.doi.org/10.1080/09518398.2013.788752>

Latour, B. (1999). *Pandora's hope: Essays on the reality of science studies*. USA: Harvard University Press.

Latour, B. (2004). Why has critique run out of steam? From matters of fact to matters of concern. *Critical Inquiry*, 30(2), 225-248. Retrieved from  
<http://criticalinquiry.uchicago.edu/>

- Leavy, P. (2014). *Oxford handbook of qualitative research*. USA: Oxford University Press.
- Leavy, P. (2015). *Method meets art* (2 ed.). New York: Guilford Publications.
- Lederman, M. (2003). Gender/inequity in science education: A response. *Journal of Research in Science Teaching*, 40, 604-606. doi:<http://dx.doi.org/10.1002/tea.10100>
- Lederman, M., & Bartsch, I. (Eds.). (2001). *The gender and science reader*. London: Routledge.
- Lee, H., Yoo, J., Choi, K., Kim, S.-W., Krajcik, J., Herman, B. C., & Zeidler, D. L. (2013). Socioscientific issues as a vehicle for promoting character and values for global citizens. *International Journal of Science Education*, 35(12), 2079-2113. doi:<http://dx.doi.org/10.1080/09500693.2012.749546>
- Lewis, B. F., & Aikenhead, G. S. (2001). Introduction: Shifting perspectives from universalism to cross-culturalism. *Science Education*, 85(1), 3-5. doi:[http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1098-237X](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-237X)
- Link, B. G., & Phelan, J. C. (2014). Mental illness stigma and the sociology of mental health. In R. J. Johnson, R. J. Turner, & B. G. Link (Eds.), *Sociology of mental health: Selected topics from forty years 1970s-2010s* (pp. 75-100). Cham: Springer.
- Living Knowledge. (2008). About. Retrieved 2017 from <http://livingknowledge.anu.edu.au/html/background/index.htm>
- Lofts, G., & Evergreen, M. J. (2014). *Science quest 10 for Victoria* (Australian curriculum edition.). Australia: John Wiley & Sons Australia, Ltd.
- Lofts, G., & Evergreen, M. J. (2015). *Science quest 9 for Victoria* (Australian curriculum edition). Australia: John Wiley & Sons Australia, Ltd.

- Lorimer, J. (2013). More-than-human visual analysis: Witnessing and evoking affect in human-nonhuman interactions. In R. Coleman & J. Ringrose (Eds.), *Deleuze and research methodologies* (pp. 61-78). Edinburgh: Edinburgh University Press.
- Luukkala, B. B. (2014). *Exploring science through science fiction*. New York: Springer.
- MacLeod, K. (2014). Pre-service physics teachers' perceptions of teaching high school physics through a science, technology, society and environment (STSE) lens: Implications for physics and educational studies. *European Journal of Physics Education*, 5(1), 1-15.  
Retrieved from <http://dergipark.ulakbim.gov.tr/ejpe>
- MacLure, M. (2013). Researching without representation? Language and materiality in post-qualitative methodology. *International Journal of Qualitative Studies in Education*, 26(6), 658-667. doi:<http://dx.doi.org/10.1080/09518398.2013.788755>
- Maldonado, J. K., Colombi, B., & Pandya, R. (Eds.). (2014). *Climate change and indigenous peoples in the united states: impacts, experiences and actions*. Switzerland: Springer International Publishing.
- Mann, S. (2016). *The research interview: Reflective practice and reflexivity in research processes*. UK: Palgrave Macmillan.
- Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: country comparisons*.  
Retrieved from  
[http://www.acola.org.au/PDF/SAFo2Consultants/SAFo2\\_STEM\\_%20FINAL.pdf](http://www.acola.org.au/PDF/SAFo2Consultants/SAFo2_STEM_%20FINAL.pdf)
- Martin, B. (2012). Immaterial land. In E. Barrett & B. Bolt (Eds.), *Carnal knowledge: Towards a 'new materialism' through the arts* (pp. 185-204). London: I.B. Tauris & Co Ltd.

- Martin, E., & Hine, R. (2014). A dictionary of biology (6 ed.) Retrieved 2017 from <http://www.oxfordreference.com/view/10.1093/acref/9780199204625.001.0001/acref-9780199204625>
- Masny, D., & Waterhouse, M. (2011). Mapping territories and creating nomadic pathways with multiple literacies theory. *Journal of Curriculum Theorizing*, 27(3), 287-307. Retrieved from <http://journal.jctonline.org/>
- Massumi, B. (2015). *Politics of affect*. UK: Polity Press.
- Mazzei, L. A. (2013). Materialist mappings of knowing in being: Researchers constituted in the production of knowledge. *Gender and Education*, 25(6), 776-785.  
doi:<http://dx.doi.org/10.1080/09540253.2013.824072>
- McConney, A., Oliver, M., Woods-McConney, A., & Schibeci, R. (2011). Bridging the gap? A comparative, retrospective analysis of science literacy and interest in science for Indigenous and non-Indigenous Australian students. *International Journal of Science Education*, 33(14), 2017-2035. doi:<http://dx.doi.org/10.1080/09500693.2010.529477>
- McCosh, L. (2012). The sublime: Process and mediation. In E. Barrett & B. Bolt (Eds.), *Carnal knowledge: Towards a 'new materialism' through the arts*. London: I.B.Tauris & Co Ltd.
- McKinley, E., & Gan, M. J. S. (2014). Culturally responsive science education for indigenous and ethnic minority students. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (pp. 284-300). New York: Routledge.
- Michie, M. (2002). Why Indigenous science should be included in the school science curriculum. *Australian Science Teachers' Journal*, 48(2), 36-40. Retrieved from <http://nla.gov.au/anbd.bib-an2624433>

- Miller, P. H., Slawinski Blessing, J., & Schwartz, S. (2006). Gender differences in high-school students' views about science. *International Journal of Science Education*, 28(4), 363–381. doi:<http://dx.doi.org/10.1080/09500690500277664>
- Miyamoto, Y. (2015). Unbearable light/ness of the bombing: Normalizing violence and banalizing the horror of the atomic bomb experiences. *Critical Military Studies*, 1(2), 116-130. doi:<http://dx.doi.org/10.1080/23337486.2015.1050268>
- Mujawamariya, D., Hujaleh, F., & Lima-Kerckhoff, A. (2014). A reexamination of Ontario's science curriculum: Toward a more inclusive multicultural science education? *Canadian Journal of Science, Mathematics and Technology Education*, 14(3), 269-283. doi:<http://dx.doi.org/10.1080/14926156.2014.874618>
- MySchool. (2017). Retrieved from <https://www.myschool.edu.au/MoreInformation/About>
- MySchool. (n.d.). Retrieved 2017 from <https://www.myschool.edu.au/>
- Nakata, M. (2010). The cultural interface of Islander and scientific knowledge. *The Australian Journal of Indigenous Education*, 39(S1), 53-57. doi:<https://doi.org/10.1375/S132601100001137>
- NASA. (n.d.). “Quantum Artificial Intelligence Laboratory.” Retrieved 2017 from <https://ti.arc.nasa.gov/tech/dash/physics/quail/>
- Nash, D. (2009). Contingent, contested and changing: De-constructing Indigenous knowledge in a science curriculum resource from the South Coast of New South Wales. *The Australian Journal of Indigenous Education*, 38, 25-33. doi:<http://dx.doi.org/10.1375/S13260110000079X>

