BECOMING DEMOCRATIC IN THE LIFE SCIENCES: REFRAMING LIFE SCIENCES TEACHING AND LEARNING THROUGH POSTHUMANISM

by

KUDAKWASHE MAMUTSE

submitted in accordance with the requirements for
the degree of

DOCTOR OF PHILOSOPHY (EDUCATION)

in the subject

PHILOSOPHY OF EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR:

PROFESSOR D.J. v. R. POSTMA

November 2020

DECLARATION

Name: Kudakwashe Mamutse

Student number: 62144138

Degree: Ph D (Education) (Philosophy of Education)

Becoming democratic in the Life Sciences: Reframing Life Sciences teaching and learning through posthumanism

I declare that the above thesis is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

01/11/20

SIGNATURE DATE

UNIVERSITY OF SOUTH AFRICA

Title of thesis:

BECOMING DEMOCRATIC IN THE LIFE SCIENCES: REFRAMING LIFE SCIENCES TEACHING AND LEARNING THROUGH POSTHUMANISM

KEY TERMS:

Posthumanism; Life Sciences; Democracy; Anthropocene; Becoming; Subalterns; Actor-network Theory; Object-Oriented Ontology; Humanism; Diffractive Pedagogy

ACKNOWLEDGEMENTS

Glory be to the Lord for everything. I wish to express my sincere appreciation to my Supervisor Professor D.J. v R. Postma for his support and kindness throughout this journey. Prof., you have been a brother, a promoter, a motivator, a friend, a colleague, a role model and a supervisor all in one. I thank you a zillion times.

Many thanks go to my family, to my wife Rossa and the kids. I know I have been very scarce because of my studies and I am grateful for your patience.

I would like to sincerely thank my mother, Mrs Esther Haruperi Mamutse who gave me the foundation to learning though she has never been to school herself. Your effort has not been in vain.

May thanks to all my teachers from Grade 1 to Form 6. Amongst all these great people I want to thank mostly my Grade 6 Teacher Mr Isaac Doro who motivated to aim very high in my schoolwork. Since then I have been motivated. Here we are. You and me.

I also want to thank UNISA for the kind hand that they extended to me financially. Great thanks also go to Dr Annelie Wassenaar for all the encouragement at work. A lot of thanks to my Language Editor Dr Postma for the splendid work on short notice.

Last, but not least I thank my brother Paul Rhinos “D” Mamutse for introducing me to studying during primary school years, and all those books and the undying testament that “*we go anywhere as long as we go forward, and we do it in the Name of Whoever”*. All those juvenile academic commitments that we made during our old days in the *Court Of Heaven* are all part and parcel of this journey. Their fabric define this PhD.

BECOMING DEMOCRATIC IN THE LIFE SCIENCES: REFRAMING LIFE SCIENCES TEACHING AND LEARNING THROUGH POSTHUMANISM

SUMMARY

The aim of the study was to develop a critical posthumanist and democratic theory that may be applied in the teaching and learning of Life Sciences in South Africa in order to achieve an expanded form of democracy that would not discriminate between human and nonhuman. Though both critical posthumanist and democratic theories have been used in pedagogical studies separately, this study focused on the development of a merged and broader theory that has elements of both of the theories. The term *nonhuman*, as used here, does not specifically refer to non-person individuals only. Rather, it also refers to people who are regarded by the *dominant humans* as nonhumans – inferiors and subalterns. The latter group of people include the poor, women, children, people of colour and the disabled. Owing to this binarisation characteristic of the Life Sciences as a subject – which it adopts from the nature of science, its curriculum, and pedagogical approaches – the impression is given that as the master of the universe, the human has unlimited power over all other entities. These other nonhuman entities are then regarded as resources for the use of humans. Yet, it is this attitude which has caused humans to abuse nonhumans to the extent that the earth is facing the catastrophe of the Anthropocene.

The adoption of a critical education approach characterised by the development of a critical posthumanist and democratic theory that may be applied in the teaching and learning of Life Sciences is essential in dealing with the issue of the Anthropocene that is threatening the earth currently. This study thus seeks to adopt a critical education approach through the introduction of democracy into the teaching and learning of Life Sciences, specifically so that humans would get to a position where they would consider nonhumans as entities with which they co-exist, and entities with equal agency within the environment. The recognition of the need for democracy would allow the humans to treat the nonhumans (such as the environment and ‘subalterns’) with respect, as their compatriots; and by doing that, the harrowing issues leading to the catastrophe of the Anthropocene could be either avoided or averted.

Key words: Anthropocene; Democracy; Life Sciences, Pedagogy; Humanism; Posthumanism; Diffraction; Planetary Boundary; Subaltern; Apartheid

OM DEMOKRATIES IN DIE LEWENSWETENSKAPPE TE WORD: DIE HEROPSTEL VAN LEWENSWETENSKAPPE-ONDERRIG EN -LEER DEUR POSTHUMANISME

OPSOMMING

Die doel van die studie was om ’n kritiese posthumanistiese en demokratiese teorie te ontwikkel wat op die onderrig en leer van Lewenswetenskappe in Suid-Afrika toegepas kan word om ’n uitgebreide vorm van demokrasie daar te stel wat nie tussen menslik en niemenslik sal diskrimineer nie. Hoewel kritiese posthumanistiese sowel as demokratiese teorieë apart in pedagogiese studies gebruik word, het hierdie studie op die ontwikkeling van ’n saamgesmelte en breër teorie wat elemente van beide teorieë bevat, gefokus. Die term *niemenslik* soos wat dit hier gebruik word, verwys nie spesifiek net na niepersoon-individue nie. Dit verwys eerder ook na mense wat deur die *dominante mense* as niemense – minderes en ondergeskiktes – beskou word. Die laasgenoemde groep mense sluit die armes, vroue, kinders, mense van kleur en gestremde mense in. Vanweë hierdie binêre eienskap van die Lewenswetenskappe as ’n vak – wat dit as gevolg van die aard van wetenskap, sy kurrikulum en pedagogiese benaderings aanvaar het – word die indruk geskep dat die mens as heerser van die heelal onbeperkte mag oor al die ander entiteite het. Hierdie ander niemenslike entiteite word dan as hulpbronne vir gebruik deur mense gesien. Dit is egter hierdie houding wat veroorsaak het dat mense niemense misbruik, in so ’n mate dat die aarde die katastrofe van die Antroposeen in die gesig staar.

Die aanneem van ’n kritiese onderrigbenadering wat gekenmerk word deur die ontwikkeling van ’n kritiese posthumanistiese en demokratiese teorie wat by die onderrig en leer van Lewenswetenskappe gebruik kan word, is noodsaaklik om die kwessie van die Antroposeen wat die aarde tans bedreig, te hanteer. Hierdie studie wil dus ’n kritiese onderrigbenadering volg deur middel van die bekendstelling van demokrasie by die onderrig en leer van Lewenswetenskappe, in die besonder sodat mense in ’n posisie sal wees waar hulle niemense as entiteite saam met wie hulle ’n bestaan moet voer, en entiteite met gelyke verteenwoordiging in die omgewing, sal beskou. Om die behoefte aan demokrasie te erken, sal die mense toelaat om die niemense (soos die omgewing en “ondergeskiktes”) as hulle landgenote met respek te behandel; en deur dit te doen, kan die pynlike kwessies wat tot die katastrofe van die Antroposeen sal lei, moontlik vermy of afgeweer word.

Sleutelwoorde: Antroposeen; demokrasie, Lewenswetenskappe; pedagogie, posthumanisme

UKUBA YINTANDO YENINGI KUSAYENSI YEZEMPILO: UKUVUSELELA UKUFUNDISWA NOKUFUNDA ISAYENZI YEZEMPILO NGOKUSEBENZISA OKWAKHIWA EMVA KOKUPHILA KOMUNTU

UKUFINGQA

Inhloso yalolu cwaningo kwakungukusungula umbono obucayi owenziwa ngemuva kokuphila komuntu nentando yeningi engasetshenziswa ekufundisweni nasekufundeni kwesayensi yezempilo eNingizimu Afrika ukuze kuzuzwe uhlobo olwandisiwe lwentando yeningi olungeke lubandlulule phakathi kwabantu kanye nokungebona abantu. Yize zombili izinkolelo ezibucayi ezenziwa ngemuva kokuphila komuntu nezentando yeningi zisetshenzisiwe ezifundweni zokufundisa ngokwehlukana, lolu cwaningo lugxile ekuthuthukiseni kombono ohlanganisiwe futhi obanzi onezici zombili zale mibono.

Igama elithi okungebona abantu njengoba lisetshenziswa lapha, alibhekiseli ngqo kubantu abangebona abantu kuphela. Esikhundleni salokho, libhekise nakubantu ababhekwa ngabantu abaphezulu njengabantu abangebona abantu – abaphansi nabasezingeni eliphansi. Iqembu lokugcina labantu lifaka phakathi abampofu, abesifazane, izingane, abantu bebala nabakhubazekile.

Ngenxa yalesi sici sokuhlukaniswa kwesayensi yezempilo njengesifundo – emukela emvelweni yesayensi, ikharikhulamu yayo, kanye nezindlela zokufundisa - kunikezwa umbono wokuthi njengomphathi wendawo yonke, umuntu unamandla angenamkhawulo kuzo zonke ezinye izinhlangano. Lezi ezinye izinto ezingezona abantu zithathwa njengezinsiza ukusetshenziswa abantu. Kodwa-ke, yilesi simo sengqondo esidale ukuthi abantu bahlukumeze abantu abangebona abantu kuze kufike lapho umhlaba ubhekene nenhlekelele yokwakhiwa nokuthuthukiswa komhlaba.

Ukwamukelwa kwendlela ebucayi yezemfundo ebonakala ngokuthuthukiswa kombono obucayi owenziwa ngemuva kokuphila komuntu kanye nentando yeningi engasetshenziswa ekufundisweni nasekufundeni kwesayenzi yezempilo kubalulekile ekubhekaneni nodaba lokwakhiwa nokuthuthukiswa komhlaba olusongela umhlaba

njengamanje. Lolu cwaningo-ke lufuna ukwamukela indlela yezemfundo ebucayi ngokwethulwa kwentando yeningi ekufundisweni nasekufundeni kwesayensi yezempilo, ikakhulukazi ukuze abantu bafike esikhundeni lapho bezobheka khona abantu abangebona abantu njengezinhlangano abaphila nazo, nezinhlangano ezinokumela ngokulinganayo ngaphakathi kwemvelo. Ukwamukelwa kwesidingo sentando yeningi kuzovumela abantu ukuthi baphathe abantu abangebona abantu (njengemvelo kanye nabasezingeni eliphansi) ngenhlonipho, njengabantu bakubo; futhi ngokwenza lokho, izingqinamba ezihlasimulisayo eziholela enhlekeleleni yokwakhiwa nokuthuthukiswa komhlaba zingagwenywa noma zivinjelwe.

Amagama asemqoka:

Anthropocene

ukwakhiwa nokuthuthukiswa komhlaba

Democracy

Intando Yeningi

Life Sciences

Isayensi yezempilo

Pedagogy

Ezokufundisa

Posthumanism

Emva kokuphila komuntu

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ANT	Actor-network Theory
BC	Before Christ
CAPS	Curriculum and Assessment Policy Statement
CFCs	Chlorofluorocarbons
CPDT	Critical Posthumanist and Democratic Theory
CPDPT	Critical Diffractive Theory and Critical Posthumanist and Democratic Pedagogy Theory
CPT	Critical Pedagogy Theory
DBE	Department of Basic Education
DT	Diffractive Theory
EDF	Electricité de France
EEC	European Economic Community
Mya	Million years ago
NOS	Nature of Science
NRC	National Research Council
OOO	Object-Oriented Ontology
OOP	Object-Oriented Philosophy
OPP	Obligatory Passage Point
PSA	Pacific Southwest Airlines
SRC	Stockholm Resilience Centre
STS	Science, Technology and Society

TABLE OF CONTENTS

CHAPTER 2: THE ANTHROPOCENE

CHAPTER 3: ACTOR-NETWORK THEORY (ANT)

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

This study focuses on the development of a critical posthumanist and democratic theory that may be applied in the teaching and learning of Life Sciences in order to achieve an expanded form of democracy that would not discriminate the human from the nonhuman. An important aspect to raise here is that the term *nonhuman* as used here, does not specifically refer to only non-person individuals. Rather it refers also to people who are regarded by the dominant *humans* as nonhumans, inferior and subalterns. This group of people include the poor, women, children, people of colour and the disabled. Due to this binarisation characteristic of the Life Sciences as a subject, that it adopts from the nature of science, its curriculum, and pedagogical approaches the subject appears to give the impression that as the master of the universe, the human, has unlimited power over all the other entities. By entity here is meant all objects (human and nonhuman) that are separate and have an existence of their own (Strawson, 2000). These other nonhuman entities are in that case regarded as resources for the use of the human. Yet it is this attitude which has caused the human to abuse the nonhuman to the extent that the earth is facing the catastrophe of the Anthropocene.

