

Methodological
Approaches to
STEM Education
Research Volume 3

Methodological Approaches to STEM Education Research Volume 3

Edited by

Peta J. White, Russell Tytler,
Joseph Paul Ferguson
and John Cripps Clark

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CONTENTS

Contributors.....	viii
Foreword	xii
<i>Urban Erikson</i>	
Introduction	xv
A ‘Post’ Perspective on Methodology <i>Russell Tytler, Peta J. White, Joseph Paul Ferguson and John Cripps Clark</i>	
Chapter 1	1
Post-Qualitative Inquiry <i>Paul Hart</i>	
Chapter 2	34
Diffractively Reading ‘Sustainability’ and the Violence of Modern Thought in Curriculum and Discourse <i>Robin Bellingham</i>	
Chapter 3	56
A Movement, a System, a Mountain, a Chorus: Art Practice within Environmental Education as a Transdisciplinary Mode of Post-qualitative Inquiry <i>Cassandra Tytler</i>	
Chapter 4	76
(Re)figuring Self-study of Practice: Storylines of Transformation in the Spaces Between of Climate Change Education <i>Bronwyn A. Sutton</i>	
Chapter 5	99
Understanding Pedagogies for Climate Change Education Through Collaborative Arts-based Autoethnography <i>Jo Raphael, Shelley Hannigan and Peta J. White</i>	

Chapter 6	129
Working with Teachers in Reform Initiatives	
<i>Russell Tytler and Peta J. White</i>	
Chapter 7	150
Honouring the Ethos of Co-design Methodology in	
Contemporary Socio-scientific Teaching Research	
<i>Seamus Delaney and Madeleine Schultz</i>	
Chapter 8	173
Collaborating across Disciplinary Lines: Generating a Framework	
for Out-of-Field Teachers in the Sciences, English, Mathematics,	
Design Technologies and the Humanities	
<i>Linda Hobbs, Lucinda McKnight, Jared Carpendale,</i>	
<i>Chris Speldewinde, Coral Campbell, Seamus Delaney,</i>	
<i>Susan Caldis, Leissa Kelly and Colleen Vale</i>	
Chapter 9	200
An Ethical Dilemma Inspiring Exploration into Netnography	
<i>Emily Rochette</i>	
Chapter 10	218
The Praxeological Sociology of Knowledge—An Introduction to the	
Documentary Method and a Sketch of an Empirical Implementation	
<i>Teresa Beck</i>	
Chapter 11	245
Researching for System Reform:	
Giving Voice to the Authoritative Outsider	
<i>Russell Tytler</i>	
Chapter 12	266
Making Explicit the Political Agenda Within Research Methodologies	
<i>R. Scott Webster</i>	
Chapter 13	286
Tensions between Theory and Practice:	
A Mathematics Education Perspective	
<i>Jill P. Brown, Carly Sawatzki and Wanty Widjaja</i>	

Chapter 14	308
Analysing Student Graphing in Mathematics and Science: The Methodological Utility of a Semiotic Framework <i>John Cripps Clark and Joseph Paul Ferguson</i>	
Chapter 15	326
Cosmic Aesthetics: Harmonising Varying Theoretical Perspectives in a Thesis by Publication <i>Saeed Salimpour, Russell Tytler, Michael Fitzgerald and Urban Eriksson</i>	
Chapter 16	350
Applying a Scoping Review Methodology to Investigate Adaptive Expertise: Insights and Challenges for Research in STEM Education <i>Lihua Xu, Kennedy Chan, Amanda Berry, Joseph Paul Ferguson, Gahyoung Kim, Jan van Driel, Colleen Vale and Wanty Widjaja</i>	
Chapter 17	369
Digital Bibliometric Visualisation Tools: Constructing Maps to Navigate the Literature <i>Melinda Kirk and Joseph Paul Ferguson</i>	

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FOREWORD

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I started my academic career studying astronomy, physics, and mathematics at Lund University in the late 80s. However, and due to a strong interest in understanding how to learn science, I turned to become an upper-secondary teacher in these subjects. I loved challenging the students with the physics of everyday phenomena and the wonders of the universe! After some years teaching at adult education schools, I got a junior lecturer position at Kristianstad University in Sweden, teaching physics and astronomy to student teachers at all the different programs. Here, I first met science education research and I started to get an understanding as to why I felt successful in my own teaching; I seemed to use teaching techniques that were found effective by education research. I had fantastic colleagues that tried to drag me into science education research and I really tried at first. But, even though supported by such great people as Prof. Gustav Helldén, my efforts failed as I could not understand the language of science education; the methods and ways of working with data seemed incomprehensible to me at the time and I went to study astronomy instead. After half a PhD (a PhD in Sweden is four years full time) I was still so incredibly fascinated by the students' hurdles in understanding the universe. My colleague, Prof. Andreas Redfors, then turned my attention to a PER group at Uppsala University and I continued my studies there, now focusing on Astronomy Education Research (AER) under the supervision of Prof. Cedric Linder. This was the turning point in my career, and I was now ready to fully embrace the methods and techniques used in science education research. I did struggle at first but thanks to Cedric's efforts and infinite patience I came to understand the ways to work with different methods to collect and analyse data to be able to answer my research question. After a few years I earned my PhD, which is part astronomy and part education research. Eight years later I am now head of the LUPER group at Lund University, supervising PhD students, a postdoc, and Master's students, when I am not head of the Department for Educational Sciences at the same university.