- Nasser, M. (2009). Science-technology-society (STS): A new paradigm in science education. *Bulletin of Science, Technology & Society*, 29(4), 287-297.  
doi:<http://dx.doi.org/10.1177/0270467609336307>
- Neimanis, A., Åsberg, C., & Hayes, S. (2015). Post-humanist imaginaries. In K. Backstrand & E. Lovbrand (Eds.), *Research handbook on climate governance* (pp. 480-490). UK: Edward Elgar Publishing Limited.
- Niccol, A. (Writer/Director). (1997). *Gattaca* [Motion picture]. In D. DeVito, M. Shamberg, S. Sher, & G. Lyon (Producers). USA: Columbia Pictures.
- Nicholas, B. (1999). Molecular geneticists and moral responsibility: "Maybe if we were working on the atom bomb I would have a different argument". *Science and Engineering Ethics*, 5(4), 515-530. Retrieved from <https://link.springer.com/journal/11948>
- NISEP. (2016). National Indigenous science education program. Retrieved 2017 from <http://nisep.com.au/>
- Nyström, E. (2009). Teacher talk: Producing, resisting and challenging discourses about the science classroom. *Gender and Education*, 21(6), 735-751.  
doi:<http://dx.doi.org/10.1080/09540250903119146>
- Pacini-Ketchabaw, V., Taylor, A., & Blaise, M. (2016). Decentring the human in multispecies ethnographies. In C. A. Taylor & C. Hughes (Eds.), *Posthuman research practices in education* (pp. 149-167). UK: Palgrave Macmillan.
- Parsons, E. C. (2014). Unpacking and critically synthesizing the literature on race and ethnicity in science education. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (pp. 167-186). New York: Routledge.

- Parsons, M., Rickard, G., Clarke, W., Devlin, J., Linstead, G., Madden, D., . . . Wood, R. (2016). *Pearson science s.b. 10* (2nd ed.). Melbourne, Victoria: Pearson Australia.
- Pedretti, E. G., Bencze, L., Hewitt, J., Romkey, L., & Jivraj, A. (2008). Promoting issues-based STSE perspectives in science teacher education: Problems of identity and ideology. *Science & Education*, 17(8-9), 941-960. doi:<http://dx.doi.org/10.1007/s11191-006-9060-8>
- Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, 95(4), 601-626 doi:<http://dx.doi.org/10.1002/sce.20435>
- Pike, F. (2016). The development of a death cult in 1930s Japan and the decision to drop the atom bomb. *Asian Affairs*, 47(1), 1-31. doi:<http://dx.doi.org/10.1080/03068374.2015.1128682>
- Pordzik, R. (2012). The posthuman future of man: Anthropocentrism and the other of technology in Anglo-American science fiction. *Utopian Studies*, 23(1), 142-161. Retrieved from [http://www.psupress.org/Journals/jnls\\_utopian\\_studies.html](http://www.psupress.org/Journals/jnls_utopian_studies.html)
- Post-qualitative research. (2013). *International Journal of Qualitative Studies in Education*, 26(6), 629-762. Retrieved from <http://www.tandfonline.com/loi/tqse20>
- Quigley, C. (2011). Pushing the boundaries of cultural congruence pedagogy in science education towards a third space. *Cultural Studies of Science Education*, 6(3), 549-557. doi:<http://dx.doi.org/10.1007/s11422-011-9335-5>
- Quinton, G., Cash, S., Tilley, C., & Craven, E. (2012). *Oxford big ideas science 10*. Victoria, Australia: Oxford University Press.
- Reed, B. C. (2014). *The history and science of the Manhattan Project* (Second Edition). Berlin: Springer.

- Richmond, G., Howes, E., Kurth, L., & Hazelwood, C. (1998). Connections and critique: Feminist pedagogy and science teacher education. *Journal of Research in Science Teaching*, 35(8), 897-918. Retrieved from [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1098-2736](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-2736)
- Rickard, G. (2012). *Pearson science 9 student book*. Australia: Pearson Australia.
- Rickard, G., Clarke, W., Devlin, J., Linstead, G., Madden, D., Parsons, M., . . . Wood, R. (2016<sup>a</sup>). *Pearson science s.b. 9* (2nd ed.). Melbourne, Victoria: Pearson Australia.
- Rickard, G., Devlin, J., Linstead, G., Madden, D., Parsons, M., Salfinger, L., . . . Wood, R. (2016<sup>b</sup>). *Pearson science s.b. 7* (2nd ed.). Melbourne, Victoria: Pearson Australia.
- Roughgarden, J. (2004). *Evolution's rainbow: Diversity, gender and sexuality in nature and people*. USA: University of California Press.
- Roughgarden, J. (2009). *The genial gene: Deconstructing Darwinian selfishness*. USA: University of California Press.
- Rule, S., Brook, B. W., Haberle, S. G., Turney, C. S. M., Kershaw, A. P., & Johnson, C. N. (2012). The aftermath of megafaunal extinction: Ecosystem transformation in Pleistocene Australia. *Science*, 335(6075), 1483-1486. doi:<http://dx.doi.org/10.1126/science.1214261>
- Ruzek, J. (2014). *"The trace beyond the human:" Exploring nonhuman otherness and human exceptionalism in contemporary and popular literatures*. (Unpublished Doctoral dissertation). University of Lethbridge, Canada.
- Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: The effects of content knowledge and morality. *International Journal of Science Education*, 28(12), 1463-1488. doi:<http://dx.doi.org/10.1080/09500690600708717>

- Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, 88(1), 4-27  
doi:<http://dx.doi.org/10.1002/sce.10101>
- Salite, I., Drelinga, E., Ilisko, D., Olehnovica, E., & Zarina, S. (2016). Sustainability from the transdisciplinary perspective: An action research strategy for continuing education program development. *Journal of Teacher Education for Sustainability*, 18(2), 135-152.  
doi:<http://dx.doi.org/10.1515/jtes-2016-0020>
- Schadler, C. (2014). Key practices of the transition to parenthood: The everyday figuration of parents' and children's bodies and personalities through the lens of a new materialist ethnography. *Current Sociology*, 62(1), 114-131.  
doi:<http://dx.doi.org/10.1177/0011392113503575>
- Schibuk, E. (2015). Teaching the Manhattan project: Bringing literacy in civic science to the chemistry class. *The Science Teacher*, 82(7), 27-33. Retrieved from  
<https://www.jstor.org/journal/scienceteacher>
- Schneider, J. (2005). *Donna Haraway: Live theory*. London: Continuum.
- Science Wars. (1996). *Social Text*. 46/47, 1-252. Retrieved from  
<http://socialtext.dukejournals.org/>
- Scott, S., & Griffiths, M. (2016). 'Brain drain' ahead with scientists leaving laboratories in droves: Deloitte report. Retrieved from <http://www.abc.net.au/news/2016-11-07/lack-of-funding-sees-scientists-leaving-labs-in-droves/7996604>
- Semali, L. M., & Kincheloe, J. L. (Eds.). (2002). *What is indigenous knowledge? Voices from the academy*. London: Taylor and Francis.