The adoption of a critical education approach characterised by the development of a critical posthumanist and democratic theory that may be applied in the teaching and learning of Life Sciences would be essential in dealing with the issue of the Anthropocene that is bewildering the earth currently. The study thus seeks to adopt a critical education approach through introducing democracy within the teaching and learning of Life Sciences, specifically so that humans would get to a position whereby they would consider the nonhumans as entities that they co-exist with, and with equal agency, within the environment. When this happens, the ways through which humans treat the nonhumans would change. Such a change would tantamount to the recognition of democracy, and ethicality among all the entities. The recognition of the need for democracy would allow humans to treat nonhumans such as the environment, weather, vegetation, rivers and so forth with respect. When this happens, humans would begin to treat nonhuman others as their compatriots, and by doing so, the issues leading to the Anthropocene would be avoided, and as such, the

acceleration and expansion of the Anthropocene would either be avoided or averted. Though there is some debate regarding whether the Anthropocene has begun (Showstack 2013; Visconti, 2014), the argument that I make in this study is based on the view of how the Anthropocene is discernible from analysing Planetary Boundaries. This view is clear from the following statement by Steffen et al. (2015:1) :

> The planetary boundary (PB) concept, introduced in 2009, aimed to define the environmental limits within which humanity can safely operate. This approach has proved influential in global sustainability policy development. Steffen *et al.* provide an updated and extended analysis of the PB framework. Of the original nine proposed boundaries, they identify three (including climate change) that might push the Earth system into a new state if crossed and that also have a pervasive influence on the remaining boundaries. They also develop the PB framework so that it can be applied usefully in a regional context.

The above quotation implies that from a Planetary Boundary perspective, some PBs are been affected more than others. If that is the case, it means there is a possibility to avert the Anthropocene through protecting the PBs that are not yet critically affected. This is the main intention of the study. However, there remains a question of how this could be achieved. I propose that the above could be achieved if the teaching and learning of Life Sciences adopts a critical posthumanist pedagogical approach. The critical posthumanist approach would pave the way for humans to recognise that there would not be any binarized and dichotomous relations between them and the nonhumans. By doing that, the environment would be drawing back towards an equilibrium that was lost when the humans declared themselves as the centre of the environment while regarding all the other entities as subalterns. In his work entitled *Subalterns and Sovereigns,* Sundar (1997) has defined the subalterns as those members of a community that are disregarded and suppressed. In this study, the term subaltern represents the suppressed in society as well. I however seek to expand the breadth of the term subaltern to include the nonhuman others within society be they living or non-living.

The chapter shall be outlined as follows. First, I give a brief overview of the South African education system and how it is oriented towards humanism philosophy. I then explore how humanist orientations manifest in Life Sciences as a subject, including where exactly there are such manifestations within the subject's curriculum., I then explore how the humanist orientations of the Life Sciences curriculum has potentially paved the way for pedagogical approaches that might promote the Anthropocene. Next, I look at how education is taking place within the context of the Anthropocene, ending by exploring how Life Sciences is being taught and learnt within the context of the Anthropocene. The foregoing discussions are in accordance with the following headings:

(a) The humanist foundations of the South African education system: a special focus on Life Sciences

(b) Exploring how current life sciences pedagogical approaches potentially promote the Anthropocene

(c) Education in the context of the Anthropocene

(d) Life Sciences teaching and learning within the context of the Anthropocene

(e) Towards an understanding of democracy

(f) Rationale for the study

(g) Statement of the problem

(h) The central research questions

(i) Purpose, aims and objectives of the study

(j) Research methodology and design

(k) Limitations and delimitations of the study

(l) Chapter outline

1.2 THE HUMANIST FOUNDATIONS OF THE SOUTH AFRICAN EDUCATION SYSTEM

1.2.1 Introduction to humanismBefore going into the details of humanism and its influence in education and in science education in particular, it would be essential to define what humanism is regarded to be. As given by Copson (2015:6):

> Humanism is a democratic and ethical life stance, which affirms that human beings have the right and responsibility to give meaning and shape to their own lives. It stands for the building of a more humane society through an ethic based on human and other natural values in the spirit of reason and free inquiry through human capabilities. It is not theistic, and it does not accept supernatural views of reality.

As indicated in the definition above, humanism is centred on the human in the placing confirming how much power and responsibilities they possess as far they shape their own destinies. As alluded to by Blackham (1965), from a humanist perspective, nothing would be exempt from the human question, and everything has to be understood from a human experience.

The history of humanism as a concept stretches from quite far. As explained by Copson and Grayling (2015), the trajectory of the origins of this word started with the appearance of the word humanist in 1589 when it was a direct translation from the Italian word *umanista*. However, it was only in the 19th century that the word humanism was developed as a translation from the German word *humanismus* (Copson & Grayling, 2015). According to the literature (Khatib, Sarem & Hamidi, 2013; Morris, 1978; Rivers,1983; Schmuck & Schmuck, 1974; Valett, 1977) humanism became a popular philosophy that has been adopted in education since the 1970s. Its main premise has been that education would only be effective upon the achievement of increased intellectual and cognitive prowess of learners. This view is described by Rivers (1983) below:

> In the individualization movement of the 1970s, humanistic education continued its struggle for recognition of the primacy of the individual personality against deterministic behaviourist emphases. Though content is

> not neglected in a class that uses humanistic techniques, in an affective or humanistic approach, students are encouraged to talk about themselves, to be open with others, and to express their feelings. (p-23-24)

The views of Rivers, and those of other scholars above indicate how humanism has been a determinant foundation of education, including Life Sciences education. This movement has spread the world over and its effects are equally felt. In the next section, I am going to explore the influences of humanism on the South African education system.

1.2.2 Humanism and science education

In order to suggest the integration of post humanism as a radical education philosophy in education, it would be ideal to first look briefly at the historical development of post humanism within education in general and science education in particular. In this historical analysis, effort shall be placed on how humanism started being considered as an alternative to what has been regarded as mainstream science. Thereafter, post humanism would then be explored in terms of how it came in as an alternative to humanism.

Koteswaraiah and Basavanna (2016) have explained that the phenomenon of humanism was advanced by an American psychologist Rogers, who was mostly concerned with humanist psychology. Rogers' argument is that education is transmitting impersonal information from teachers to learners with an over-emphasis on performance rather than the development of affective values. He argues further that the major emphasis is on the development of cognitive abilities more than affective skills. He thus postulates the need for the development of an experiential learning pedagogy with a greater emphasis on the development of the self experientially and in relation to the other. This has been reported in the literature elsewhere as the school science's tendency to prepare the learners for the next level science course (Frederick, 1991; Millar & Osborne, 1998) without due cognizance of its importance in their daily lives. Aikenhead (2007) refers to this as the pipeline phenomenon arguing that school science provides tunnel understanding to learners. It has been reported in the literature (AAAS, 1989; Atkin & Helm, 1993; Lyons, 2003; Reiss, 2000) that one of the reasons behind the introduction of humanistic science has been school science's

tendency to be organised in a manner that only allows learners to appreciate it and its national importance.

In his study on the development of humanistic science Aikenhead (1994) mentions that the first movement towards humanistic science has been the Science-Technology-Society movement. Alluding to Bevilacqua and Giannetto (1998) have mentioned this saw the integration of two almost broad categories of science (i) the field related to how scientists worked in science, (ii) the social interactions that were common within the scientific community. This combination then led to the advocacy for humanistic science (Yager, 1983; Ziman, 1984) whose grasp of societal issues made it an applied science (Hunt, 1988).

In his analysis of the importance and relevance of the humanistic science approach, Berkowitz (1975) points that the approach is special in the way through which it emphasises the development of the learner as a whole person. He elaborates further that the "wholeness" development emanates for the humanism's emphasis on the associative development of both actions and feelings and its emphasis of the importance of the environment and the context. Berkowitz says that eventually learners would be in a position to educate themselves according to ways that are suitable to them in a manner that is informed by constructivism.

The move from the positivistic science towards humanistic science is also attributed to Kuhn's (1962) work on *The Structure of Scientific Revolutions*. In his work Kuhn challenged the unrelenting positivism and realism that were associated with traditional science (Abd-El-Khalick & Lederman, 2000; Kelly, Carlsen & Cunningham, 1993). Kuhn argues that science remains more of a doctrine than a discipline often closed to the outsiders.

The influence of humanism on science has also been explained by Restivo and Zenzen (2003). They have argued that humanistic science came in to unify science with other modes of inquiry and social processes that were based on humane values. For instance, aspects such as caring, consciousness and vision were brought in, to contextualise the then aloft science. As described by Restivo and Zenzen, humanistic science came in to negate and reverse the view of science as "science-as-it-is" and in

the process, transform it into a holistic and unitary globalised. Restivo and Zenzen (2003:1) detailed the humanistic perspective as follows:

> The adjective "humanistic" is a reminder that as humanists fostering scientific inquiry, we are engaged in the general struggle to revolutionize a society that is producing crippled and crippling "monstrosities" instead of nurturing loving, lovable, liberated, and wise human being.

An analysis of how humanism entered into science and what it was meant to be gives the impression that the intention of this drive was to take over science from what was regarded as the canonical monopoly of the scientists which regarded science as a self-referring enterprise to a human-centred enterprise. In that process, the author argues in this thesis that the human beings through science have declared themselves the centre of the universe. By doing that they did injustice to other entities and beings that existed within the universe. Their understanding of ecology was skewed to their own advantage and thus the concept of democracy was lost. Everything was now supposed to be understood in terms of humankind perceptions and units, despite the prevalence of other non-human entities. As time progressed, more contemporary scientists have come to question the validity and authenticity of humanism as theory of how to understand the relationship between science and the humans. The analysis of the relationship between humans and other entities began to gain momentum. This analysis led to the development of post humanism as a theory focused on the ecological relations that between human and non-human entities on the earth.

1.2.3 Humanism and the South African Life Sciences Curriculum

In this section, I am looking into the extent to which the South African education system has a humanist orientation and how this humanist orientation has influenced the focus of Life Sciences to be towards humanism. It would be ideal to mention that irrespective of the various attempts by the Department of Education to reform education from the Apartheid ideology since 1994, there have been issues that some elements of the old ideology remained embedded in the new system (Badat & Sayed, 2014; Chisholm, 2012; Cross, Mungadi & Rouhani, 2002; Jansen, 1998; Nel & Binns, 1999). The apartheid education system by its nature of being founded on the ideology that only whites were humans and the non-whites were not human therefore followed a

humanist approach (Aloni, 2013). By being humanist-oriented, the curriculum in South Africa possibly lacks democracy. The lack of democracy is implied in the Apartheid policy that was legislated against certain races within the country. In the process, subjects such as Life Sciences were not spared by the paradigm shift. To begin with, the concept of democracy is quite new to the generality of South Africa. Prior to 1994, democracy was only reserved for certain sections of the population. The education system within the country was equally undemocratic. As explained by Ashley (1989) the education system in South Africa prior to 1994 followed a moulding philosophy. In accordance with this philosophy, learners were supposed to be moulded into pre-fabricated and pre-cast ways of thinking and behaving that tally with their respective roles in society (Collins, 1971; Bowles & Gintis, 1976; Thobejane, 2013).