One of my biggest problems at the time of my PhD was what methods to use. Now, supervising PhD students, I see them struggling with the same problems as I had. We have had so many good discussions on the methodological issues related to framing a research plan, including collecting and analysing data; this is understandable since our research field is young and diverse. There are so many different methods in the literature; in Sweden we have a saying: ‘You do not see the forest for all the trees’. This is similar to what many novices in our field experience when starting to do research in Discipline-Based Education Research (DBER) in STEM or STEAM; one risks drowning in the sea of methods available. Moreover, when reading research papers, the methodology sections are often remarkably short and do not really give enough details on the challenges the authors have had while working on their projects and reporting on them in a paper. Many novice PhD students in PER, AER, or DBER, come from science disciplines and are thus familiar with the methodologies used there—*quantitative methods*—and have great difficulties accepting that one can do research using *qualitative methods*. I feel a strong empathy with my PhD students here as the transition is not easy.

During my career I have not really found any conference that takes a particular focus on methodological issues in DBER, until I came across the *Contemporary Approaches to Research in Mathematics, Science, Health & Environmental Education* symposia (CAR), organised by Deakin University since 1993. Unfortunately, it was not until 2020 that I became aware of this symposium, thanks to Prof. Russell Tytler, and I was so relieved that I finally found one! Here, I have found rare opportunities to discuss and refine methodological understandings from a broad spectrum of related science disciplines. However, for such a symposium to be successful, the organisers must create a safe and trusting environment, so that participants are willing to share their thoughts and be open to constructive scholarly critique. I have found that CAR symposia offer such a unique environment and allow presenters to open up for discussions on possible weaknesses and strengths in their presented projects, and participants engage in and critique the work in a very professional, yet friendly, manner, something I find unusual at many other conferences and symposia.

This year’s symposium focuses on practical and theoretical aspects of research methodology and was designed to promote substantive discussions of methodological issues. This year also saw a broadening of the methodological focus to include new materialists and post qualitative inquiry.

The presentations for this year's symposia, and hence chapters in this book, held a very broad range of topics in the designated focus area. They stretch from methodological issues and considerations in thesis writing in cosmology education research (Salimpour et al. - chapter 15) to netnography (Rochette - chapter 9), and even the political aspects of methodology (Webster - chapter 12). Several of the chapters deal with aspects of environmental and climate change education (Sutton - chapter 4; Tytler, C. - chapter 3; Raphael et al. - chapter 5), and related subjects (Bellingham - chapter 2), and are thus very relevant today. Some chapters focus very much on the methodological aspects of DBER, such as Xu et al. - chapter 16, where they raise four methodological issues faced in their project and present thoughts on these in a clear and concise way; and Beck - chapter 10, who describes the 'Documentary Method'. These contrast with most other chapters, where the authors have chosen to clearly flesh out the methodologies used in a subject context to highlight its advantages and possible disadvantages. Finally, there are chapters dealing with various aspects of teaching, both from student perspectives and teacher perspectives (Hobbs et al. - chapter 8; Brown et al. - chapter 13; Clark & Ferguson - chapter 14; Delaney & Schultz - chapter 7; Tytler, R., & White - chapter 6). Some chapters are more focused on certain methods, such as Kirk & Ferguson's chapter 17 on how to methodically navigate the research literature using bibliometric visualisation tools.

Finally, Paul Hart's - chapter 1 exploration of post-qualitative inquiry gives a comprehensive overview of qualitative research and includes the 'posthumanist new materialist philosophy'.

In total, the contributing authors and chapters give a broad overview of the field and can function as a very good starting point for anyone interested in learning more about the current status of research methodology in STEM education research.

Thanks to the organisers for arranging and continuing the CAR symposium and thanks for the opportunity to share my thoughts with you on the very interesting chapters in this book.

Enjoy reading it.

INTRODUCTION

A ‘POST’ PERSPECTIVE ON METHODOLOGY

Methodological Approaches to STEM Education Research Volume 3 represents the practical experience and theoretical insights of education researchers grappling with methodological issues at the cutting edge of the field. The seventeen chapters offer explorations further developed from a long running annual symposium (Contemporary Approaches to Research: CAR) focused on strategically addressing contemporary methodology and methods in STEM education research, distinct from the customary focus on substantive findings that characterise most research gatherings.