- Shibley, I. A. (2003). Using newspapers to examine the nature of science. *Science & Education*, 12, 691–702. Retrieved from <http://link.springer.com/journal/11091>
- Shulman, B. J. (2001). Implications of feminist critiques of science for the teaching of mathematics and science. In M. Lederman & I. Bartsch (Eds.), *The gender and science reader* (pp. 407-422). London: Routledge.
- Silvester, H. (2016<sup>a</sup>). *Oxford science 7: Victorian curriculum*. Australia: Oxford University Press.
- Silvester, H. (2016<sup>b</sup>). *Oxford science 9: Victorian curriculum*. Australia: Oxford University Press.
- Silvester, H. (2016<sup>c</sup>). *Oxford science 10: Victorian curriculum*. Australia: Oxford University Press.
- Singer, A. (2013). Enough is enough — Pearson education fails the test again and again. Retrieved 2017 from [http://www.huffingtonpost.com/alan-singer/enough-is-enough-pearson-b\\_3146434.html](http://www.huffingtonpost.com/alan-singer/enough-is-enough-pearson-b_3146434.html)
- Smith, D. A. (2009). Reaching nonscience students through science fiction. *The Physics Teacher*, 47, 302-305. doi:<http://dx.doi.org/10.1119/1.3116843>
- Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, 85, 6-34. Retrieved from [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1098-237X](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1098-237X)
- Somerville, M. (2014). Developing relational understandings of water through collaboration with indigenous knowledges. *Wiley Interdisciplinary Reviews: Water*, 1(4), 401-411. doi:<http://dx.doi.org/10.1002/wat2.1030>
- Somerville, M., & Green, M. (2015). *Children, place and sustainability*. UK: Palgrave Macmillan.

- Sonu, D., & Snaza, N. (2015). The fragility of ecological pedagogy: Elementary social studies standards and possibilities of new materialism. *Journal of Curriculum and Pedagogy*, 12(3), 258-277. doi:<http://dx.doi.org/10.1080/15505170.2015.1103671>
- Sullivan, N. (2012). The somatechnics of perception and the matter of the non/human: A critical response to the new materialism. *European Journal of Women's Studies*, 19(3), 299-313. doi:<http://dx.doi.org/10.1177/1350506812443477>
- Sundberg, J. (2014). Decolonizing posthumanist geographies. *Cultural Geographies*, 21(1), 3-47. doi:<http://dx.doi.org/10.1177/1474474013486067>
- Suvin, D. (2005). Estrangement and cognition. In J. Gunn & M. Candelaria (Eds.), *Speculations on speculation: Theories of science fiction* (pp. 23-36). USA: The Scarecrow Press.
- Suzuki, S. (2008). *Posthuman visions in postwar U.S. and Japanese speculative fiction: Re(con)figuring western (post)humanism*. (Unpublished Doctoral dissertation). University of California, USA.
- Taguchi, H. L., & Palmer, A. (2013). A more 'livable' school? A diffractive analysis of the performative enactments of girls' ill-/well-being with(in) school environments. *Gender and Education*, 25(6), 671-687. doi:<http://dx.doi.org/10.1080/09540253.2013.829909>
- Takeuchi, M., & Taguchi, M. (2015). Second-generation survivors of the atomic bomb. *Bulletin of the Atomic Scientists*, 71(4), 1-9. doi:<http://dx.doi.org/10.1177/0096340215590797>
- Taylor, C. A. (2013). Objects, bodies and space: Gender and embodied practices of mattering in the classroom. *Gender and Education*, 25(6), 688-703. doi:<http://dx.doi.org/10.1080/09540253.2013.834864>

- Taylor, C. A. (2016). Edu-crafting a cacophonous ecology: Posthumanist research practices for education. In C. A. Taylor & C. Hughes (Eds.), *Posthuman research practices in education* (pp. 5-25). UK: Palgrave Macmillan.
- Taylor, C. A., & Hughes, C. (Eds.). (2016). *Posthuman research practices in education*. UK: Palgrave Macmillan.
- Taylor, C. A., & Ivinson, G. (2013). Material feminisms: New directions for education. *Gender and Education*, 25(6), 665-670. doi:<http://dx.doi.org/10.1080/09540253.2013.834617>
- Thiele, K. (2014). Pushing dualisms and differences: From 'equality versus difference' to 'nonmimetic sharing' and 'staying with the trouble'. *Women: A Cultural Review*, 25(1), 9-26. doi:<http://dx.doi.org/10.1080/09574042.2014.901110>
- Thomas, A. C. (2015). Indigenous more-than-humanisms: Relational ethics with the Hurunui River in Aotearoa New Zealand. *Social & Cultural Geography*, 16(8), 974-990. doi:<http://dx.doi.org/10.1080/14649365.2015.1042399>
- Thompson, G., & Cook, I. (2014). Manipulating the data: Teaching and NAPLAN in the control society. *Discourse: Studies in the Cultural Politics of Education*, 35(1), 129-142. doi:<http://dx.doi.org/10.1080/01596306.2012.739472>
- Transversal practices (n.d.). Transversal practices: Matter, ecology and relationality VI conference on new materialisms. Retrieved 2016 from <http://www.newmats2015.net/about.html>
- Tsai, C.-C. (2002). A science teacher's reflections and knowledge growth about STS instruction after actual implementation. *Science Education*, 86, 23-41. doi:<http://dx.doi.org/10.1002/sce.10006>

- Tsai, C.-C., & Liu, S.-Y. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education*, 27(13), 1621-1638. doi:<http://dx.doi.org/10.1080/09500690500206432>
- Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future*. Retrieved 2017 from <http://research.acer.edu.au/cgi/viewcontent.cgi?article=1002&context=aer>
- USDA. (2016). *Biotechnology regulatory services (BRS)*. Retrieved from <https://www.aphis.usda.gov/aphis/ourfocus/biotechnology>
- Vrasidas, C., Avraamidou, L., Theodoridou, K., Themistokleous, S., & Panaou, P. (2015). Science fiction in education: Case studies from classroom implementations. *Educational Media International*, 52(3), 201-215. doi:<http://dx.doi.org/10.1080/09523987.2015.1075102>
- Wagner-Lawlor. (2011). Doomed by hope: Environmental disaster and the 'structured ignorance' of risk in Margaret Atwood's speculative fiction. *Arena Journal*, 35/36, 173-195. Retrieved from <https://arena.org.au/category/arena-journal/>
- Walker, R. L. (2014). The living present as a materialist feminist temporality. *Women: A Cultural Review*, 25(1), 40-61. doi:<http://dx.doi.org/10.1080/09574042.2014.901107>
- Wallace, J. (2010). Literature and posthumanism. *Literature Compass*, 7/8, 692-701. doi:<http://dx.doi.org/10.1111/j.1741-4113.2010.00723.x>
- Wan, Z. H., Wong, S. L., & Hin Wai Yung, B. (2011). Common interest, common visions? Chinese science teacher educators' views about the values of teaching nature of science