Following the demise of apartheid, the new government immediately started the process of restructuring the education system with the intention of democratising the policies, the system and the pedagogy itself. As explained by Lomofsky and Lazarus (2001) the intention was to get rid of the previous dispensation that was characterised by legalized inequality and discrimination (Bray, 2000). To achieve this ideal, the Department of Education then came up with a policy framework called the *Manifesto on values, education and democracy* (Department of Education, 2001). The aim of the manifesto is multifold and includes the need to resolve issues such as conflict (Sasinsky, 1993), poor self-concept and self-esteem (Whistler, 1991) and social adjustment (Donald, Lazarus & Lolwana, 2000; Heleta, 2018).

An analysis of all these aspects indicates that indeed, democracy is one of the key fundamental values that are enshrined in the manifesto on values, education and democracy, a policy embodiment that seeks to lay the groundwork for the emphasis, implementation and manifestation of education based on values and democracy in South Africa. This was the first step towards the introduction of democracy into education, and the democratization of the entire education sector. In the policy document's executive summary, it is stated that democracy within the South African education system shall be moved forward through the observance of an all-embracing value system that recognises all in society (Department of Education, 2001). This is perhaps the onset of humanist orientation of the education system. The extension of democracy to all in society leaves undertones of the *all* in question to be humans. In

that way, democracy is allocated strictly to the humans, and it excludes the nonhumans. This is quite problematic in the sense that it assumes the dichotomisation and binarisation of the human and the nonhuman. I want to emphasise that the problem per se does not come with the desire to introduce democracy into the education system. Indeed, this study wants to oversee the adaptation and integration of democracy in the teaching and learning of Life Sciences. The problem rather, is how democracy is conceptualised in the curriculum. This conceptualisation has left democracy as a human attribute, which it is. However, conceptualising it like that is problematic in the sense that it excludes the nonhuman. When democracy discriminates against other entities, it loses the very goal that it seeks to achieve, which is to ensure that all voices within the collective are heard. It is the loss of such voices such the voices of the nonhuman such as weather patterns that would potentially leads to the onset and acceleration of the Anthropocene.

Despite the tabling and adoption of the legislation through the manifesto, later studies have indicated that the level of implementation of the policy differed from what had been expected (Pillay & Ragpot, 2011; Wolhuter, Janmaat, van der Walt & Potgieter, 2020). Pillay and Ragpot have found in their study that the application of the manifesto has remained mythical with very little understanding and willingness to apply it across the board. In essence, the plan to have democracy-informed education has not been successful. Nonetheless, its humanist footprint has remained, and has also been reflected in subjects such as Life Sciences. Further studies should be done to explore ways that may be followed to make this a success. Such is the desire of this study, though it will focus on the Life Sciences. In the following section, in a bid to achieve that, I shall explore how the humanist attributes in Life Sciences manifest in a manner that that has potentially driven the pedagogical approaches in the subject towards the acceleration of the Anthropocene due to its minimalist view of democracy that disregards the nonhumans.

1.3 EXPLORING HOW CURRENT LIFE SCIENCES PEDAGOGICAL APPROACHES PROMOTE THE ANTHROPOCENE

1.3.1 The Anthropocene phenomenon

The term Anthropocene which has currently become a buzz word in the discussions of the earth systems was suggested by Paul Crutzen and Eugene Stoermer in 2000 (Crutzen & Stoermer, 2000; Crutzen, 2002; Steffen et al., 2018). It came after their observation that human activities had propelled the earth into a new geological era. They concluded that this new geological era involves how humanity radically brings about massive alterations to the earth's natural systems and cycles (Zalasiewicz, Williams, Steffen & Crutzen, 2010; Zalasiewicz, Waters, Williams & Summerhayes, 2019). Human activities that led into the Anthropocene include more mechanised farming which comprised the use of non-biodegradable chemicals to increase agricultural yields. As such, the onset of the Anthropocene is associated with the industrial revolution and the economic boom in terms of productivity in the world, especially the developed world (Zalasiewicz et al., 2008; Zalasiewicz et al., 2010). In this study, I argue that the acceleration of the Anthropocene is partly caused by the lack of a comprehensive application of the concept of democracy in the teaching and learning of Life Sciences. This minimalised and unilateral application of democracy disregards the application of the concept to the nonhuman. In that regard, democracy as shall be illustrated with the South African curriculum, is restricted to the humans. To that extent, the teaching and learning of the subject is generally undemocratic. As such, the ways in which the pedagogical approaches used in Life Sciences are linked to the onset and acceleration of the Anthropocene have to be briefly explored. By denying nonhumans the opportunity to participate in the same democracy with the humans, the current curriculum and its envisaged pedagogical approaches fail to provide what Fedosejeva, Boce, Romanova, Ilisko and Ivanova (2018) refer to as sustainable education. They argue for the development of educational goals that have the potential to address phenomena such as the Anthropocene:

> From this perspective, the choice of a broader holistic perspective in the current circumstances should begin with setting the educational aim. Following Whitehead's view of the educational aims, we have already highlighted the need for educational goals that do not restrict the use of the holistic framework and the implementation of the society's targeted activities as well as do not restrict the possibility of implementing the reorientation of unsustainable activities towards achieving a common educational aim. The phenomenon of Anthropocene is a substantial reason, which indicates the impact of more narrow and specific educational goals not only on education, but also on the quality of the whole system, which was most affected and is still affected by changes in nature-human relations. Public support for the implementation of the Education for Sustainable Development (ESD) goals has increased, but the state of nature-human relations has remained under the dominant influence of anthropocentrism, egocentrism and currently apparent techno-centrism (Fedosejeva et al., 2018:160).

An astounding characteristic of the Anthropocene is the manner in which it is compared to earlier equally massive planetary scale changes of the earth, such as those of the ice-ages (Moore, Underdal, Lemke & Loreau, 2001). Due to this comparison, there has therefore been debates regarding the actual onset of the Anthropocene (Gough, 2021; Lewis & Maslin, 2015; Smith & Zeder, 2013), with the issue regarding the date of its actual onset being regarded as being scientific on one hand, and political on the other (Saldanha, 2020). Some scholars argue that for the activities of humanity to yield such an enormous force and effect comparable to natural hazards, it has probably taken place over a very long time. This view however could be disagreed with. For instance, the acceleration that has taken place over the past 2000 years has been very fast to the extent that it has led to the suggestion that perhaps not so much time may be needed for the progression of the Anthropocene as had been previously assumed. This line of argument posits that there is a likelihood that the rate of acceleration of the Anthropocene might be influenced by the extent to which mankind managed to exacerbate powers through the harnessing of other entities such as technology. For instance, humans have succeeded to associate with technologies in order to collect powers from the others. In that case, the acceleration of the Anthropocene ceases to be directly influenced by human action, but would

rather be influenced by the actions of a collective that includes the association of the human and the nonhumans. Despite the divergence amongst various scholars regarding the onset of the Anthropocene, it is however generally agreed that for the precise onset of the Anthropocene to be established, there would be a need to follow a synchronous global signature identification within geological-forming materials (Turney et al., 2018:1).

In this study, the focus is on how to address the minimalised conception of democracy that is followed in the pedagogical approaches used in Life Sciences. I regard the current conception of democracy as minimalised due to its focus on only the human while at the same time excluding the nonhuman as not deserving of democracy. In addition to that, the use of the term human in this case refers to only the dominant creed of humanity. This dominant group regards the other humans outside their group as inferior. The inferior humans thus include people of colour, women, the disabled and children. These so-called inferior humans are thus regarded as lesser humans that are grouped together with the nonhumans. This is the point where the essence of democracy becomes skewed and unilateral. It is such action that in my view results in the onset and acceleration of the Anthropocene. The inferiorisation of some humans by others is of critical importance in the South African context due to country's Apartheid legacy which was based on discrimination of the non-white population in most life aspects including education.

1.3.2 The organisation of Life Sciences in South Africa

In this section, an overview is given of how Life Sciences as a school subject is currently organised, taught and learnt in South Africa. I will then describe how such an outlook is informed by humanism and as a result tends to promote the acceleration of the Anthropocene. In the foregoing section, I have presented the argument that the Anthropocene phenomenon is exacerbated by the manner through which school subjects such as Life Sciences are taught and learnt in schools. This includes the way tin which the curriculum is organised, and the ways in which the subject is assessed. It has been reported in the literature (Guosheng, 2001; Lynning, 2007 & Varela, 2009) that Life Sciences is taught and learnt in a pro-humanist manner, which consequently leads to the perpetration of the Anthropocene. Pro-humanist approaches tend to

promote the Anthropocene due to their centralisation of human agency ahead of all else within the collective. Such approaches emphasise the prominence of human cognition as a measure of difference between the human and the nonhuman (Berkowitz, 1975). This is alluded to by Firdaus and Mariyat (2017:1) below:

> The ultimate purpose of humanistic approach in education is the learning process that was started and is intended for the benefit of humanizing mankind. Humanising humans is to achieve self-actualization, self-understanding, and self-realization people to learn optimally. The concept of humanistic approach in education according to Freire is a process of liberation from the oppressive system and raised awareness of the critical processes centred on educators and learners as subjects in the process of teaching and learning. The implication of humanistic approach in education is how to educators to encourage students to think critically and act according to the values of humanity. Since then, the humanistic approach in education should be applied in the process of learning and teaching in order to produce a good learner and critical of reality.

The way pro-humanist approaches informed the Anthropocene is the subject of much debate. For instance, in their work on the influence of race and coloniality, Baldwin and Erickson (2020) have brought in a very radical approach to the understanding and conceptualisation of the Anthropocene. They delved deep into analysing what exactly is meant by humanism. In their analysis, they found that humanism is a loaded statement which has racial undertones. They augment their view through an analysis of how the Anthropocene is not race-neutral. This is clear from the following statement:

> …lurking just beneath the surface of the Anthropocene concept is a racialised narrative about white Earthly possession.(Baldwin & Erickson, 2020, p.1)

Taking the broadside of the argument posed by Baldwin and Erickson, the very basis of the Anthropocene across all disciplines and discourses is the dichotomisation tendency where certain races of humanity classify themselves as the real humans, and categorise the rest of humanity together with the nonhumans, and regard them as the subalterns. It is this group of humans, western and white by origin, whose fingerprints and footprints are everywhere where the Anthropocene is evident. The

unfortunate part of it is that they control the knowledge dimensions and directions of the world to the extent that even the curricula taught in schools conform to their ontological views. They are responsible for the onset and acceleration of the Anthropocene yet on the other hand they expect the subaltern cohort to work with them in addressing it (Davis, Moulton, Van Sant & Williams, 2019; Küpers, 2017; Luke, 2020). The subalterns are therefore being made accountable for a process that has been caused by the dominant. The implication here is that the dichotomisation that is often regarded as the main challenge responsible for the Anthropocene is not necessarily between the human and the nonhumans in a general way, rather, it is between the dominant humans and the subalterns. That means, in this thesis, when I refer to humanism, I am not taking a blinkered view of what it means to be human. My view is multi-focused and has been reported earlier in the literature (Roziek, 2015; Snaza & Sonu, 2016; Springgay, Truman & Turner, 2019). Humanism in my view refers to how the dominant races of humans control the rest of the earth including those human races that they regard as inferior. In Chapter 7, I shall now continue to explore how the traces of dichotomisation manifest in the Life Sciences curriculum in South Africa (Department of Basic Education, 2011; Ramnarain & Moleki, 2017) where emphasis is placed on the need for the science curriculum to be relevant to everyday life.

1.4 EDUCATION IN THE CONTEXT OF THE ANTHROPOCENE

In the above section, I have explored how the organisation, teaching and learning of Life Sciences is pro-humanist and thus tend to promote the Anthropocene following its pedagogical approaches. In this section, I seek to explore how education takes place within the context of the Anthropocene. In that case, I need to discuss issues regarding the Anthropocene. Having brought about the Anthropocene, how the dominant humans organised education would be a critical aspect to discuss here. The dominant humans are regarded to be white Christian, rational and propertied (Harris, 1993; Liu, 2017; Moore & Moran, 2016).