Each volume has its own emphases. Volume 3 features a number of chapters that take up a post-qualitative perspective on methodology with two keynote addresses by Emeritus Professor Paul Hart from the University of Regina, and Dr Robin Bellingham from Deakin University. A second theme in the book continues this exploration of self-study, auto-ethnographic methodologies particularly relating to climate change education and sustainability. Further chapters explore diverse topics and perspectives: co-design methodologies; interdisciplinary research method and theory; ethical issues in research; and questions of analysis, data representation and approaches to literature review with contemporary tool application.

The CAR symposium has been an important focal point for researchers in the Deakin University Science, Technology, Engineering, Mathematics, and Environmental (STEME) Education Research Group and a wider set of education researchers who gather annually for the event. The underlying premise driving the symposium is that, as educational researchers, our knowledge and practice of methodologies is critical in framing our research and moving the field forward. Innovation in methodology is part of our brief, and attention to the selection and application of appropriate methodologies and awareness of their underlying epistemologies, their strengths and limitations, is an important aspect of our craft. Changing methodological traditions respond to or drive the theoretical approaches that open up new perspectives on educational practice.

Over the years, the CAR symposium has been a major stimulus for raising the profile of methodological practice and innovation for an increasingly international community, and researchers' awareness of issues and challenges, possibilities and limitations of different approaches to research in education (<https://deakinsteeme.org/event-category/car-symposiums/>). This includes the role of theory and theory-method intersections, and the interrelations between research approaches, research designs, methods and methodology. The symposium represents an annual conversation about a variety of epistemological and ontological topics central to research in education.

The symposium format encourages in-depth engagement with methodologies through extended discussion around grouped presentations. The insights emerging from these discussions in many cases have informed the development and refinement of the chapters in this book. Participants range from experienced researchers to research students grappling with issues of theory and methodology, such that the topics, and the chapters in this book, range in focus from practicalities of methods and their adaptation to different contexts, to sophisticated overviews of theory-methodology interactions, and reviews of trends in theory and method driving rethinking of practice. Unlike formal volumes on methodologies, the chapters attend to context-specific practices, raising questions and speculation about methodological innovation and the challenges of pursuing research in practical contexts. They offer a view of education researchers' practice in framing methods and responding to challenges, which is informative for educational researchers at all levels. It is our intention, through this series, to raise the level of methodological awareness, and methodological debate, within our research community, extending what the symposium itself has done for more than two decades.

Peta. J. White
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CHAPTER 1

POST-QUALITATIVE INQUIRY

PAUL HART

Abstract

This chapter is an exploration of the ways that post-qualitative inquiry creates openings for educational research. In moving beyond conceptual limits of qualitative research, it engages and exposes conceptual limitations of qualitative research. It creates conditions for critical engagement with concepts from posthumanist new materialist philosophy. In so doing, post-qualitative inquiry creates a new vocabulary for re-engaging crucial discussions of (new) empirically-based inquiry framed by new ethics of performativity, as naturally occurring and as uninterpreted, within educational and natural settings. Researcher representation is replaced by active conceptual engagements with diffractions, rhizometrics, entanglements, assemblages, refrains, affective intensities, as well as a growing range of cartographic mappings of lines of flight, unfoldings and complexities of human-nonhuman intra-actions. At play is the ‘politics of engagement’ grounded within post-Anthropocene philosophy as a new base for more activist environmental education and political post-humanist critical actions against liberal humanist individualism. When such complexities become entangled with ethics and empirics, they become matters of political agency within post-Anthropocene times. As educational researchers we must decide: Who must we become and what must we do, for the next generation?

Keywords: Post-qualitative, ethics and politics of inquiry, new empiricist inquiry

Speculation

Sometime in the early 21st century, scholars in educational research, and particularly in environmental education research, will encounter issues related to post-qualitative inquiry and its background theory. With the role of science and knowledge production at a crossroads, as societal transformation challenges dominant forms of knowledge production, educational research is challenged (Lotz-Sisitka et al., 2016) to explore transgressive ways of thinking (Temper et al., 2019), and approaches to inquiry prerequisite to societal transformation. Implicated are empirical and ethical theories related to new materialisms and posthumanisms as questions for new empiricisms and new ethics (Clough, 2009; Temper et al., 2019). These impending changes reflect ontological re-orientation which creates conditions for critical bioethical and biopolitical discussions of the nature of being, as well as basic categories of long-term existence. And as we learn to reconceive relations of knowledge and being, relations between human and nonhuman become profoundly ethical-environmental-educational in ways that foreshadow an evolution of thinking about educational inquiry along different planes of thought. St. Pierre et al. (2016) describe this work in terms of an ethical imperative (Braidotti, 2013) that compels educational researchers to explore educational inquiry in terms of alternative futures and to find ways to live a different existence, beyond the Anthropocene. Basic questions concern whether and how it is possible collectively to imagine or speculate on conditions of existence. Perhaps post-qualitative thinking as a beginning, can create points of intersection that compel environmental educational researchers to rethink their responsibilities within the evolving dynamics of social science inquiry?