- to prospective science teachers. *Science Education*, 95(6), 1101-1122.  
doi:<http://dx.doi.org/10.1002/sce.20451>
- Wan, Z. H., Wong, S. L., & Zhan, Y. (2013). When nature of science meets Marxism: Aspects of nature of science taught by Chinese science teacher educators to prospective science teachers. *Science & Education*, 22(5), 1115-1140. doi:<http://dx.doi.org/10.1007/s11191-012-9504-2>
- Watson, A., & Huntington, O. (2014). Transgressions of the man on the moon: Climate change, indigenous expertise, and the posthumanist ethics of place and space. *GeoJournal*, 79, 721-736. doi:<http://dx.doi.org/10.1007/s10708-014-9547-9>
- Wetherell, M. (2013). Affect and discourse – what’s the problem? From affect as excess to affective/discursive practice. *Subjectivity*, 6(4), 349-368.  
doi:<http://dx.doi.org/10.1057/sub.2013.13>
- Whap, G. (2001). A Torres Strait Islander perspective on the concept of Indigenous knowledge. *The Australian Journal of Indigenous Education*, 29(2), 22-29.  
doi:<http://dx.doi.org/10.1017/S132601100001368>
- Wilkie, A., Savransky, M., & Rosengarten, M. (2017). *Speculative research: The lure of possible futures*. Oxon, UK: Routledge.
- Williamson, K., & Garton, A. (2011<sup>a</sup>). *Science essentials 7*. Victoria, Australia: Macmillan Education Australia.
- Williamson, K., & Garton, A. (2011<sup>b</sup>). *Science Essentials 8*. Melbourne, Australia: Macmillan Education Australia.

- Williamson, K., & Garton, A. (2011<sup>c</sup>). *Science essentials 9*. Australia: MacMillan Education Australia.
- Williamson, K., & Garton, A. (2011<sup>d</sup>). *Science essentials 10*. Australia: MacMillan Education Australia.
- Wilson, R. E., & Kittleson, J. (2013). Science as a classed and gendered endeavor: Persistence of two white female first-generation college students within an undergraduate science context. *Journal of Research in Science Teaching*, 50(7), 802–825.  
doi:<http://dx.doi.org/10.1002/tea.21087>
- Woinarskia, J. C. Z., Burbidge, A. A., & Harrison, P. L. (2015). Ongoing unraveling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Sciences of the United States of America*, 112(15), 4531–4540. doi:<http://dx.doi.org/10.1073/pnas.1417301112>
- Wolfe, C. (2010). *What is posthumanism?* USA: University of Minnesota Press.
- Wolfe, M. J. (2016). Refracting schoolgirls: Pedagogical intra-actions producing shame. *Discourse: Studies in the Cultural Politics of Education*, 1–13. doi:  
<http://www.tandfonline.com/doi/full/10.1080/01596306.2016.1143451>
- Yeung, C. L., & Grace, M. (2012). Students' reasoning and decision making about a socioscientific issue: A cross-context comparison. *Science Education*, 96(5), 787–807.  
doi:<http://dx.doi.org/10.1002/sce.21021>
- Yunupingu, D., & Muller, S. (2009). Cross-cultural challenges for Indigenous sea country management in Australia. *Australasian Journal of Environmental Management*, 16(3), 158–167. doi:<http://dx.doi.org/10.1080/14486563.2009.9725232>

- Yoruk, N., Morgil, I., & Segken, N. (2010). The effects of science, technology, society, environment (STSE) interactions on teaching chemistry. *Natural Science*, 2(12).  
doi:<http://dx.doi.org/10.4236/ns.2010.212173>
- Zeidler, D. L., & Sadler, T. D. (2008). Social and ethical issues in science education: A prelude to action. *Science & Education*, 17, 799–803. doi:<http://dx.doi.org/10.1007/s11191-007-9130-6>
- Zeidler, D. L., Herman, B. C., Ruzek, M., Linder, A., & Lin, S.-S. (2013). Cross-cultural epistemological orientations to socioscientific issues. *Journal of Research in Science Teaching*, 50(3), 251-283. doi:<http://dx.doi.org/10.1002/tea.21077>
- Zeimbicki, M. R., Woinarski, J. C. Z., & Mackey, B. (2013). Evaluating the status of species using Indigenous knowledge: Novel evidence for major native mammal declines in northern Australia. *Biological Conservation*, 157, 78-92.  
doi:<http://dx.doi.org/10.1016/j.biocon.2012.07.004>

APPENDICES

APPENDIX 1: RECRUITMENT MATERIALS

**EXPLANATORY STATEMENT**

Project: Pre-Service Teachers' Views about Science and Ethics

**Chief Supervisor's name**

Professor Jane Kenway

Faculty of Education

Phone: [redacted]

email: jane.kenway@monash.edu

**Student Researcher's name**

Blue Mahy

Faculty of Education

Phone: [redacted]

email: blue.mahy@monash.edu

You are invited to take part in this study. Please read this Explanatory Statement and the Consent Form in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

**What does the research involve?**

This study will be conducted by Blue Mahy towards the completion of a Doctor of Philosophy (PhD) degree.

The aim of this study is to gain understanding of pre-service teachers' views on science and ethics, as well as how they develop their views. Additionally, understanding will be sought regarding if and how gender might contribute to pre-service teachers' views about science and ethics.

Participants in this study will be asked to be involved in two individual semi-structured interviews. The first interview will involve a short questionnaire for the participants to fill out before they will be asked questions about two topics related to science and ethics: genetically modified human embryos and renewable energy (wind farms). Following this, the participants will be asked to complete a short activity by writing on cards what aspects of their background and education have most influenced their responses to the previous questions. Lastly, this activity will be followed up by general questions about their backgrounds and education history. Following this interview, participants' will receive by e-mail and be asked to read a summary of data analysis concerning the first interview. The second interview will provide the opportunity for the participants to give feedback on the data analysis as it relates to them and to amend or change any of their responses from the first interview.

Each interview is expected to last between 1 and 2 hours, and time taken to read the analysis is expected to take no longer than 30 minutes. The maximum time for participation is approximately 5 hours. The interviews will be conducted over a period of approximately four months at Monash University, Clayton.

### **Why were you chosen for this research?**

You were chosen for this project because you are a second, third or fourth year Bachelor of Education student. You were also chosen because you have provided your e-mail to the researcher to indicate interest in participating.

### **Consenting to participate in the project and withdrawing from the research**

In signing the consent form you are consenting to participate in this research and to having information from you and about you being collected and stored for a period of five years.

You have the right to withdraw from the project at any time, for any reason, and for information about you to be destroyed up until that information is published and out of the researchers' control.