The first aspect to note is that it is indeed an important step that humanity has realised their excesses that have led to the Anthropocene. Though there is some considerable disagreement within the literature (Bauer & Ellis, 2018; Steffen, 2003; Visconti, 2014)

regarding whether the Anthropocene has started or not, with some level of consensus being reached that the phenomenon started around the 20th Century (Moore, 2016; Zalasiewicz et al., 2015) the promising thing is that at least there is an acknowledgement of its existence. It is indicated in the literature that learners need to be taught about the Anthropocene for both their own wellbeing and the wellbeing of the earth. For instance, Curren and Metzger (2019) have indicated that the inclusion of issues regarding the Anthropocene has the potential to teach the learners of the need for them to be cognisant of the sustainability of the earth's system. Such a recognition would be important in the sense that it is actually part of their right to live within a sustainable environment.

However, given this acknowledgment of existence, it is left to be explored how this manifests in education. As explained by Bauer and Ellis (2018), education should now include new standards that seek to emphasise and expose the relationship between the human and the nonhuman in a manner that would suggest ways of revealing the Anthropocene as a phenomenon. Nonetheless, evidence has it that this is hardly happening. For instance, though the literature (see Obol, Allen & Bach, 2003) indicates that the South African government has made some strides in trying to address issues such as the Anthropocene through education, the problem was that the aspect belonged to more than one ministry such as the Ministry of Education and the Ministry of Environment. Coordinating the sharing of resources between multiple ministries in order for the content to be taught in schools was found to be problematic. Elsewhere, for instance, in a study that was carried out by Curren and Metzger (2019) it was realised that learners have a very limited understanding of critical Anthropocene aspects such as the geological time period stratification of the earth. Their study has further revealed that learners are not cognisant of the role and impact of humans regarding planetary impact. The study further indicates that very little earth science is taught and learnt adequately in schools for learners to appreciate issues related to the Anthropocene. Further findings from the study have revealed that quite a considerable percentage of learners generally believe that both the earth and human beings were divinely created, and this was found to be in line with the general public opinion. This finding agrees with the findings that were reported by the National Research Council (2011) that climate science is hardly taught in schools in the United States. The

promising aspect was however given by the study of Curren and Metzger (2019) which indicates a general consensus that:

> …schools should provide science-based instruction in at least some aspects of the realities of living in the Anthropocene. (p.2)

Within the South African context, a number of studies (see Blyth & Meiring, 2018; Murris, 2019) have been conducted with the intention to explore the extent to which the curriculum promotes the teaching and learning of aspects related to the Anthropocene. The verdict from these studies is the same, the education system is not well prepared to deal with this.

What is clear from the discussion so far is that the education system is perhaps not paying sufficient heed to the issues of the Anthropocene despite the overwhelming need for it. Perhaps there is a need to explore ways of bringing issues of the anthropocene through suggesting, the kind of education that might be necessary within the context of the Anthropocene. This is the gap that this study seeks to fill.

1.5 LIFE SCIENCES TEACHING AND LEARNING WITHIN THE CONTEXT OF THE ANTHROPOCENE

Having discussed in the above section how education is taking place within the context of the Anthropocene, in this section, I am going to discuss how Life Sciences teaching and learning in particular is taking place within the context of the Anthropocene. In order to achieve this, I will discuss its humanist orientation and end with how the teaching could be re-conceptualised in order to follow a critical posthumanist and democratic approach.

The footprints of humanism in education date back to as far as the beginning of knowledge. As a philosophy, humanism believes in the centrality of humans in the universe including the availability of free-will within an environment that was supposed to cater for human needs before anything else (Duchesne & McMaugh, 2016; Veugelers, 2011). As explained by Shih (2018) below, the humanisation of education was seen as a necessity for various reasons:

> In fact, while the problem of humanization has always been humankind's central problem, it has taken on the character of an inescapable concern. This concern for humanization leads to the recognition of dehumanization not only as an ontological possibility, but as an historical reality. As an individual perceives the extent of dehumanization, he or she may ask if humanization is a viable possibility. (p.1)

As a result of the desire to adopt humanism, education was therefore regarded as a means to an end with the end being the achievement of good by mankind. Education was therefore used as vehicle for the confirmation, authentication and spread of the humanism project (Zucca-Scott, 2010). The humanist orientation of education is well documented. The proponents of a humanist curriculum such as Aikenhead (2006; 2007) have praised how the approach would be the best alternative to what they regard as the pipeline ideology of education that has tended to lack diversity. As such, the adoption of humanist ideology in science education has been attributed to the deficiencies that have been noticed in the science current. These deficiencies include the steep decline in student enrolment in science subjects (Dekkers & De Laeter, 2001; Hurd, 1989; Osborne & Collins, 2000), the incompatible and sterile nature of the curriculum to the learners' experiences that deny them any relevance (Gaskell, 1992; Milne & Taylor, 1998; Osborne & Collins, 2000; Reiss, 2000), and the lack of meaning in the mythical manner through which the curriculum was presented (Anderson & Helms, 2001; Hart, 2002).

Having discussed how humanism found its way in education and science education above, I now need to explore how this manifested in the South African Life Sciences curriculum. In order to explore how the pro-humanism is embedded within Life Sciences as a subject, I shall engage with The Curriculum and Assessment Policy Statement (CAPS): Grades 10-12 Life Sciences (Department of Basic Education, 2010), which is the current curriculum for the subject. From the curriculum document, I extract the information that is illustrated in Table 1 below. This information is the one within which aspects of the climatic change planetary boundary are found.

Table 1: Curriculum statement on climate change (Department of Basic Education, 2010, p.51)

TOPIC	**CONTENT**
Human Impact on the Environment: Current Crises for Human Survival: Problems to be Solved Within the Next Generation	Causes and consequences of the following (relate to conditions and circumstances in South Africa): • **The atmosphere and climate change** - carbon dioxide emissions; - concept of 'carbon footprint' and the need to reduce the carbon footprint; - deforestation; - greenhouse effect and global warming: desertification, drought and floods; - methane emissions; - ozone depletion.

A general overview of Table 1 above shows that the focus of the curriculum is on human actions and responsibilities. For instance, the topic deals with the human impact on the environment with a particular focus on how humans are geared for survival through their generations. On the right side of the table is the content that has to be covered. A close look at this content also indicates that it is humanistic-oriented as well. For instance, all the aspects are presented as either effects or consequences of human activities, in the process regarding all the nonhuman entities involved as inert and passive. The problem with this presentation and outline of the content in this way, is that by not expressing the events such as deforestation, as unfortunate and undesirable effects of human activities, they are actually presented as if they are indispensable and necessary trophies for mankind. The nonhumans are presented as inert objects which are acted upon by the humans. The aspect of them possibly having agency and being able to respond actively to interactions is disregarded. This in essence is a humanist orientation that has to be addressed.

An analysis of the Life Sciences curriculum gives further evidence of the pro-humanist orientation of the subject. For instance, the given purposes of the subject clearly confirm it. The purposes are as follows (Department of Basic Education, 2010, p.12).

(i) Development of scientific knowledge and understanding

Scientific knowledge and understanding can be used to answer questions about the nature of the living world around us. It can prepare learners for economic activity and self-expression. It lays the basis of further studies in science and prepares learners for active participation in a democratic society that values human rights and promotes acting responsibly towards the environment.

(ii) Development of science process skills (Scientific Investigations)

The teaching and learning of science involves the development of a range of process skills that may be used in everyday life, in the community and in the workplace. Learners can gain these skills in an environment that supports creativity, responsibility and growing confidence.

(iii) Development of an understanding of the roles of science in society

Both science and technology have made a major impact, positive as well as negative, on our world. Careful selection of scientific content and use of a variety of ways of teaching and learning science, should promote understanding of science as a human activity as well as the history of science and the relationship between Life Sciences and other subjects. It also helps learners to understand the contribution of science to social justice and societal development as well as the need for using scientific knowledge responsibly in the interest of ourselves, of society and the environment. Understanding science also helps us to understand the consequences of decisions that involve ethical issues.

An analysis of the purpose of Life Sciences as a subject as stated in the curriculum shows that the subject in no way allows the voice of the muted (non-living) within the collective to be heard. All three given purposes are focused towards the understanding and enhancement of life, particularly human life. I argue that the way the Life Sciences

curriculum is planned and organised is humanistic and as such lacks sufficient democratic attributes to let learners understand Life Sciences as a subject that would help them to understand life in a democratic manner. I further argue that by being anthropocentric, the Life Sciences curriculum does not present democracy in a way that is inclusive of the non-human living and the non-living others. This prevents the development of a comprehensive and all-inclusive understanding of democracy that is not founded on the binarisation of the human and the nonhuman. In that manner, the curriculum fails to pick up on the issues of the Anthropocene which it should. Consequently, it fails to recognise the being-hood of the other entities that are not human and by being segregatory like that it fails to be democratic in the broader sense argued here. It is therefore a question of how democracy may be adequately addressed within the Life Sciences pedagogy and curriculum, with particular reference to the issue of the Anthropocene.

I have so far explained how the humanist orientation of education in South Africa manifests in Life Sciences. I have further explained how such a manifestation of humanism in Life Sciences implies a human-centred notion of the subject. In the next section I am going to look at how education takes place within the Anthropocene. In an attempt to address the issue of science teaching and learning within the Anthropocene context, Inkpen and DesRoches (2019) have carried out a study where they sought to find solutions to the burning issue. Their main finding is that due to the nature of the Anthropocene which tends to be based on a combined narrative that transcends the sciences and the humanities, it therefore becomes essential that an Anthropocene science be developed and integrated in the curriculum. They argue that such a science should be based on questions regarding how a transdisciplinary approach may be developed in order to address the Anthropocene. An interdisciplinary approach would include the effort of both natural and social scientists and has been hailed in the literature (Bostic 2016; Bostic & Howey 2017; Castree, 2014; Castree, 2016; Ellis et al. 2016; Ledford, 2015; Rylance 2015) as being of profound importance in addressing the Anthropocene. This view is emphasised by Inkpen and DesRoches (2019) below:

> …such discussions exemplify how recent changes within science justify rethinking a prevailing image of how science is done, and with it, the working

> relationship between scholars in the humanities, natural scientists, and social scientists.(p.2)

This new suggestion about the teaching and learning of science is advocating for a revamped and redirected ontological refocus. As advocated by Andersen (2016) this would mean a call for the abandonment of the canonical foundations of science, especially the tendency of parcelling scientific knowledge into fixed opaque disciplines. There has to be a paradigm shift in order to address issues of the Anthropocene. The conceptualisation of the image of science has to change and address critical deficiencies such as the common belief in science that the social and the natural are distinct (Inkpen & DesRoches, 2019). This discrepancy has also been pointed out by Latour (1991) in his work where he disputes that humans have ever been modern, and where he proposes the flattening of the plane between the social and the natural. Similar sentiments have also been shared by Corlett (2015):

> …if humans are now the dominant ecological force on the planet, then it is impossible to separate 'human' and 'nature' in the way that conservation has traditionally tried to do.(p.39)

Corlett is arguing above that the conception of the Anthropocene as a human force brings tremendous changes to natural systems such as the climate. As a result, the previously held lack of interconnectedness between the natural and the social has to be disregarded, and a new approach that emphasises the material interconnectedness of the two has to be ushered in.

The demand for a new approach in the teaching and learning of science within the context of the Anthropocene has been described by Inkpen and DesRoches (2019) as a new, different account. They argue that this new, different account would usher in a new status quo consisting of thick concepts that contain both descriptive and normative elements. This new dispensation would ensure that science not be divorced from social values again, and because of that, the addressing of Anthropocene would become a possibility. In conclusion as reiterated by Inkpen and DesRoches (2019):

> Moving forward, natural scientists need to more fully embrace their colleagues in the social sciences and humanities who are specifically trained to deal with such issues.(p.4)

This moving forward that is being suggested by Inkpen and DesRoches is what this study seeks to do here: the bringing in of democracy, which is often regarded as a social science concept, to deal with the Anthropocene which is a concept within the natural sciences. The integration of democracy would essentially remove the boundaries between the natural and social. The removal of such boundaries would do away with situations during which humans discriminate against the nonhuman. Nonetheless, there is a need for me to explore what exactly I mean by democracy in this case, before I suggest how it may be integrated in the teaching and learning of Life Sciences. Conceptualising democracy is what I am going to do in the next section. But just as a spoiler alert, to conceptualise ways of introducing democracy into the subject, the thesis would take a journey through which it introduces critical posthumanism as a theoretical framework to guide how democracy may be introduced through education. This agrees with Dewey's (1980) views that education is the midwife in the delivery of democracy.