Introduction: Post-qualitative inquiry within a complex of theoretical starting points

At the turn of this century, Denzin and Lincoln (2002) presumed to introduce the field of qualitative inquiry. They presented a critical framing for interpretive and critical paradigms that displaced quantitative with qualitative inquiry. They described qualitative inquiry within participatory and collaborative processes as grounding for social critique and social action, encompassing a wide range of epistemological viewpoints and research strategies for better understanding people within their natural contexts and in terms of new quality criteria evolving from the ‘paradigm wars’ and poststructural work of the 1990s. They created openings for scholars such as Elizabeth St. Pierre who described a sixth moment of

qualitative inquiry as a rethinking of the ethics of research practices, after Deleuzian ethics principles and figurations provided the grounding for thinking with concepts such as ‘rhizome,’ ‘fold,’ ‘nomad,’ and ‘haecceity’ to question researcher subjectivity. St. Pierre (1997, 2002) and Lather (1997) described this work as mappings for shifts in thinking as concepts/figurations were introduced to challenge inquiry in terms of interpretation and representation. St. Pierre proposed ethical principles from Deleuze and Guattari (1987) to think differently about qualitative methodologies. These philosophical shifts (Braidotti, 1994) enabled mappings of the ‘new’ empiricism and ‘new’ ethics as justification for post-qualitative strategies.

In the early years of the 21st century, post-qualitative possibilities have become more common across a wide range of scholarship within educational research, grounded at various levels of thought, within educational inquiry. Jackson and Mazzei’s (2012) *Thinking with Theory* challenged simplistic treatment of ‘data,’ and demonstrated how thinking within conceptual perspectives provides another way of making sense of ‘performance’ in the material world. These philosophical and conceptual groundings served as underpinnings for educational researchers who began to experiment directly from within ‘live’ engagements, in educational and field settings.

Certain concepts, within this return to ‘realism’ (Le Grange, 2018), served as ‘starting points’ for researchers to think with theory within a philosophy of immanence, framed by new ethics, new empiricisms, posthumanisms, and new materialisms. These changes, particularly in research areas related to environment and environmental education, served as new beginnings for environmental and educational shifts toward what Haraway (2016) describes as ‘New Planetary Ethics: Beyond the Anthropocene.’

This chapter focuses on those theoretical and conceptual starting points within what Carol Taylor (2016) calls a cacophonous ecology that responds within an epoch in which humans have become an ecological force with planetary impact. It is manifest, for example, in feminist PhEmaterialisms (Ringrose et al., 2019) which combine realist theories of posthumanisms and new materialisms with questions of ethics and empiricism. It offers new ways of thinking about educational research that cut across issues of education, gender, social justice, and nature/culture/technical interfacts.

St. Pierre (2019) characterises post-qualitative inquiry as setting aside qualitative methodology and instead reading philosophy widely in order to

understand the theory-base. What becomes apparent is an immanent philosophy of presence (agential realism) that challenges methodology-based qualitative research practice (Barad, 2007). Following this new theory, educational researchers are working to reconceptualise educational research from the ground up, creating conditions for change within theory in terms of immanent knowledge practices that diverge from ‘truth telling’ informed by research interpretation and representation.

Post-qualitative inquiry has emerged within background theory as ‘transgressive,’ as thinking directly from philosophy, and implicates environmental as well as educational theory. For example, Temper et al. (2019) and Elfreich (2019a, 2019b) actively challenge dominant forms of knowledge production in favour of activist approaches to research as transgressive and transformative (see, for example, Hsiung, 2016; Kuby et al., 2016; Lotz-Sisitka et al., 2015, 2016). Theoretical resources include, amongst many others, nomadic theory (Braidotti, 2013), new materialisms (Braidotti, 2002; Coole & Frost, 2010; Dolphijn & van der Tuin, 2012), posthumanisms (Braidotti, 2013), posthuman performativity (Barad, 2003), material feminisms (Alaimo & Hekman, 2008), and bodily nature (Alaimo, 2010, 2016). This literature has become more complex and diverse as background within an emerging post-Anthropocene politics of inquiry and new planetary ethics, beyond the Anthropocene (Haraway, 2016).

This rapidly expanding background for post-qualitative inquiry is beginning to think across transgressive spaces in relation to the politics of nature/planet that follow from post-Anthropocene possibilities. As new grounding for educational/environmental educational research, and within the short span of two decades, theory-savvy researchers, following from Lather, St. Pierre, MacLure, Jackson and Mazzei, Lenz-Taguchi, Taylor, Nordstrom and many others, have engaged a variety of post-qualitative perspectives. This diversity, however, is centered by immanent theory/practice and theory-driven methods, reconceptualised within the conceptual spaces of posthuman and new materialist entanglements and underpinned by new empirical and new ethical thinking.