### **Possible benefits and risks to participants**

The aim of this research project is to understand pre-service teachers' views about science and ethics and how this might have consequences or implications for teacher education, teaching methods as well as broader socio-political consequences. The anticipated benefits for participants could be having the opportunity to be involved in research that may benefit their understanding of research in general, as well as being introduced to the opportunities and practices around research in education as it functions in relationship with teachers in the field. Another possible benefit is for the participants to have the opportunity to reflect on themselves as teachers and how their backgrounds, experiences and beliefs does or does not affect their identity and practices as teachers.

It is estimated that there will be little inconvenience, discomfort or risk of harm to participants in this project. Participants will be informed of each step and at all times have the right to withdraw from the data collection process for any reason, without any negative repercussions or disadvantages. While the use of pseudonyms and other measures will be taken to provide participant anonymity, it is however possible due to the small size of the participant group, members of which are likely to be known to each other, that full anonymity cannot be guaranteed. Therefore, there is a minor risk of discomfort if the participant is inadvertently identified in publication of the results of this project.

There is additionally some risk of discomfort during the interviews. This includes the possibility of at times broaching personal topics or issues.

### **Services on offer if adversely affected**

<http://www.monash.edu.au/counselling/>

<http://www.beyondblue.org.au/>

<https://www.lifeline.org.au/>

### **Payment**

In recognition of your valuable time given to this project, you will receive one movie voucher OR a \$20 Coles Group & Myer gift card at the conclusion of the second interview.

### **Confidentiality**

Research from this study will be published in academic articles, a dissertation and academic conference presentations. All means possible will be applied to ensure participants' anonymity, including the replacement of any real names of people and places with pseudonyms.

### **Storage of data**

Identifiable data collected will be stored in a locked filing cabinet on Monash University premises for a period of 5 years, in accordance with Monash University regulations. Data will be protected by password access and in a locked Monash University office. It will also only be accessed by the researchers involved in this project. Participants will only have access to the data collected about themselves.

### **Results**

The results of this research project are intended to be published in a dissertation and may also be published in a journal article and presented during conference presentations. Participants can request to receive the results from Blue Mahy [REDACTED]

### **Complaints**

Should you have any concerns or complaints about the conduct of the researcher, you are welcome to contact the researcher's main supervisor, Professor Jane Kenway, or alternatively the **Executive Officer, Monash University Human Research Ethics (MUHREC)**:

Executive Officer  
Monash University Human Research Ethics Committee (MUHREC)  
Room 111, Building 3e  
Research Office  
Monash University VIC 3800

Tel: +61 3 9905 2052      Email: [muhrec@monash.edu](mailto:muhrec@monash.edu)

Fax: +61 3 9905 3831

Thank you,



**Chief Investigator's name**

Blue Mahy

## CONSENT FORM

**Project:** Pre-Service Teachers' Views about Science and Ethics

**Chief Investigator:** Blue Mahy

This consent form is for the purposes of a PhD research project, please read it in full before signing.

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement concerning what this project is about and I hereby voluntarily consent to participate in this project.

I consent to the following:	Yes	No
Participation in a semi-structured audio recorded interview about my opinions on two science and ethics topics and my education and personal history/background.	<input type="checkbox"/>	<input type="checkbox"/>
Participation in reading a data analysis summary from information I provided in the first interview.	<input type="checkbox"/>	<input type="checkbox"/>
Participation in a semi-structured audio recorded interview about my response and feedback to the data analysis summary	<input type="checkbox"/>	<input type="checkbox"/>
That the data I provide may be published in a thesis, article or conference presentations, which will not include identifiable information.	<input type="checkbox"/>	<input type="checkbox"/>
The data that I provide may be used in future projects/research.	<input type="checkbox"/>	<input type="checkbox"/>

I understand I have the right to withdraw from the project for any reason without any negative consequences or disadvantages.

I understand that I can request to view/read data (e.g. interview transcript) I have provided and ask for any or all data I have provided to be withdrawn and destroyed before publication.

Name of Participant \_\_\_\_\_

Participant Signature \_\_\_\_\_ Date \_\_\_\_\_

---

APPENDIX 2: INTERVIEW MATERIALS

---

SURVEY 1

Research Project: Pre-Service Teachers' Views about Science and Ethics

Participant Questionnaire

Name (will be kept confidential): \_\_\_\_\_

Age: \_\_\_\_\_

Nationality: \_\_\_\_\_

Country of birth: \_\_\_\_\_

Religion/Spirituality: \_\_\_\_\_

Gender Identity: \_\_\_\_\_

What [university name redacted] course are you doing? \_\_\_\_\_

What year level are you in? \_\_\_\_\_

Which [university name redacted] education subject(s) are you mainly interested in?

---

---

---

Which subject(s) are you mainly intending on teaching?

---

---

---

---

SURVEY 2

Participant Questionnaire 2

Name: \_\_\_\_\_

Primary School Name(s):

---

---

Secondary School Name(s):

---

---

Places you have lived:

---

---

---

---

## QUESTION GUIDE/PROMPTS

### SESSION ONE

#### Genetically Modified Humans

What is your opinion about scientists developing the technology for genetically modified humans?

Could you take a guess on why people might hold the opposite opinion to you?

How would you describe how your education background might have influenced your opinion on this topic?

How would you describe how your general background (that is, your upbringing, your family and so on) might have influenced your view on this topic?

If you were to run a [year level] class on genetically modified humans, how would you go about it?

#### Wind Farms

What is your opinion about the development and use of wind farms?

Could you take a guess on why people might hold the opposite opinion to you?

How would you describe how your education background has influenced your opinion on wind farms?

How would you describe how your background (upbringing, family etc...) has influenced your position on this topic?

If you were to run a [year level] class on this topic, how would you go about it?

#### General Science & Technology

In general, how interested are you in science and technology?

What do you find most interesting about science & technology?

Do you believe science is more of a good or bad influence on the world?

How would you describe what the main aims are of scientific development/progress?

How would you describe the relationship between ethics and science? Is every bit of science ethical?

Should scientists and science teachers learn about ethics?

Should humanities teachers know and teach about science and ethics?

How would you explain the relationship between gender and science?

Do you believe certain kinds of people are more likely to do science and if so why?

### Primary Education

How would you describe your primary school(s) in general?

How would you generally describe your experience of primary school?

What did you most/least like about primary school?

Please describe your experience learning science in primary school?

I'd like you to describe a scientific/science-related assignment or project you had to do and what you thought of it.

Is primary school a good place for students to start learning about science, technology and ethics?

### Secondary Education

How would you describe your secondary school(s) in general?

How would you describe your experience of secondary school?

What did you most/least like about secondary school?

Please describe your experience learning science in secondary school?

Was science compulsory for you and if so, how long for?

Tell me about any science electives you took, why you chose them and your experience of them?

Tell me about what you most/least enjoyed about science in secondary school?

Please describe how science was advertised or dealt with at your school and how important it was considered to be?

Did you ever do a project or learn about socioscientific issues, or ethical science issues, such as climate change or the use of nanotechnology etc?