1.6 TOWARDS AN UNDERSTANDING OF DEMOCRACY

In this section I am going to explore the concept of democracy. To achieve this, a brief overview will be provided of the concept. I shall then discuss how democracy is a humanist concept, thus in a way contributes towards the Anthropocene. I shall end the section by discussing how the concept of democracy could be re-invigorated in order to address the pedagogical outlook.

1.6.1 Democracy: An overview

To explore the possibilities of integrating democracy in Life Sciences, it would be necessary to first explore what is meant by the term democracy itself. In the literature (Bobbio,1987; Dahl, 1956; Sartori, 1965; Schumpeter, 1962; Woods, 2005) the concept of democracy is one of the most contested when it comes to definition. As explained by Woods (2005) this points towards the possibility of the use of a multiplicity of indicators that point towards democracy.

According to Dewey (1916) democracy should simply be regarded as a way of life of a people that is informed by the interrelatedness of the people's perceptions,

assumptions and common shared experiences. A key component of Dewey's definition that has direct relevance in this study is the issue that democracy is about living together within a common world. Living together in such a manner essentially means sharing a number of attributes common within the common world. The term "living" must, however, be used with care. It has the potential to mute the participation of the non-living. I therefore suggest that democracy should simply be defined as being together with.

Munck (2016) has mentioned that in its simplest form, democracy is a synthetic platform composed of political freedom and political equality. Munck's definition brings in another parameter: *politics*. In general, politics is the science of governing (Lauth, 2015). Munck elaborates, however, that though democracy considers individual participation, under no circumstances should it lead to situations whereby the majority would turn the political freedom and equality of the minority into mere formality. He then goes further to look at democracy as simply the value of freedom. This freedom is aligned with Rousseau's (1997) view of freedom which regards it as one's obedience to self-prescribed law. This self-prescribed law would be informed by the general law that governs everybody. This view is regarded by Galston (2000) as value pluralism. Based on that democracy is the ability to enjoy individual freedom without undue interruption to and from others, and within the equally-applied jurisdiction of the law (Dagar et al., 2018).

In his analysis of democracy Woods (2005) places democracy in four categories as explained below. He termed the first category of democracy liberal minimalism. He explains that this category of democracy deals with protecting the individual citizen from oppression and unjustified ruling from other citizens. As such the focus in this category is that of minimal participation and the promotion of the liberty of the individual. It therefore focuses on the justifiable equality of all individuals in terms of political rights and choice of leaders. As elaborated further by Woods (2005), individuals are regarded as mere consumers of the democracy.

Woods termed the second category of democracy civic republicanism. He emphasised that this involves citizens' well-being and level of participation in both civic and political life. It explores the extent to which common good would be achieved by the individual

ahead of personal interests within the community. As elaborated by Woods (2005), this category emphasises the need for the development of dialogue between the individual and the leadership within communities.

The third category of democracy according to Woods is deliberative democracy. As the name suggests, this category is solely dependent on the need to maintain harmony within diverse and heterogeneous societies. Woods emphasises that this harmony is sustained through a warm reasoned dialogue mechanism that is between individuals and the leadership. He goes further to mention that this category of democracy is regulative and seeks to deal with misunderstandings and conflict in a way that is inclusive of all individuals within a society. Such a way would seek to respect diversity and go against any form of inequalities that may arise within a society (Woods, 2005).

The fourth and final category of democracy is developmental democracy. As explained by Woods (2005) developmental democracy focuses on the realization and scouting of human and individual potential. The underlying assumption is that through democratic participation individuals develop positive attitudes fostering positive development of their communities. Developmental democracy as such seeks to enhance the development of human capacities and potentials within a society where each individual has a moral obligation to do the best for the development of both the self and the community (Woods, 2005). Woods brings in a further dimension of how through developmental democracy individuals come to enhance and influence each other's development through the realisation of social justice. The focus of developmental democracy is thus the collaborative realisation of human potential as a way to satisfy essential human interests (Woods, 2005).Having gone through a brief overview of what democracy is, it is necessary to explore the importance of democracy in the teaching and learning process in general, and particularly in the teaching and learning of Life Sciences as a subject.

1.6.2 The importance of democracy in education

To have an elaborate metaphysical analysis of democracy in Life Sciences there would be a need to look at democracy in education first. Şanlı and Altun (2015) have defined democratic education as the process of educating society through the

transference of the principles and rules of democracy. They elaborate that the transference must be done in an open and transparent manner, and in situations and contexts that manifest in democracy itself. This view is alluded to by Edwards (2008) who reiterates that the success of a society in being democratic is totally dependent on the extent to which its education is democratic.

From another angle, in their analysis of the concept of democracy in education, Hartnett and Naish (1993) have mentioned that education is tied to the concepts of politics and power to the extent that their composition is the one that has the potential to breed the concept of democratic education. They go on to explain the profound and underlying core of democracy is the ability to co-exist. The co-existence under discussion can be both physical and conceptual; physical in the sense that it might imply the sharing of physical space between entities within a given society. This view alludes to Latour's concepts of composition and collective. From a conceptual point of view, the co-existence implied in the statement of Hartnett and Naish (1993) is that of tolerance of the difference between opinions. Thus, democracy in this case implies that irrespective of the difference in views, the views are nonetheless juxtaposed. This dimension emphasises the need for tolerance and compromise with regard to how things are viewed. In another way, its references to the tolerance of views also implies to the views of the voiceless.

The role of democracy in education is clear from Dewey's (1980) assertion. He mentions that democracy needs to be transformed from generation to generation and to do this is the role of education. Dewey's views place education at the centre of the transmission of democracy across generations. Democracy is generally associated with freedom, social justice, fairness, equitable citizenship and the rule of law among others. Though it takes various forms, democracy is often also associated with citizenship. However, there has to be caution in the application of the term citizenship which is humanistic in nature. Citizenship in this case should relate to both human and nonhuman entities within the collective.

The importance of democracy thus, is linked to its emphasis of the inclusive sharing of both space and ideals within a common world. Democracy as mentioned by Latour (2007) aims to bring a world that has no boundaries between the entities, that all the

entities care for, and in turn also get sustenance from. Democracy emphasises the co-existence of both the human and nonhuman within the collective, and in doing that it seeks to allow all the voices to be heard for the achievement of common good on one hand, and also for the progress of the common world. In that way, democracy seeks to be inclusive to all and make sure that no entity is excluded.

The foregoing discussion of democracy has highlighted some very important characteristics of the concepts that are important for this study. For instance, the discussion has highlighted critical issues such as how democracy fosters the need for a co-existence of all entities within a collective. The co-existence is very important as it promotes the companionship between human and nonhuman that is desperately needed within a collective. The discussion has also highlighted that democracy promotes both morality and inclusivity among the entities within a common world. Despite these very crucial contributions of democracy, there are, however, still some shortfalls. In that case, democracy as a process remains generally human-centred. This is discernible from its failure to address issues such as the binarisation between the human and the nonhuman. I argue that these adequacies of the current conceptualisation of democracy are not enough to address the issue of the Anthropocene. These shortfalls shall be addressed when democracy is extended to the nonhuman entities within the collective, in the teaching and learning of Life Sciences in the forthcoming chapters.

1.7 RATIONALE FOR THE STUDY

In this study, the intention is to explore ways through which a notion of democracy which includes nonhumans may be integrated into the teaching and learning of Life Sciences. Before the ways through which this may be achieved, it is important to justify why democracy must be integrated into the teaching and learning of Life Sciences.

The integration of democracy in education has been very minimal and a contested field (Darling-Hammond, 1996). Democracy has generally been regarded and considered to be a social science issue and as such was not addressed in the Life Sciences. In this study the posthumanist argument is followed, that wants to remove the boundary between nature and the social (Latour, 2007), and human and non-

human beings (Mulhall, 2013). By doing this, the author seeks to bring democracy into the teaching and learning of Life Sciences. This would essentially allow the learners to understand the subject and thus be in a position to comprehend and contribute to debates around issues such as global warming, genetic engineering, cloning and other related issues that may never be easily understandable in the teaching and learning of Life Sciences.

The introduction of concepts such as democracy in Life Sciences would also give learners an opportunity to understand the essence of critical education. Critical education would be essential particularly in their understanding of socio-scientific issues that generally remain both elusive and controversial. Such issues in Life Sciences include organ donation, sperm and ova donation, feminism, transgender, the Anthropocene, and so forth. All these issues have to be addressed in Life Sciences as the key subject that deals with the relationship between the living and non-living, including the shared roles and responsibilities that they have within the environment.
In their thesis on how posthumanism may be brought to education, Snaza et al. (2014) have indicated that issues such as posthumanism have to be brought to the attention of learners so much so that they may understand that schools in general and learning in particular have both latent and explicit connections with the nonhuman world. It is their further argument that failure to let learners appreciate the presence of other non-human entities would continue to support humanism during teaching and learning. As I have suggested above, humanism deliberately yet mistakenly places humans at the centre of the universe when in fact the universe is a heterogeneous network comprising of the human, non-human, living and non-living entities existing together ecologically. By placing humans at the centre of the universe, humanism misses posthuman ethics. This is also related to the need for the observance of ethics in the way that science is operated by mankind (Willmott,1998). This is elaborated below by MacCormack (2016:1) when she talks about posthuman ethics:

> Posthuman Ethics asks not what the posthuman is, but how posthuman theory creates new, imaginative ways of understanding relations between lives. Ethics is a practice of activist, adaptive and creative interaction which avoids claims to overarching moral structures. Inherent in thinking posthuman ethics is the status of bodies as the site of lives inextricable from philosophy, thought,

> experiments in being and fantasies of the future. *Posthuman Ethics* examines certain kinds of bodies to think new relations that offer liberty and a contemplation of the practices of power which have been exerted upon bodies. The privileged site of *Posthuman Ethics* is historically and philosophically the oppressed site of life which does not register as entirely viable within humanist operations of knowledge, power and majoritarian systems.

Issues such as the Chernobyl nuclear disaster call for the close analysis of the relationship between humans and non-humans and the *translative* processes between them with particular respect to the continued sustainable existence of both (Tsing, Swanson, Gan & Bubandt, 2017)

It should be investigated that the integration of democracy in science teaching and learning removes the boundaries that scientists have historically strategically placed between the social and the natural. This would essentially open broader approaches to the understanding of the ecological relations among the human and the nonhuman within the universe. By assuming such an understanding, they will be able to understand the importance of democracy at inter- and intra-entity at entity level. It is such an understanding that would allow them to appreciate issues such as global warming, nuclear power generation, air pollution among many others, all of which affect their day-to-day lives as individuals as well as nations and the globe at large. Beyond the understanding and the appreciation of democracy, the learners would also be able to develop a very different relationship with other entities, human as well as nonhuman.

A number of contributions are expected from this study. For instance, the work on democracy in relation to how it may be infused into pedagogy through a critical posthumanist approach has the potential to contribute towards the debates and discussions regarding the rationale, aims, purposes and nature of education. A typical point of departure might be regarding how education might be used to contribute towards the understanding of how materiality critically connects human to human and also to nonhuman in the process potentially expanding the concept of democracy within and without education. Key issues such as the realisation and recognition of intra- and inter-entity democracy could contribute towards the wide understanding of

how collectives work within the community. By intra-entity democracy I mean democracy as it exists between entities of the same kind. A typical example would be democracy as experienced between human beings. On the other hand, inter-entity democracy would be democracy between entities that are different. A typical example would be democracy between human and nonhuman. Further to that, the thesis shall help in the understanding and expansion of the scope of political ecologism as encompassing both humans and nonhumans.

1.8 STATEMENT OF THE PROBLEM

The problem that this study seeks to address is how the humanist orientation of the teaching and learning of Life Sciences may contribute to the Anthropocene. This happens in the following way. One of the characteristics of the humanist philosophy is its emphasis on how the human is the centre of the universe. By doing that, humanism causes the binarisation of the human and the nonhuman. Due to the binarisation of the human from the nonhuman, the human regards the nonhumans as subalterns which according to Spivak (1988) are the underdogs, downtrodden, underrated and made-inferior others. The problem is therefore that the pedagogical approaches being used in the teaching and learning of Life Sciences have a restricted view of democracy.