As an example of how environmental education comes to ground directly from within philosophical perspectives that implicate post-Anthropocene ethics and new empiricisms, the recent *Environmental Education Research* special issue on new materialisms (Clarke & McPhie, 2020) works toward meetings of politics and ethics. They illustrate how underscoring immanent performativity creates transgressive spaces for thinking differently about research processes as intra-actions captured ‘live’ from classroom and field

experiences. It is in the lived experiences themselves that we can begin to see transgressive flows as human ‘becomings’ within the entanglements of their educational experiences. Exploring what is really going on within these entanglements of in-school or field experiences as well as speculative engagements and action-oriented, live explorations, the papers in this special issue work to align environmental education research with post-qualitative perspectives.

As a reflection of several discussion sessions at the 2021 Deakin CAR symposium, this chapter focuses on these theoretical and conceptual complexities of thinking with post-qualitative theory to create openings for critical discussion of new conceptual starting points. Concepts such as diffraction, which originate directly within theory, form the ‘live’ substance for viewing and exploring participants’ voices and actions in real time. This process, not unlike dimensions of participatory action research, is intentionally grounded within a complex of theory-based concepts. Barad’s (2007) ideas of an immanent philosophy of presence and posthuman performativity challenge educational researchers to work directly with theory outside of pre-existing qualitative research methodologies. There are no pre-existing research methodologies, just certain theoretical and conceptual starting points that illustrate how theory grounds post-qualitative inquiry (see, for example, Kuntz & St. Pierre, 2020).

Post-qualitative possibilities: A complex of new theory bases

Post-qualitative inquiry begins with a return to realism framed by new empiricism within an immanent philosophy of presence (i.e., Barad’s [2007] agential realism) at a time when forces in the world (i.e., encounters with difference) require breaking old habits, such as the structures of conventional ‘humanist’ social science inquiry (i.e., methodology). Following St. Pierre (2002, 2021), after the crisis of representation, researchers’ interpretations of the ‘real’ can only be an ambiguous and unreliable mediation between observers and realities. By engaging an ontology of immanence, researchers are encouraged to work with concepts/figurations (e.g., rhizome, haecceity) to rethink traditional definitions of empirical research practices.

Different ontological presumptions about modes of being implicate a new ethics of engagement by including a nonhuman dimension that questions what counts and who matters beyond the scope of qualitative methodologies

and methods. Within these parameters, new inquiry processes are needed to focus on how humans are embedded within the politics and ethics of experiences. This philosophical ‘sea change’ creates conditions for post-qualitative inquiry to rethink/reworld with nonhuman ‘others’ and with different assemblages of ecological relations, and decolonial and Indigenous perspectives, as part of the dynamics of shifting forces operating on people (Snaza & Weaver, 2015; Taylor & Hughes, 2006).

New materialisms and posthumanisms (Alaimo & Hekman, 2008; Braidotti, 2002, 2013, 2019; Coole & Frost, 2010; Dolphijn & van der Tuin, 2012; Haraway, 2016; Taylor & Bayley, 2019; Taylor and Hughes, 2016), new empiricisms and posthuman ethics (de Freitas & Truman, 2021) have evolved from philosophical underpinnings for post-Anthropocene inquiry, and in particular for environmentally focused educational inquiry. The response to rapidly emerging concerns about planetary climate change has positioned research in environmental education strategically to adapt into a leading role in this new politics of unsustainability (Blok & Bruun Jensen, 2019).

Gaining understanding of these underpinnings and essences as ‘sea changes,’ that ground thinking for a post-qualitative turn requires thinking with new frames of inquiry. These new frames have the capacity to articulate conditions for less hierarchical value systems. Such framings refuse the ontological primacy of humans and create openings for thinking differently within contexts that range from micro-classroom episodes to those with planetary implications.

Educational researchers are now actively encouraged to work in nomadic, yet deliberate, ways to explore real conditions and commitments using media such as videos, photos, artworks, and poetry in relation to ‘live’ enactments and performances, materialised in spaces/places where researchers, along with viewers and readers, can vicariously participate in generating and posing onto-epistemic questions for understanding and perhaps to generate ideas for making a difference. Examples include Malone, Tesar, and Arndt (Book Series); Reinertsen (2016); Ringrose et al. (2019); Ivinson & Renold (2016); Clarke and Mcphie (2020), and the special issue of the *Australian Journal of Environmental Education* (2022).

Post-qualitative inquiry: Creating conditions for new theory/new inquiry

If the overall purpose of critical theory is to create new modes of thought to help us critically engage global education perspectives that serve the dominant (institutional) power structures and control current systems of education and educational research, how can we also engage new theories to illuminate destruction scenarios that continue to emerge in our lives, despite our best efforts to change (Brookfield, 2009)? How can we also learn to disentangle how and what it is that we have learned to accept through educational research and through environmental education research, making it possible to see differently (Hart, 2014, p. 371)?