### Tertiary Education (And Australian Curriculum)

How would you describe your experience of undertaking the Bachelor of Education?

What led to your choice to undertake this course?

Why do you want to be a teacher? What sort of teacher do you see yourself being?

What is your main aim as a teacher?

Please explain what in your life has led you to be interested in [discipline]?

Could you please explain how much you know about the Australian secondary curriculum's guides on ethical and moral development for students?

How have you experienced learning about the curriculum?

What do you think about the inclusion of ethical development of students in the Australian curriculum?

Overall, how important do you think getting students to learn about understanding the impacts of science and technology – how they change the world – is?

If you had to run a general lesson on science and ethics, how would you do so and what would you focus on?

### Informal Education

Please describe times when you learned about science outside of school?

What aspect of your life outside formal education gave you the best or most rewarding understanding of science?

Who outside of formal education has contributed anything to your knowledge about science?

Has religion or spirituality played a large part in your life? Relationship to science? Relationship to ethics - science?

What kind of science related issues did your family discuss together?

Please describe your experience with science museums or other science related events or places?

What books, films, TV shows or documentaries have influenced how you think about science? What kind of books etc do you enjoy?

Have you done much travelling? How has this influenced you as a person?

---

SESSION TWO

QUESTION PROMPTS

---

Secondary School Textbooks

Do you remember the brand of science textbooks you used in high school?

How would you generally describe your experience of these textbooks?

Do you remember anything specific from them that has stuck with you?

Do you remember learning anything about the relationship between science and society in these textbooks?

What about ethics in science or any ethical issues?

Other

Do you have a teaching mentor? If so, how did this relationship develop? How does your mentor support you?

How would you describe where you situate yourself on the political spectrum?

Can you describe to me your daily life that relations to science and technology? For instance, do you have a smartphone, what kind is it, how often do you use it? What kind of computer do you have? Etc.

Have you had any thoughts about our last interview at all? Anything you remember saying that you would amend or something you want to add that you didn't say?



APPENDIX 3: ANALYSIS EXAMPLES

REPORTS

*STEM: Country Comparisons (Marginson et al., 2013)*

<i>Example:</i>	Extract	Page Number
<i>Economic imperative</i>	‘...governments want to lift the overall scientific literacy of their populations and to draw most students or all students into senior secondary school studies in STEM (‘science for all’). Hence the centrality of STEM. The STEM disciplines are seen as essential for work and citizenship, while providing the cut through in global economic competition and social creativity’	14
	‘The interest of international organisations in both education and the labour market in STEM fields is closely tied to an overall economic agenda. This is based on research that connects cognitive ability levels in the population, as measured by tests of scientific, mathematical and reading literacy, to long-term economic growth and competitive advantage. In this argument, economic growth signifies the overall wellbeing of the population and not simply the wealth of the economy’	58
	‘We need to persuade more young Australians to aspire to science and mathematics because learning in those fields is economically and socially useful, and intrinsically worthwhile, and a powerful intellectual formation that can be foundational to many different kinds of individual achievement’	69
	‘National STEM or science and technology policy is generally conceived in human capital terms. Emphasis on the ‘pipeline’ of school and tertiary	94

	STEM education is frequently motivated by issues concerning the STEM labour force’	
	‘Improvements in participation and performance in STEM are seen to enhance human capital and innovation, thereby lifting national economic growth and international competitiveness’	140
	<i>Re-imagining science education (Tytler, 2007)</i>	
<i>Example: ‘Humanistic’ science education</i>	‘This is consistent with the views of Aikenhead (2006) who argues that there is abundant evidence that traditional school science is not meeting the needs of students, and that curricula with the characteristics he identifies with humanistic science are of more interest’	10
	‘Aikenhead (2006) labels this the ‘pipeline’ version of the science curriculum providing training for future science professionals, as opposed to a humanistic version that would present science more broadly as a human endeavour rather than a technical disciplinary training’	19
	‘Instead, the informants emphasised the need to develop in students a positive view of science that disposes them, on leaving school, to engage with science ideas and developments. This position is consistent with a ‘humanistic’ perspective on school science (Aikenhead, 2006; Fensham, 2006)’	19
	Calls for a science literacy perspective, or a humanistic perspective, have in common a focus on students’ understanding how science works – the nature of science and its processes – as well as the content of science.	23

	‘Aikenhead (2006, p. 33) argues that canonical science content is the wrong type of content to use in most socio-scientific settings. He argues for knowledge about science and scientists as an important aspect of a humanistic science curriculum’	30
<i>Example:</i>	‘While there are potentially many implications to be drawn from this for the contemporary science curriculum, Ziman’s particular focus was the need for scientists to explicitly acknowledge the ethical implications of their work, something that science has traditionally eschewed in its maintenance of a disinterested ethical position in regard to knowledge production’	23
<i>Social/ethical dimension</i>	‘A second set of themes which more than half of the expert participants judged to warrant inclusion in the curriculum included (p. 713) links with technology, moral and ethical dimensions, the empirical base of scientific knowledge, and the cumulative and revisionary nature of scientific knowledge’	26
	‘...study described earlier emphasised the importance of scientists having the ability to communicate effectively to multiple audiences, to be able to work in multi-disciplinary teams, to have well-developed analytical thinking skills, to understand the social and ethical context in which they work and to have developed the desire and ability to be lifelong learners’	28
	‘These indicated a need to rethink the nature of the science degree, as the major component of secondary science teacher education, such that it represented a more contemporary view of the	58

practice of science, including the social and ethical implications of science’

‘Greater attention needs to be paid to the workings of science in contemporary society, including sociological and epistemic aspects. That is to say, the curriculum should strongly represent the way science interacts with society and technology and include concepts such as risk and questions of value and ethics’

---

TEXTBOOKS

*Science Quest 10 for Victoria (Lofts & Evergreen, 2014)*

<p><i>Example:</i></p> <p><i>Anthropocentrism</i></p> <p><i>(general)</i></p>	<p>Some of the ways in which wild species affect our lives are described below. 119</p> <ul style="list-style-type: none"> <li>• Wild plant and animal species provide a source of wonder and beauty for large numbers of people.</li> <li>• Rainforests provide a huge store of untapped genetic material, much of which may be useful to humans.</li> </ul> <p>[...]</p> <ul style="list-style-type: none"> <li>• Most of our modern crop plants were domesticated from wild plants. With the increase in the world's population, finding suitable food crops from wild species may well be an issue in the future.</li> <li>• Wild species help to recycle nutrients in the soil, providing us with fertile soil for crop growth.</li> </ul>
---	---

*Science Essentials 7 (Williamson & Garton, 2011<sup>a</sup>)*

Our resources are economically important because they can be used to make money and produce wealth for the country. The wealth of a country often depends on both the natural resources it has and the resources it is able to manufacture and sell overseas. 204

Using our resources 215

So far we know that resources:

- can come from living or non-living things
- are often processed to make them more useful
- are economically useful
- can often be recycled
- can be used to make synthetic materials
- can be renewable or non-renewable.