I problematise the incidence of the Anthropocene as caused by how humans monopolise the concept of democracy to relate only to themselves. In doing that, they treat other entities undemocratically leading to problems and consequences. As such, I further seek to problematise how the issue of the Anthropocene may be discussed and understood through the integration of a broader notion of democracy in the teaching and learning of Life Sciences. This would go a long way in transforming the current pedagogical approaches in the subject which fundamentally disregard the need for the accordance of democracy to the nonhumans.

Having identified the above as the problem, this study seeks to reconceptualise a new understanding of democracy, that could be used in the teaching and learning of Life Sciences. The study therefore seeks to expand the concept of democracy to the nonhumans. By origin, the concept of democracy is entirely humanist due to its emphasis of the peaceful co-existence of humans. In that way, it does not regard the

human and the nonhuman as neighbours that should also co-exist alongside and together with each other. Democracy shall then be regarded as a state that is characterised by the equilibrium of relations between the human and the nonhuman.

1.9 THE RESEARCH QUESTIONS

The study shall be guided by the following question and sub questions. The main question is as follows:

> *How could a critical and democratic posthumanist pedagogy in the Life Sciences address the devastating effects of the Anthropocene?*

The study shall moreover be guided by the following sub-questions:

> *a. What is critical posthumanism?*
>
> *b. How does posthumanist democracy address the problematic of the Anthropocene?*
>
> *c. How could a critical and democratic pedagogy be developed in the Life Sciences?*

1.10. PURPOSE, AIMS AND OBJECTIVES OF THE STUDY

In this thesis, I seek to explore how democracy may be integrated as a key component in the teaching and learning of Life Sciences. To achieve this, the author explores how a major concern in Life Sciences (The Anthropocene) may be addressed through the recognition of the commonality of democracy to all entities within the collective. The introduction and integration of democracy shall be informed by a philosophical application of a critical posthumanistic perspective.

In summary, this study seeks to develop an understanding of how the curriculum and pedagogy of the Life Sciences could contribute towards democratic practices which include nonhumans whether living or non-living. This conception of democracy is essential in a time when the suffering of the earth, and of everything that depends on it, cannot be ignored any further (The Anthropocene). This conception of democracy therefore goes beyond inter-human interaction towards multiple entity-interaction. The Life Sciences is very well located in the reconceptualisation since within it aspects of

ecology are discussed such as the relation between humans, the nonhuman living and the non-living.

1.11 RESEARCH METHODOLOGY AND DESIGN

The methodology proposed in this study is that of philosophical analysis. Philosophical analysis is characterised by a close reading of the texts which is accompanied by a thorough and careful analysis of words, sentences and concepts, and the raising of both first order and second order questions (Sehon & Stanley, 2003). As described by Botes (2002) philosophical analysis is:

> The whole process of unfolding, exploring and understanding concepts through concept analysis. The purpose of concept analysis is to give meaning, develop, delineate, compare, classify, correct, refine and validate concepts as well as to develop measuring instruments.(p.22)

According to Burns and Grove (1993) the sole purpose of philosophical inquiry is the performance of research when using the intellectual analysis in order to clarify meanings. This method has been hailed in the literature (e.g. King, 1998) for its ability to allow students to develop independent thinking. As explained further by King (1998) philosophical analysis offers a sound presentation of knowledge and autonomy of understanding and representation to the student. As such it brings logic through the tactful introduction of deep questions and propositions as objects of analysis. Kings further mentions that philosophical analysis goes deep into the object of analysis to verify the conditions under which it may be correct and informative.

The philosophical analysis in this study shall be informed by a number of related and interweaved theories. It shall be applied as follows. To address the humanist orientation of the pedagogical approaches of Life Sciences which are fuelling the onset and perpetuation of the Anthropocene, the author therefore seeks to explore how Life Sciences may be taught and learnt following a critical posthumanist approach. To do this, I shall develop and think with a critical posthumanist theory as an alternative to humanism theory in terms of the pedagogical foundations of Life Sciences teaching and learning. The adoption of critical posthumanism in the teaching and learning of Life Sciences has the potential to bring about democracy in the manner in which the human and the nonhuman are understood, and could potentially provide a panacea to

the challenge of the Anthropocene currently being faced by the world. The understanding, appreciation and adoption of democracy by learners may be regarded as the main intended role of education whose goal according to D'Ambrosio (1990) is the achievement of equality by all within the collective. This is achieved through what Dewey (1934) referred to as the social transaction among members with the term member being inclusive of the non-human and the non-living, living and non-living entities within a collective. Despite the potential challenges and pitfalls facing this thesis as a result of its following various theoretical perspectives, as the author, my stance is that democracy shall be heeded and applied in the teaching and learning of Life Sciences through the adoption of a critical posthumanistic approach as the theoretical framework. However, a deserving acknowledgment of sources used to build these accounts shall be made.

1.12 LIMITATIONS AND DELIMITATIONS OF THE STUDY

One of the key limitations of my study would be the interpretation of my findings. This is because the findings are based on literature. In addition to that, though scholars such as Donna Haraway and Astrid Schrader are in the Life Sciences and are critical posthumanists amongst others, none of the studies has looked at the South African context in particular. In that regard, such lack of previous related studies could be one of the limitations facing the study. Nonetheless, this could be overcome through a thorough conceptual analysis with the main intention to gain an elaborate understanding of the underlying concepts. This strengthens the study due to it being explained within its intellectual tradition.

The delimiting factors in this study include the focus on the pedagogy and curriculum of the life sciences, and the development of a posthumanist perspective. Though the study is expected to be applicable to the other science related subjects, its current focus is on Life Sciences. The choice of the theories used in the study, namely Object-Oriented Ontology (OOO), Actor-network Theory (ANT), Critical Diffractive Theory and Critical Posthumanist and Democratic Pedagogy Theory (CPDPT), also delimit the boundaries of the study.

1.13 CHAPTER OUTLINE

CHAPTER	TOPIC	DESCRIPTION
CHAPTER 1	INTRODUCTION	Introduces the study
CHAPTER 2	ANTHROPOCENE	This chapter focuses on an exploration of the Anthropocene.
CHAPTER 3	CHAPTER THREE: ACTOR-NETWORK THEORY (ANT)	In this chapter the focus was on Actor-network Theory (ANT) and subsequently some relevant themes were extracted from it that and were used in chapter 6.
CHAPTER 4	CHAPTER FOUR: OBJECT-ORIENTED ONTOLOGY (OOO)	In this chapter I focused on Object Oriented Ontology and concluded the chapter by giving a concise outline of the themes that I am going to use later.
CHAPTER 5	CHAPTER FIVE: CRITICAL DIFFRACTIVE PEDAGOGY THEORY	In this chapter, I developed a Critical Diffractive Pedagogy Theory (CDPT). To develop this, I diffracted principles of Critical Pedagogy Theory (CPT) and Diffractive Theory (DT) and came up with a new view of their intra-action.
CHAPTER 6	CHAPTER SIX: TOWARDS A CRITICAL POSTHUMANIST AND DEMOCRATIC PEDAGOGY THEORY (CPDPT)	In this chapter, I synthesised and developed a Critical Posthumanist and Democratic Pedagogy Theory (CPDPT). In my working on this, I sought to use the themes that I extracted from the following chapters: Chapter 3 (Object Oriented Ontology), Chapter 4 (Actor-network Theory) and Chapter 5 (Critical Diffractive Theory).

CHAPTER 7	TOWARDS THE APPLICATION OF A CRITICAL POSTHUMANIST AND DEMOCRATIC EDUCATION IN LIFE SCIENCES: CONCLUSION AND RECOMMENDATIONS	Having developed the CPDPT in Chapter 6, in this chapter, I then sought to discuss how it may be adopted, adapted and applied in the teaching and learning of Life Sciences in order to address the challenges that I mentioned above. I achieved that through using what I singled out as the key themes of the theory. This chapter also provides a conclusion to the study as a whole.

CHAPTER 2: THE ANTHROPOCENE

2.1 INTRODUCTION

This chapter focuses on an exploration of the Anthropocene. In order to achieve this, I use the concept of planetary boundary to trace human activities from the interaction of human and nonhumans from the Holocene period to now. Such an analysis traces how the harmony that once existed between the human and the nonhuman during the Holocene period was eventually lost or at least on at the verge of being lost leading to the Anthropocene. The chapter ends by making a critical analysis of the Anthropocene including how the powerful in society have made it a burden to the subalterns (such as the poor, black, rural and women). This analysis makes it clear that the Anthropocene is more than a physical phenomenon as it explores its social implications. I will summarise the chapter by looking at what can be done to avert the catastrophic epoch's further encroachment and effects.

Humankind has survived a very stable life that was sustained by the epic period of the Holocene. As explained by Gillings and Hagan-Lawson (2014) the Holocene had a very stable offering to mankind. It was often characterised by perpetual environmental stability proffered to mankind for engagement in agriculture and extensive farming (Han, Liu, Fang, Zhang, Li & Zhao, 2007; Richerson, Boyd & Bettinger, 2001). It is this period that saw the dawn of civilisation and extensive modernisation by humanity. It can be argued therefore, that during the Holocene, there was harmonious entanglement between and among the human and the nonhuman within the environment. This harmony was ecologically stable, and the relationships between the human and the nonhuman was not characterised by one exploiting the other.

2.2 BACKGROUND AND HISTORY OF THE ANTHROPOCENE

In their analysis of the Anthropocene Zalasiewicz, Williams, Steffen and Crutzen, (2010) mention that the history of the earth is divided into geological periods. They elaborate further that each period is divided into epochs. In Table 2.1 below, I illustrate the various geological periods that the earth has gone through so far. Greater emphasis is placed on the Holocene period, which is recorded as the most significant with regard to the advancement of human progress (Kalis, Merkt & Wunderlich, 2003;

Waters et al., 2016). In the table, the major illustration is that of the Cenozoic Era and its two key sub-eras: The Quaternary Era (Age of man) and the Tertiary Era (Age of mammals) (Gibbard & Walker, 2014). The focus on these two eras is mainly due to their prominence when discussing mammals, humanity and aspects of climatic change. In this study however, the focus shall be on the Holocene sub-era of the Quaternary Era. This era which is regarded as the era of man is the time when the advancement of human activities abounded, the same advancement that has led to the Anthropocene.

Table 2.1: The annotation of the Cenozoic Era (Berggren, 1998; Head, Aubry, Walker, Miller & Pratt, 2017; Pomerol, Curry & Donovan, 1982)

Era	**Sub-era**	**Age**	**Significant and observations characteristics**
Tertiary Era (Age of mammals)	Palaeocene	65-55 Million years ago (Mya)	• Climate tropical • Modern plants appear • Mammals diversify into a number of primitive lineages following the extinction of the dinosaurs • First large mammals • Alpine orogeny • Himalayan orogeny
	Eocene	55-38 Mya	• Extensive terrestrial sedimentation • Re-glaciation in South Pole • Dawn of mammalian dominance • Subordinate position for reptiles • Moderate, cooling climate • Archaic mammals flourish • Primitive whales' diversity is seen • First grasses appear
	Oligocene	38-25 Mya	• Warm but cooling climate • Rapid evolution and diversification of fauna

			especially the mammals and modern flowering plants • Early ancestral elephants • Carnivores and ungulates become well-established
	Miocene	25-5 Mya	• Moderate Icehouse climate • Extensive glaciation in Southern Hemisphere • Orogeny in Northern Hemisphere • Modern mammal and bird families become recognizable • Horses and Mastodons diversify • First Apes appear • Whales, Apes and grazing mammals dominate • Widespread volcanism and basalt flows are seen • Notable advances in the horses and elephant families • Spread of grasslands as forests contracted
	Pliocene	05-02 Mya	• Worldwide elevation continues • Continental uplift and mountain building • Ice Age begins • Seas restricted

			• Cool and dry climate • Many of the existing generation of mammals and recent molluscs appear • Homo habilis appears • Horses and Elephants become almost modern in appearance • First known appearance of hominids (human like primates) • Large carnivores are dominated
Quaternary Era (Age of man)			
	Pleistocene	1.6-0.01 Mya	• The Era of ice ages • Glacial climate • Four great ice advances and retreats • Flourishing and then extinction of many large mammals • Evolution of modern humans • Dawn of human stone-age cultures • Volcanic eruptions destroy human populations • Cro-Magnon man – first appearance of present species

			• Neanderthal man – Palaeolithic culture • Heidelberg man – Palaeolithic culture • Formation of large-scale deserts – Sahara was formed • Planetary spread of homo sapiens over Eurasia • Extinction of many species due to ice ages • Extinction of many large mammals and birds due to humans
	Holocene	10000 years ago	• Rise of human civilization • Major habitat changes and deforestations caused by Introduction of pests and habitat destruction • Beginning of agriculture • Humans build cities • Palaeolithic and Neolithic cultures begin around 10000 BC • Copper Age 3500 BC • Bronze Age 2500 BC • Iron Age (1200 BC) • Man uses iron implements in 1350 BC • Youthful landforms, high relief

Based on the information that is illustrated in Table 2.1 above, the rise of human civilisation is associated with the Holocene era. As such, the issues of the Anthropocene are discussed within a particular focus on the activities that took place during the Holocene era. What is however very significant are the transactions that take place during the transition from one epoch or period to another. As described by Waters, Zalasiewicz, Williams, Ellis and Snelling (2014) this transition between the periods and or epochs is characterised by major geological and palaeontological events. As alluded to by Gillings and Hagan-Lawson, these events often leave meaningful signatures that resist the effect of time on the geological record (Condie, 2004).