Some time ago, critical theory was proposed as a means to examine dominant institutional-political power structures that support and maintain the status quo. What seems to have transpired within the movement to post-qualitative inquiry is a more critical evolution of thinking concerning what counts as research in education. An increasing number of forward thinking theory-based researchers, such as Nordstrom and Ulmer (2017), are concerned that researchers might take up post-qualitative inquiry without crucial knowledge about why and how it came to exist as a challenge to interpretive/representational methodology of qualitative inquiry. So how can transgressive thinking, which has created conditions for change in educational research by unmasking the status quo and by raising consciousness concerning material and humanist conditions as manifest in post-qualitative inquiry, work to expose power/knowledge relations between qualitative and post-qualitative which have become political?

- Post-qualitative inquiries are situated as agentic assemblages which implicate agential realism and assemblage thinking as figurations (concepts) that characterise **actual** experiences, each from within the unique politics of their places.
- Reading philosophy is required. For example, following Nordstrom and Ulmer (2017) post-qualitative inquiry engages different theory and theory differently as new ways of thinking and doing research (i.e., ‘thinking with theory,’ not methodology [Mazzei, 2021, St. Pierre, 2016]). ‘Post-qual’ is informed directly by philosophy (e.g., Deleuze & Guattari) using concepts as ways of re-orienting thinking, as not interpretive but in concrete encounters with ‘the real’ (Mazzei, 2021).

- ‘Post-qual’ is described as ethical inquiry (Lather & St. Pierre, 2013) that embraces the inseparability of ethics, ontology and knowledge (Le Grange, 2018). Concepts, such as haecceity, rhizome, refrain and diffraction, provide different perspectives (i.e., lines of flight/new thoughts and connections in and about ‘live’ encounters) that enable new thoughts and connections in ‘real-time’ (Jackson & Mazzei, 2018; St. Pierre, 2013).
- The texts themselves are agentially real (Barad, 2007, p. 712). Each experience, in classroom or field study with human and nonhuman agents forms parts of an overall process as ‘affecting or being affected’ by human and/or nonhuman relations (Rousell, 2019, p. 897).
- Post-qualitative inquiry resists binaries such as theory/data, researcher/participant/philosopher, writer/reader, so that hierarchies are flattened and the human subject is problematised as the sole source of meaning.
- Relational ways of engaging experiences, from maths lessons to pond studies, can be viewed through multiple conceptual frames, actively engaging the real-lived material complexities and political value of not being able to generalise findings, thus opening to multiple possibilities.
- Concept-as-method turns to theory for creative design experimentation and to focus on engaging ‘live’ experiences as they lay themselves out naturally in real life.
- In critiquing humanisms, post-qualitative inquiries also raise questions about what counts as knowledge and whose knowledge counts, and about how certain knowledge becomes foundational (i.e., secures truth) within imbrications of knowledge and relations of power; how knowing re-produces being/becoming, produces knowing and so on (St. Pierre, 2013, p. 648).
- Fundamental to this is the Deleuzian concept of immanence (Hein, 2019, 2020) which opens new forms of ethical inquiry as intra-active responsibility. Engaging inquiry immanently also implicates cultural phenomena, including Indigeneity and decolonisation, as essential, albeit political, from various vantage points.

- Working within immanence also has the potential to address affective intensities within immanent material ontologies of field and classroom experiences as transgressive writings and uses of video (Mayes, 2019). These fundamental interrelated concepts are increasingly framed within posthumanist and new materialist perspectives.

Posthumanisms

A growing body of scholarship has taken up the challenge of rethinking the limits of human growth and development in our relationship with earth others. The theoretical core of posthumanism draws attention to life beyond the human self, as immanent forces of life, and to knowledge systems that enable a clearer vision of the three ecologies—environmental, socioeconomic and subjective. Braidotti and Bignall (2019) define a ‘posthuman turn’ as a convergence of posthumanism with post-Anthropocentrism, as a complex and multidirectional discursive and material event that recognises humans as a geological force capable of affecting all life on the planet. For (environmental) education, it offers a crucial frame for understanding how interlaced assemblages of living things co-exist with nonliving forms and forces within planetary limits. Posthuman perspectives search for ways to reconceive ‘humans in relation’ with other beings and things, interrogating differences that deterritorialise concepts such as nature/culture, human/nonhuman, body/mind (Hohti, 2018; Holmes & Jones, 2016; Taylor et al., 2013).

Reclaiming human agency with accountability seems crucial for collective resistance to the unprecedented state of social and environmental collapse resulting from contemporary politics and ethics. Engagement in educational research and practice is recognised as crucial in understanding agential responsibilities for engaging critical discussion concerning ethical and political accountability and the tasks associated with framings of ‘earth ethics’ for geo-ecological and political accountability (e.g., Braidotti, 2013).