*Science Essentials 8 (Williamson & Garton, 2011<sup>b</sup>)*

Our supplies of fossil fuels are very limited and it makes much better sense to use renewable energy sources that can be replaced. 176

*Science Essentials 9 (Williamson & Garton, 2011<sup>c</sup>)*

Australia is a large country with few people. The cities, power stations and industrial centres are a long way apart. So any pollutants released into the air are soon spread out and don't become a problem.

The use of pig organs in humans is also being investigated. Pig cells contain a gene that causes the human body to reject them, but scientists have found a way to remove this gene. However, the issue of transferring pig viruses to humans is a concern to many people. 80

*Nelson iScience for the Australian Curriculum 7 (Bishop et al., 2012)*

Which energy resource is better for our long-term 80  
future? [...] Some of these resources will not run out,  
but some are in limited supply and we need to be  
careful how we use them if we want them to last  
beyond our lifetime.

*Nelson iScience for the Australian Curriculum 10 (Champion et al., 2012)*

Fossil fuels are a finite resource. They take millions of 139  
years to form, and the supply is being used at a rate  
that has many scientists predicting we will run out by  
the middle of this decade. Consequently, scientists  
are undertaking research to develop alternative fuels.

*Oxford Big Ideas Science 7 (Cash et al., 2011)*

Our supply of energy resources is running out, so we 195  
need to consider how we use energy more carefully  
now so that there is enough energy in the future.

One of the products of nuclear fission is radioactive 198  
waste. Countries that have developed nuclear power  
need to manage this waste. The waste needs to be  
stored or disposed of to keep it secure and isolated  
from people.

*Oxford Science 7: Victorian Curriculum (Silvester, 2016<sup>a</sup>)*

Humans have always relied on the natural resources 78  
of the Earth – in the air, the water and the ground.  
Oxygen and water are essential for keeping us alive.  
Soil is necessary for us to grow food for ourselves and  
our livestock. Minerals from the Earth that feed the  
mining industry are essential to manufacturing and  
to Australia's economy.

*Pearson Science 9 S.B. (Rickard et al., 2016<sup>a</sup>)*

Four reasons for protecting ecosystems are: 366-367

Cultural value: some species have a value as part of the way of life of a country or region. For example, a kangaroo, emu and golden wattle are included in the Australian coat of arms [...]

Economics: Some plants and animals have an economic or financial value. People can make money from ecosystems in many ways. For example, many tourists want to see untouched ecosystems and so these ecosystems provide income and jobs. Harvesting from the wild or farming species such as eucalyptus trees, prawns or kangaroos also creates wealth. New pharmaceutical drugs are still being discovered using plants that had not been previously tested. Some animals could be possible biological agents for controlling new pests.

*Science Quest 9 for Victoria (Lofts & Evergreen, 2015)*

*Example:* By controlling the conditions in which embryonic stem cells are grown, scientists can either keep them unspecialised or encourage them to differentiate into a specific type of cell [...] Imagine being able to cure paralysis or spinal cord injury. In the future, stem cells may also be used to treat and cure Alzheimer’s disease, motor neurone disease, Parkinson’s disease, diabetes and arthritis. 139

*Anthropocentrism*  
*(positives of science/technology first)*

*Science Quest 10 for Victoria (Lofts & Evergreen, 2014)*

Is artificial evolution of our species possible? DNA technology, drugs and implants for existing or experimental therapies could make this a reality. We can already insert new genes into various parts of the adult human body. In the future, this may also include gametes and embryos. We have the 289

technology to cut and paste various genetic sequences, not only within the same species, but between species. How might these modifications affect future generations?

It is believed that biotechnology promises the greatest revolution in human history. The commercialisation of molecular biology has occurred with astonishing speed and is considered to be the most stunning ethical event in the history of science. 290

Scientists have already designed artificial cells. One of these is an artificial red blood cell. These tiny machines carry stores of oxygen and carbon dioxide with sensors to detect levels of these gases. When levels of oxygen are low they release oxygen, and when carbon dioxide levels are high they absorb carbon dioxide. These artificial cells are around 200 times more efficient than our current red blood cells; this may allow us to swim underwater or sprint for 15 minutes without needing to take a breath. 299

Nanoscaffolds could be implanted into different parts of the body to encourage the regrowth of damaged tissue [...] What will future production factories look like? Imagine millions of tiny robots working together on an invisible, submicroscopic production line. 300

*Science Essentials 7 (Williamson & Garton, 2011<sup>a</sup>)*

The future of gene technology 241

Here are three examples of transgenic organisms.

<sup>1</sup> Cotton is grown in Australia but it has to be sprayed with large amounts of pesticide to kill the

caterpillars that feed on it. Genetic engineers have developed a genetically modified cotton called Bt cotton. It contains a gene from a naturally occurring bacterium called Bt. This gene produces a protein in the cotton that kills the caterpillars when they eat it, so less pesticide is needed.

2 Some of the foods we eat are made using imported soya beans produced by plants genetically engineered not to be killed by weed killers.

Scientists have also successfully bred frost-resistant tomatoes. They did this by inserting into the tomatoes ‘anti-freeze’ genes from North Atlantic fish that live in subzero waters. These new tomatoes have not been released for sale because many people are reluctant to eat genetically modified (GM) food.

3 GloFish is the world’s first transgenic pet—a fish that glows in the dark. It contains fluorescent proteins produced by genes extracted from sea anemones and coral.

*Science Essentials 8 (Williamson & Garton, 2011<sup>b</sup>)*

Scientists have been examining ways to use stem cells to help people whose cells don’t work as they should [...] Stem cells could also be used to grow replacement organs, instead of using transplants. They could also be used to cure diseases such as diabetes.

*Science Essentials 10 (Williamson & Garton, 2011<sup>d</sup>)*

Write a two-page argumentative essay discussing the following statement: ‘Parents should be allowed to select the characteristics they want for their children.’

*Science Quest 10 for Victoria (Lofts & Evergreen, 2014)*

<i>Example:</i>  <i>Anthropocentrism</i> <i>(human</i> <i>survivability first)</i>	As a result of the thinning ozone layer in the atmosphere, we are exposed to increasing amounts of UVB radiation that can damage (or mutate) our DNA.	43
	Could Earth get too hot for humans? Is there enough variation within our species so that if things do get too hot to handle at least some of us will survive and our species will continue?	233
	To function normally we need to maintain a core body temperature around 37 °C. If this core temperature rises above 42 °C, we die.	233
<i>Science Essentials 7 (Williamson &amp; Garton, 2011<sup>a</sup>)</i>		
Sustainability is about preserving the Earth's resources for future generations. Our use of a particular resource such as water, timber, oil or plastic is sustainable only if we can continue using the resource for a very long time without using it up and without damaging the environment.		
<i>Science Essentials 9 (Williamson &amp; Garton, 2011<sup>c</sup>)</i>		
Apart from its effect on human health, acid rain affects plant growth. It also speeds up the corrosion of metals, and damages buildings and statues.		
<i>Science Essentials 10 (Williamson &amp; Garton, 2011<sup>d</sup>)</i>		
	If we select the characteristics we think are important and allow only the organisms with these characteristics to grow and reproduce, are we reducing biodiversity? Will humans come to rely on only a small variety of organisms to survive?	140