An analysis of Table 1 above shows that traces of human-induced signatures can be traced back to around 8000 years ago (Ellis, 2011). In essence, human influence on the geological scale can be traced back to the Holocene period. This is because the Holocene period provided sufficient stability in terms of its environmental outlook to the extent that a wide spectrum of human activities ranging from farming to urbanization were sustained. The Holocene epoch has been described as being characterised by very stable weather and climatic patterns (Rioual et al., 2001) with very few unexpected fluctuations. The reliable weather patterns have driven mankind towards stable life forms (Gillings & Hagan-Lawson, 2014; van der Leeuw 2008).

The stability of the Holocene period as mentioned above has provided both comfort and desire for further exploration by mankind. This perhaps saw the onset of the modernisation of communities characterised by the less controlled use of natural resources to meet the expanding and diverse needs of mankind (Dora et al., 2015; Richerson & Boyd, 2001). The modernisation mentioned here refers to the advancement in thinking by humanity, and how that advancement led to the discovery of technology that would enhance their productivity. This is partly attributable to the population increases that came with higher demand for resources such as food. However, with the modernization also came the unlimited demand for energy, the wide sharing of matter and further development. Consequently, the wide-spread alteration of the earth's environmental and biogeochemistry started (Gillings & Hagan-Lawson, 2014), in the process pushing the whole earth scenario into rampant unpredictability.

Due to the continued benevolence of the Holocene, the earth systems eventually became overwhelmed. At this point, humans started to separate themselves, and as they do so, they relentlessly started to place themselves above all the other entities within the environment. Humanity began to regard all the others as a resource that would be available to themselves for use in ways that they deemed necessary. It was at this point that the harmony that had been experienced in the environment was lost. As a consequence of the excesses of human activities, the carrying capacity of the earth as an ecological system was eventually at the verge of being exceeded. This downside has seen the onset of the Anthropocene. The details surrounding the Anthropocene are still neither very clear nor agreed upon (Olsson, Moore, Westley & McCarthy, 2017). Nonetheless, there is a major consensus that positions the overwhelming event (Steffen, Crutzen & McNeill, 2016) that characterises the final phases of the Holocene, the Anthropocene set the pace, and rolled into action. Figure 1 below illustrates some of the activities of humanity that have set the Anthropocene into motion. The issue of global warming is such a haunting issue to humanity that it has developed as they continue to expand their modernity during the Holocene.

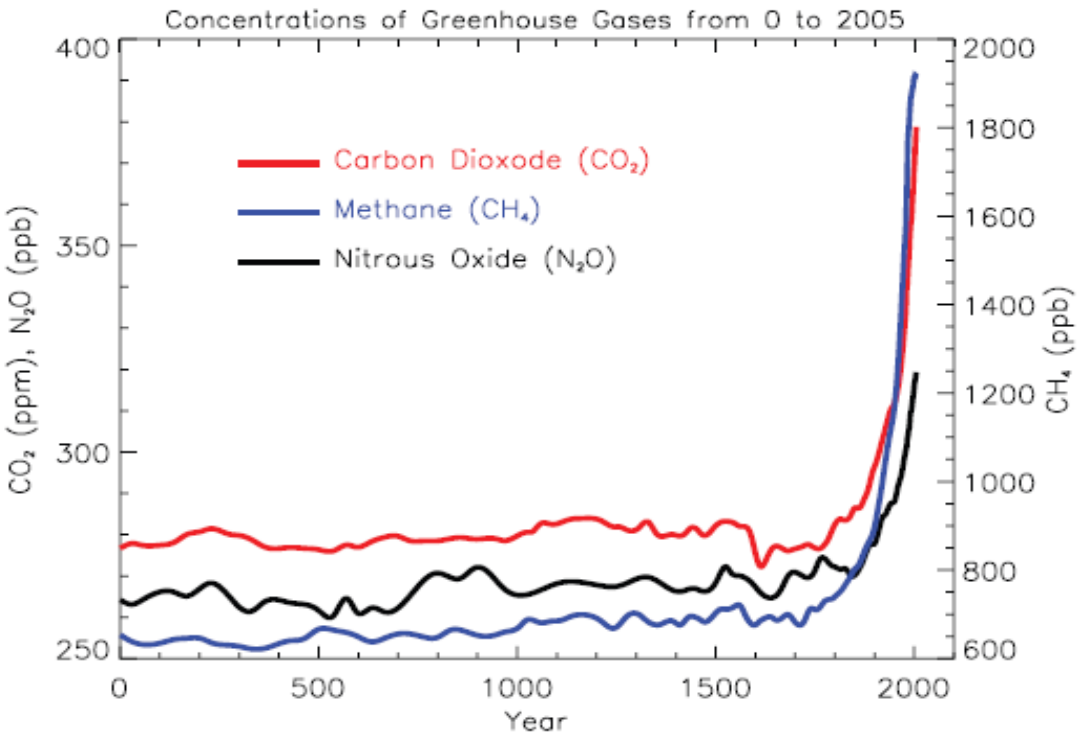

Figure 1: How humanity triggered the Anthropocene through releasing greenhouse gases (IPCC,2007, p.1)

There is therefore a proposal that since then, the earth has moved into another epoch - the Anthropocene (Crutzen, 2002; 2006; Steffen et al. 2007), which is often described as the age of man (Gillings & Hagan-Lawson, 2014).

The term Anthropocene which has currently become a buzz word in the discussions of the earth systems was suggested by Paul Crutzen and Eugene Stoermer in 2000 (Crutzen & Stoermer, 2000; Crutzen, 2002). It came after their observation that human activities had propelled the earth into a new geological era. They concluded that this new geological era involves how humanity radically brings about massive alteration to the earth's natural systems and cycles (Zalasiewicz, Williams, Steffen & Crutzen, 2010). Human activities that led into the Anthropocene include more mechanised farming which included the use of non-biodegradable chemicals to increase agricultural yields. As such, the onset of the Anthropocene is associated with the industrial revolution and a boom of manufacturing in the world, especially the developed world (Zalasiewicz et al., 2010).

An astounding characteristic of the Anthropocene is the manner in which it is compared to earlier equally massive planetary scale changes of the earth, such as those of the ice-ages (Moore, Underdal, Lemke & Loreau, 2001). Due to this comparison, the actual onset of the Anthropocene (Lewis & Maslin, 2015; Smith & Zeder, 2013) has been much debated. Some scholars argue that the activities of humanity probably took place over a very long time to yield such an enormous force and effect comparable to natural hazards. This view however could be disagreed with. For instance, the acceleration that has taken place over the past 2000 years has been very fast to the extent that it has led to the suggestion that perhaps not so much time is needed for the progression of the Anthropocene. This line of argument posits that there is a likelihood that the rate of acceleration of the Anthropocene might be influenced by the extent to which mankind have managed to exacerbate their powers through the harnessing of other entities such as technology. For instance, humans have succeeded to associate with technologies in order to collect powers from the others. In that case, the acceleration of the Anthropocene ceases to be directly influenced by human action, but was probably influenced by the actions of a collective that includes the association of the human and the nonhumans. Though there is a general consensus that we have since found ourselves in the Anthropocene, there is

a need for us to explore, analyse and make conclusions regarding the veracity of such claims. For instance, there is a need for evidence regarding: (i) what changes are there between the previous epoch (the Holocene) and the supposed epoch (the Anthropocene); (ii) the changes in terms of atmospheric conditions, biotic conditions, and environmental conditions; and (iii) the potential changes to expect in the future (Gillings & Hagan-Lawson, 2014). The next section is therefore dedicated to the evidence and challenges of the Anthropocene.

2.3 EVIDENCE AND CHALLENGES OF THE ANTHROPOCENE

The onset of the Anthropocene is often debated (Brondizio et al., 2016; Chernilo, 2017). Nonetheless, what is clear is that the onset of this era started during the Holocene era, and thus marked the end of the Holocene era. The onset of the Anthropocene is characterised by how the dominant humans after having realised the generosity of the Holocene era, began to exploit nonhumans and other humans for their own benefit. By doing that, the humans have set themselves apart from the rest that they began to regard as objects that should be available for their own benefit. However, as indicated in the literature (Brown et al., 2013; Gale & Hoare, 2012) the best way for us to conceptualise and address the Anthropocene is to engage in critical thinking whereby the humans are taken back to the collective from which they had separated themselves, and be placed as equal objects that exist in the general collective of the global ecological system in a commonality with other human and nonhuman objects. This aspect of object oriented ontology shall be discussed in Chapter 3 ahead. By doing that, we want to open opportunities for the achievement of an uncompromised analysis of the roles that we play, and the extent to which our actions and those of other objects potentially contribute towards the Anthropocene.

The concept of planetary boundaries is very important in the exploration of the Anthropocene phenomenon. This concept is a yardstick that could possibly be used to identify the point during the Holocene era when humanity went rogue and started to engage in acts of depleting other entities. As explained by Rockström et al. (2009), the planetary boundary is an asymptotic imaginary line that represents a boundary within which human activities are sustainable to the threshold of the earth systems, and outside which the earth systems become overwhelmed, and thus transgressed. The

planetary boundary concept is therefore an attempt to explore how human activities during the Holocene have set pace for the Anthropocene. This occurs by means of analysing traces of human activities that have characterised the tendency of humanity to harness and exploit the other entities for their own benefit, while this has simultaneously led to an avalanche of environmental challenges. The concept places the boundary between the egalitarianism and harmonious co-existence of the human and the nonhuman entities within the environment before and after the onset of the Anthropocene. It does this by singling out the most important interactive encounters between the human and the nonhuman that are key markers of the transition from the Holocene to the Anthropocene.

From another angle, the concept of planetary boundary transgression is thus based on the position of the boundary's tipping point. This view is alluded to by Gillings and Hagan-Lawson (2014) who have mentioned that the tipping point of a planetary boundary lies at the centre of the level of sustainability of each planetary boundary. They define the tipping point as the point beyond which the threshold of the earth systems is lost and thus the onset of damage and trouble. This is the point beyond which irrecoverable and irreversible damage is experienced, and the global systems become characterised by uncertainty and possible peril (Gillings & Hagan-Lawson, 2014).