A posthuman turn in educational provision implicates ethical and moral issues of social and environmental justice as age-appropriate predicaments acknowledged in relation to common issues of climate change. Whether posthumanist perspectives provide a plausible framework within complex political ecologies of the present education systems seems to rest upon convergences within vital material intersections, as well as educators’/teacher educators’ awareness of transformations across new

materialist ethical spaces (Kuby, 2017). Questions remain concerning our educational responsibility to translate new ways of knowing/being into (environmental) educational praxis. For example, Haraway's (2016) speculative realist feminism and Barad's (2007) agential realist theory have been generative in creating conditions for human/more-than-human intra-actions with nature/cultures, with techno-bio power questions of local and global dimensions, and with questions that implicate many other dimensions of education that encompass reconceptualised theories of new materialisms within new empiricisms and new ethics.

New materialisms

Fox and Alldred (2015) follow Coole and Frost's (2010) 'New Materialisms': Ontology, Agency and Politics, and van der Tuin and Dolphijn's (2010) 'transversality' to explore underpinnings of new materialism within social inquiry. They found that influential philosophers such as Barad (2007), Hird (2010), and Haraway (2008) were, in different ways, 'always already' framing a 'politics of the future' for educational inquiry. Following Barad's (2007) focus on performativity, and Kirby's (2008) 'there is no outside the text' as 'there is no outside of Nature,' these materialist shifts are grounded within post perspectives on inquiry by Deleuze and Guattari's (1987) refusal of the interpretation/representation of language as the dominating mode of social educational inquiry.

Each of these theorists, in their own way, rethinks educational research as underpinned by engagement with 'live' episodes as research assemblages in what Barad (2007) calls 'intra-actions.' At issue is the new materialist perspective which eschews linguistic translation and searches for new framings within the dynamics of material intra-action. Thus, 'live action,' as already always material/discursive, is what becomes important, rather than the mimicking of a positivist correspondence theory of truth found in the qualitative linguisticism of interpretation/representation. In essence, the philosophy-based grounding by these theorists/researchers is rooted in breaking free from linguistic representationalist theories of matter as movement from epistemology to ontology, or in Kirby's (2008) terms, what if culture was nature all along (Alaimo & Hekman, 2008)? This thinking aligns with van der Tuin and Dolphijn's (2010) notion of the transversality of new materialism, which resonates with Fox and Alldred's (2015) new materialist perspective of thinking about educational and environmental education inquiry as direct viewings of educational experiences.

Twenty years ago St. Pierre and Pillow (2000) in *Working the Ruins* questioned whether humanism's inscription of reality/knowledge and the subject were dangerous fictions and what might a different 'science' look like? After two decades of exploration of this question, Rousell (2019) argued that the field of EE, in view of the evolution of 'thinking with theory,' may now have the political potential to occupy a more central role within the debates about direction in educational research and practice. Many others have worked to integrate the role of feminist, new materialist, and posthuman thinkers to actively engage decolonial and Indigenous reconfigurations of childhood natures as groundings for educational inquiry (see Cutter-Mackenzie-Knowles et al., 2020; Malone, Duhn, & Tesar, 2020).

New materialist and posthuman strategies as conceptual starting points

New materialist and posthuman strategies break free from interpretivist research orthodoxies in search of rhizomatic spaces for new conditions of possibility. These movements 'in process,' open inquiries beyond textual representations and focus on 'performance' as enacted and embodied in 'live' experiences. 'Knowing' is the result of direct material engagement in lived experiences, that is, realist intra-actions. Holmes et al.'s (2020) interest in videoing young children's 'games' of play in exploring knotted collections of 'naturecultures' in children's play provides an example.

Fox and Alldred (2015) describe a number of characteristics for a new materialist paradigm as one that explores:

- how desires, feelings, and meanings contribute to social production (Braidotti, 2013);
- breaks in the culture/nature divide and how the culture/nature divide works with 'live' (living evolutions of working with a conception of agency not tied exclusively to human actions);
- how new assemblages can work as relational networks (animate or inanimate);
- research assemblages of bodies, things, territories, abstractions;

- how engaging affective flows can (de) stabilise, (de)territorialise assemblages (territories as the means and places where society and history unfold);
- dynamic materialities filled with affects, forces and desires, flows and intensities, assemblages and disaggregations as ‘becomings’ rather than ‘beings’;
- schizoanalytics as mappings of lines of becomings/affects/flows in schizo- rhizo-nomadological methods.