*Nelson iScience for the Australian Curriculum 7 (Bishop et al., 2012)*

Water reservoirs are supplemented with water from desalination plants, such as the Kwinana plant in Western Australia. This, however, will still not satisfy our water needs into the future. 190

Sustainable development is use of the environment such as mining, farming, industry and forestry that meets our needs now but doesn't compromise the ability of future generations to meet their needs. 174

*Nelson iScience for the Australian Curriculum 10 (Champion et al., 2012)*

Scientists predict that, over the next two to three decades, climate change due to global warming will see higher death rates from heatwaves, floods and droughts. Diseases such as malaria and dengue fever, which are traditionally found in human populations in tropical areas such as equatorial African countries, will spread to Europe. Temperature rises of 4-5°C are expected to lead to increases in other health problems, such as malnutrition, diarrhoea and cardio-respiratory and infectious diseases. 198

Seagrasses are one of the most important marine ecosystems for humans as they play a vital part in the fishing industry. 201

*Oxford Science 7: Victorian Curriculum (Silvester, 2016<sup>a</sup>)*

Too much exposure to radiation can be harmful for humans. 85

*Oxford Big Ideas Science 10 (Quinton et al., 2012)*

It would be a fair comment to suggest that the greatest concern regarding the effects of climate change would be the impacts on humans. Many 126

populations will be forced to relocate, or perish, and standards of living will shift sideways and down for most as resource availability decreases.

Therefore, new transgenic organisms can be produced, such as pigs that can produce more muscle or bacteria that produce a human protein that can be extracted and used to treat illnesses. 162

*Oxford Science 10: Victorian Curriculum (Silvester, 2016<sup>c</sup>)*

Cyclones intensify over warm ocean waters, another consequence of increasing global and ocean temperatures. We can also expect to see an increase in the loss of human lives as a result. 134

Health and disease 123  
Higher temperatures in summer have increased heat-related deaths. A heat wave in Europe in 2003 was estimated to have killed between 22 000 and 35 000 people. Global warming is also thought to extend the zones for infectious diseases, such as dengue fever and malaria...

Biodiversity is important for many reasons. Plant biodiversity is important as we rely on plants for all our food. More diversity of plant species gives us a greater variety of crops. 310

*Pearson Science 9 Student Book (Rickard, 2012)*

Sustainable living for humans means acting in a way that maintains the living conditions of our environment. It involves careful use of resources so that they do not run out, and ensuring that natural ecosystems that keep us alive are not damaged by our actions. 295

	<i>Pearson Science S.B. 9 (Rickard et al., 2016<sup>a</sup>)</i>	
	Four reasons for protecting ecosystems are: [...]	366-367
	Survival: We get our oxygen, water and our food from the environment around us. Pollution and overfishing reduces the food available to us and clearing trees for agriculture can result in eroded soils. As a result, less land is available so less crops can be grown. Air pollution makes the air unfit to breathe and produces acid rain that can kill crops.	
	<i>Science Quest 10 for Victoria (Lofts &amp; Evergreen, 2014)</i>	
<i>Example:</i>  <i>Anthropocentrism (climate change &amp; human impact doubt)</i>	While most scientists agree that an increase in the amount of carbon dioxide in the atmosphere is the main cause of global warming, they argue about the details of the cause and about the effects of global warming. The key arguments that scientists are involved in investigating and discussing can be divided into three categories:  1. Are humans responsible for global warming?  2. What will the effects of global warming be?  3. What can be done to stop global warming?	240
	Alternative theories about climate change have been developed. Climate change sceptics, for example, believe that humans are not to blame for rising global temperatures and that what is being experienced is merely part of a natural cycle.	240
	<i>Nelson iScience for the Australian Curriculum 10 (Champion et al., 2012)</i>	
	- scientific evidence that supports the concept of global warming	184

- scientific evidence that does not support the concept of global warming.	
There are some scientists, however, who dispute that this current global warming is any different from what has occurred previously in Earth's history. They argue that the Earth undergoes such cycles naturally.	199
Reflect	206
12 What are the arguments that are put forward to deny human-induced climate change? What do you think?	

---

INTERVIEWS

	<i>Entity 1</i>
<i>Example:</i> <i>'Neutral/objective'</i> <i>teaching</i>	'...as a science teacher I'd want to talk about the science behind it. And I think, you know, if it was a different class maybe an ethics class or something it'd be another type of debate. So, I guess if it was a science class I would try to look at the science behind it'
	<i>Entity 2</i>
	'Well, having a science background, I'd probably try to focus on the science component of it and look into what the processes are...'
	<i>Entity 3</i>
	'Oh, well, they're [students' opinions are] all valid because we're never going to know – if, you know, in a hundred years we've modified all these babies and then suddenly something – like it does revert the natural order or something goes wrong'
	'But if it's fine to just teach the subject ... you know introduce what genetically modified is – give sort of the real scientific background and

then possibly have, like, a discussion or a debate about it in the class because even – you know, depending on the year level – even Years 7 and 8s would have some sort of beliefs either way [so I would] let them discuss it and then at the end maybe finish with ... not my beliefs but the belief that both the beliefs are right?’

*Entity 4*

‘I would probably start off by giving them some general information from both sides to make sure it wasn’t biased...’

*Entity 5*

‘I think I’d respect the learner’s opinion’

*Entity 6*

‘I think it’s important as a science teacher to be really kind of objective and not biased [...] or firstly I’d just educate them about what it is and kind of just tell them the facts [...] and show them a balance of the positives and the negatives and then try and let them make up their own minds, so that they can [...] so I’m not influencing them too much because that’s really not my role’

‘...there can come times when you really have to kind of sit back and you go, well that’s their [students] view and I have to respect that – like there might not be any amount of education you can kind of give them, or facts that you can give them to change their mind’

*Entity 7*

‘obviously it’d be controversial [...so I would] minimise I suppose just, like, negative emotions and, like, offending anyone or anything like that’

‘I wouldn’t really want my bias to affect the class I don’t think, so I’d try and set up something that’s a little more mutual...’

*Entity 8*

'I dunno, I think you have a very live and let live kind of philosophy when you're teaching such a div – it's such a diverse country. I don't think I'd – that's their opinion, I don't think I'd tell them off or tell them they're wrong'

*Entity 9*

'I would try not to put in my own opinion too much, like, try to give it to them as unbiased as possible so they can kind of make up their own mind about it'

*Entity 10*

'I would probably just explain the technicalities of it ... if it was possible [...and] I wouldn't cover the moral side of it I don't think'

'I wouldn't want to cover the moral side of it because everybody has very different opinions and I think – I also think it would be unfair to put my views on someone else, or try and teach students, you know, this is how it should be or this is my opinion because, you know, I think teachers have a big influence on what students might think'