Fox and Alldred (2015) also characterise a posthumanist paradigm as one that explores:

- by engaging critical discourses that interrogate and challenge relations among human/nonhuman Anthropocentrisms and humanist reflexes;
- by reconfiguring how we understand ‘politics’ and ‘knowledge’ by troubling humanist concepts such as settler colonialism, racism, sexism, and politics in educational participation in curriculum studies and environmental education;
- by reconsidering humanist politics as incapable of escaping capitalist tendencies and traditions;
- by finding ways to reconceive humans, in relation with other beings and things, as well as interrogating and deterritorialising differences;
- by searching for ways of accounting for things in non-Anthropocentric ways, conscious of the politics of change;
- by engaging in speculations (speculative realisms) with how we must reconceive educational practice and inquiry within new models of the political within communities as relational fields;
- by exploring many curriculum reformations as embedded in post-Anthropocene thinking;
- by engaging in politically sensitive areas of planetary considerations as ecological dimensions of emergent ethics and posthuman politics;

- by engaging politics in research differently in terms of post-Anthropocentric ethics within, for example, feminist, post-colonial, anti-racist projects.

Post-qualitative perspectives have become the focus of special issues in education research periodicals such as the journal *Reconceptualizing Educational Research Methodology*, as well as in such publications as Koro-Ljungberg et al. (2017) and Ringrose et al. (2019). These materials have engaged, in particular, feminist posthumanisms and new materialisms within an entanglement of theory-praxis, as the PhEmaterialism movement that seeks to actualise and account for the layers of complexity in mapping connections and intra-actions across the layers (plateaus) of educational thought.

As a critique of Anthropocentric humanism, posthumanisms have opened inquiry to the more-than-human world with less hierarchical value systems (Braidotti, 2013; Haraway, 2016). The researcher, as ‘modest witness,’ is not detached or ‘objective’ and works beyond ‘representation’ with video, photos, artworks, and poetry, often as performances materialised in spaces where viewers/readers intra-act in generating onto-epistemic questions about these processes to make a difference. Thus, post-qualitative/posthuman methods ‘break free’ from qualitative research methodological orthodoxies in search of new rhizomatic spaces for conditions of possibility.

The research focus shifts from textual interpretations and representations to postcritical and post-Anthropocentric material engagements with participants’ posthuman conceptions of change in empirical educational research (Boden et al., 2021). ‘Knowing’ is a result of direct engagement (i.e., direct experience) with the material world (at whatever scale). Serious ethical questions about the ‘self’ within the relational entanglements with human and nonhuman matter (e.g., plants and animals, technologies, nature cultures) are implicated. Inquiries often evolve along ‘planes of existence,’ for example, in terms of desires, knots, diffractions, political and personal motivations, and more-than-human entanglements.

In fieldwork, researcher interest is immanent. That is, how to capture what is ‘going on’ in real ‘live’ situations without recourse to traditional interpretive methodologies. Inquiries into immanent practices begin with perspectives of research ‘concepts’ such as diffraction, lines of flight, rhizomes, haecceities, folds, affects, and others become useful as ways of viewing, becoming with, and seeing diffractively across complexities of

relationships, encounters, emotions and more. These realities are explored as constantly shifting, contingent and uncertain assemblages of relational entanglements that generate questions of how to begin to make sense of these dynamic practices and then to generate arguments for change in educational practice (see, for example, Osgood & Giugni, 2015). These arguments become the ‘empirical’ starting points for post-qualitative inquiry in rethinking education research, as grounded materially, and as posthuman possibilities.

Rethinking empiricism – The politics of new empiricisms

Drawing from Deleuze’s conceptualisation of new empiricisms, Clough (2009) proposed a rethinking of empiricism, as a theory of knowledge, that allowed for a rethinking of bodies, matter and life through encounters with ‘transgressive’ underpinnings, beyond the positivist, quantitative, statistically oriented method linked to behaviourism, and beyond interpretive methodologies. Clough (2009) traced this evolution of thinking through Deleuze’s transcendental empiricism that allows a rethinking of bodies/matter/life through encounters with embodiment, visceral perception, and preconscious affect (Massumi, 2021). Beyond the 1990s, assumptions that social practices could be captured using applied science methods were replaced by qualitative methodologists, questioned by critical theory/research, and refused by poststructuralists within a crisis of representation. More recently, explorations of an expanded (new) empiricism within posthumanist and new materialist theories are argued for agential realist engagements (de Freitas, 2017; de Freitas & Truman, 2021; Jackson & Mazzei, 2018; St. Pierre, 2016).

Where classical empiricism relied on knowledge gained from ‘measured’ observation, post-qualitative empiricisms are collective, relational, ‘knowing together’ in working with concepts such as rhizome, haecceity, or diffraction to explore ‘live’ intra-actions in and out of class situations and field activities. In this post-qualitative shift, the focus is decentering human (individual) agency within relations, across live experiences, where ‘becoming’ together is engaged as ‘live’ collectives. Thus infra-empiricism, as new empiricism, is found with realist (authentic) accounts of actual experience, uninterpreted.

Rethinking inquiry beyond interpretation coincides with rethinking empiricisms in terms of immanence. Following St. Pierre (2016) and Mazzei and Jackson (2017), when rethinking matter, we must rethink the