The concept of the planetary boundaries is a brainchild of Rockström and others who founded the Stockholm Resilience Centre (SRC). The rationale is explained below by Selbekk (2014):

> In 2009, SRC suggested a new way to work towards a global sustainability, presenting the work done by 28 different scientists, with the Executive Director for SRC Johan Rockström as lead author. The proposition consists of nine different categories, where each category represents a global environmental issue, each with their own boundary for safe operation for sustainability.(p.17)

The nine different categories that are indicated by Selbekk above, are the planetary boundaries. The planetary boundaries as further described by Rockström et al. (2009) are an illustration of some safe operating space within which human activities would not offset the sustainability of the environment. When the human activities exceed the

sustainability of these environmental parameters, a process of transgression ensues. In essence, a planetary boundary has two aspects to it: it has the safe operating zone and the transgressed zone. The safe part of the boundary represents the Holocene era, while the transgressed part represents the Anthropocene. This is perhaps a solution to the aspect raised in the literature (Brondizio et al., 2016; Chernilo, 2017) that the exact onset of the Anthropocene is a debatable issue. The planetary boundary would thus be used to identify a critical area where the human and the nonhuman interacted, which interactions would have taken place and the effects of such interactions. What is clear is that if there is sustainability within a planetary boundary, then that means that boundary is still within the Holocene. On the other hand, where there is depletion within a planetary boundary, then that planetary boundary would have transitioned into the Anthropocene. Any transgression of the planetary boundary would lead to the devastating effects associated with the Anthropocene (Gillings & Hagan-Lawson,2014; Rockström et al., 2009). As a concept, the planetary boundary is categorised into two: boundaries with thresholds and boundaries without thresholds. The two are illustrated in Figures 2a and 2b below.

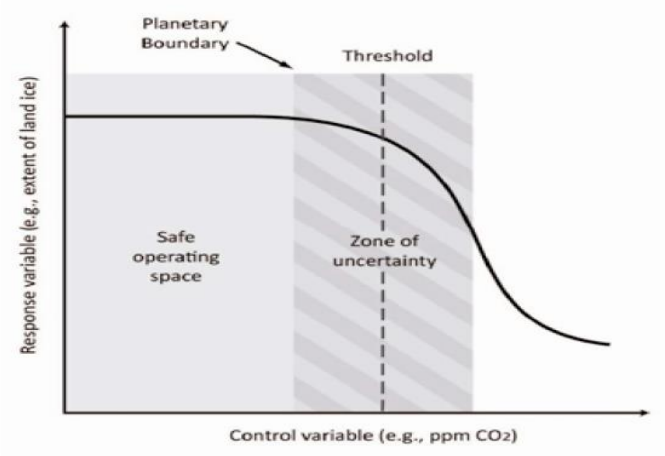

Figure 2a: Planetary boundary with a threshold (Rockström et al., 2009, p.4)

In Figure 2a is an illustration of the planetary boundary concept with a threshold. As can be seen in the figure, there is a safe operating space and at the very end of it lies the threshold point. The threshold point itself is the midpoint of a zone of uncertainty. The planetary boundary itself is depicted as a tipping point at the end of the safe operating zone. Any activities beyond the threshold may be catastrophic.

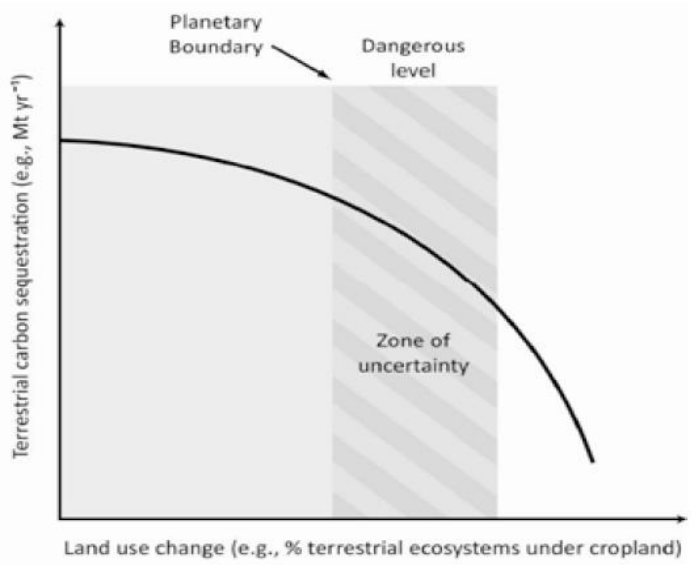

Figure 2b: Planetary boundary without a threshold (Rockström et al., 2009, p.4)

In Figure 2b above is an illustration of a planetary boundary without a threshold. In this case, though the tipping point is not easily discernible, it is however still understood that there would be consequences if the planetary boundary is transgressed. Like in the case with a threshold point, there is still a zone of uncertainty. As explained by Rockström et al. (2009), in the case where there is no threshold point, the effect of the transgressions would be discernible in the manner in which such boundaries encroach onto the operations of other boundaries. This view is clear in the following quotation from Rockström et al. (2009):

> Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems.(p.3)

The foregoing statement gives an impression regarding the interconnectedness of the planetary boundaries. Thus, the transgression of one boundary could trigger a cascading effect on the behaviour of the other boundaries that might result in their transgression too. For instance, the transgression of the climate change planetary boundary could lead to the change in the climate of a certain area. On the other hand, the change in climate would impose new regimes of weather patterns which in themselves could also lead to the change in land use as humans try to adjust to the new climatic patterns. In addition to that, the adjustments undertaken by humans while adapting to the new climatic patterns would also lead to new realities in the state of

the global freshwater use. The pattern cascades further and further. As described by Rockström et al. (2009, p.8) nine planetary boundaries have been identified viz:

- Climate change
- Ocean acidification
- Stratospheric ozone depletion
- Atmospheric aerosol loading
- Biogeochemistry – nitrogen and phosphorus cycle
- Global freshwater use
- Change in land use
- Biodiversity loss
- Chemical pollution

The planetary boundaries are illustrated in Figure 3 below where they are categorised into three indicators:

(a) The green area indicates the safe operating space, with the boundary being the outer ring of the green area.
(b) The blue area indicates the zone of uncertainty.
(c) The red segment indicates the level that is reached.

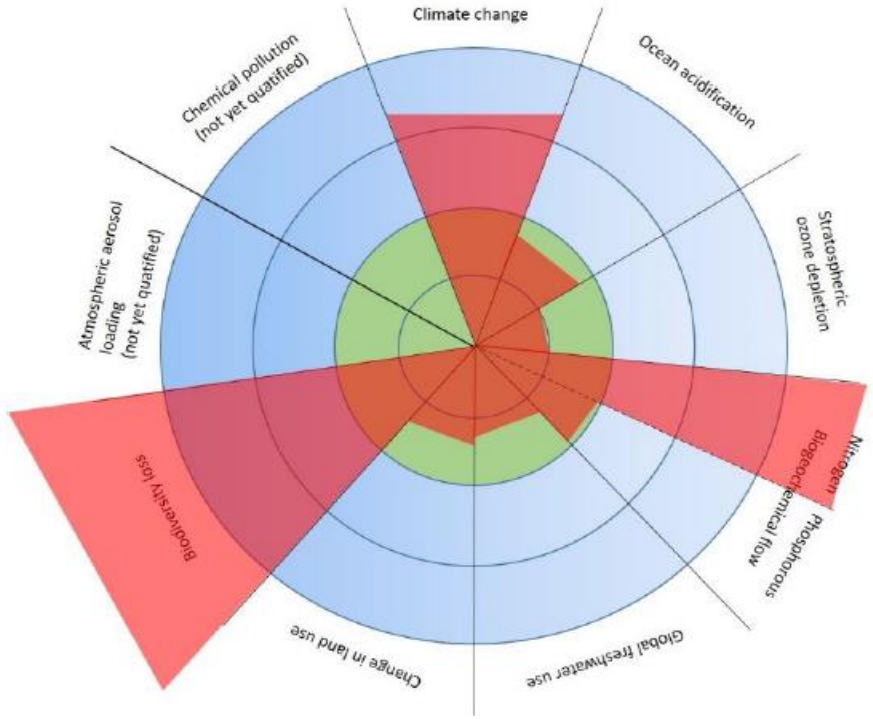

Figure 3: An illustration of the nine planetary boundaries (Rockström et al., 2009, p.24)

As illustrated in Figure 3 above, Biodiversity loss, Climate change and the Nitrogen and Phosphorous cycles planetary boundaries have already been transgressed, while atmospheric aerosol loading, and chemical pollution are not yet quantified.

An important aspect to raise at this point would be that the concept of planetary boundary is used in this study to depict how the harmony between the human and the nonhuman was lost. The planetary boundary is a measure of such a transition, and so is the measure of such a loss of harmony between the human and the nonhuman. This concept is very important in this study as it helps illuminate the issue that has been raised in the literature that the concept of the Anthropocene is a fairly elusive concept (Malhi, 2017) which is regarded by some scholars as being the current position, and by others as about to happen. The planetary boundary concept therefore allows me to trace the interaction of the human and the nonhuman, including the associated activities from the Holocene period to now. It therefore allows me to trace the harmony between the human and the nonhuman, leading to the Anthropocene. In the next section I am going to look at the Anthropocene onslaught on the earth with a particular focus on the nine planetary boundaries that are indicated in the literature (Steffen et

al., 2015; Whiteman, Walker & Perego, 2013). I am going to look at these planetary boundaries in two ways, both of which relate to the interactions of the human and the nonhuman within the environment:

(i) As evidence of the onset and advancement of the Anthropocene;
(ii) The challenges that they bring along.

2.3.1 Climatic change

One of the outright evidences of the arrival of the Anthropocene regards how the climate has begun to rapidly change during the last half century. Climatic change is one of the key and foremost planetary boundaries. The influence of human activities on the climate is well documented in the literature (Doran & Zimmerman, 2009; Gillings & Hagan-Lawson, 2014; McMichael, Campbell-Lendrum, Kovats, Edwards, Wilkinson, Wilson, ... & Schlesinger, 2004; Page, 2008; Zhen, 2021). It is estimated that through their involvement with carbon cycling, human carbon emission activities can be traced to about 800 000 years. As elaborated by Steffen et al. (2011a) the use of carbon isotope method has been used to trace the carbon signature dating back to thousands of years until the onset of the Anthropocene. What is surprising though, is that the effect of climate has not been closely monitored up to the point where it began to cause severe economic losses (Changnon, 2003; Fawzy, Osman, Doran & Rooney, 2020; Karl & Easterling, 1999; Smolka, 2006).

Though there is some debate regarding the real onset of the climatic change episode, there is nonetheless some general consensus that around 30 years ago, there were some worries and suggestions that the temperatures on earth were going up (Agnihotri & Dutta 2013). The increasing temperature was discussed and analysed with particular respect to the already exceeded boundary of 350ppm of carbon dioxide (Steffen et al., 2007; Rockström et al., 2009). The climate change due to increase in temperature was thus found to be related to the accumulating and out of bounds levels of carbon dioxide.

The influence of climatic change has the potential to influence and affect society tremendously in many ways (Dietz, Shwom & Whitley, 2020; McMichael, Woodruff & Hales, 2006). For instance, climate change could pave way for the development and occurrence of extreme weather patterns such as heatwaves, and cyclones (Coumou

& Rahmstorf, 2012; Mirza, 2003; Repetto & Easton 2010; Pétursdóttir, 2017; Rosenzweig, Iglesias, Yang, Epstein & Chivian, 2001; Scheffer, Carpenter, Foley, Folke & Walker, 2001). This observation is alluded to in the literature (Bouwer 2012; Knowlton et al. 2011), with further indications that the extreme weather patterns have the potential to be extremely catastrophic to the extent of causing a lot of casualties to living organisms. A recent example is the cyclone Idai that hit southern Africa, particularly Mozambique, Malawi and Zimbabwe. The cyclone left a trail of infrastructural destruction, destroying almost 90% of Beira and killing thousands in the three countries (Gruenbaum, 2019; Scully, 2019; World Health Organization, 2019). There have been related circumstances for instance how Hurricane Sandy has led to the rampant destruction of infrastructure and postponement of more than 20 000 flights in New York and New Jersey in the United States of America in 2012 (Abramson & Redlener, 2012; Halverson & Rabenhorst, 2013; US Department of Housing and Urban Development, 2013) costing around 50 million US dollars (Tollefson, 2012). Extreme heat-related issues have also been reported in the tropical areas with dire consequences (Bhattacharya, Pal, Biswas, Karmakar & Banik, 2012), with extreme flooding also reported in the Mediterranean regions (Siccardi, 1996). As indicated in the literature (Bouwer 2012; Linnenluecke, Griffiths & Winn, 2012) the cost incurred by the extreme weather continues to escalate, often with a devastating effect on the side of the global economy that faces high risks under those circumstances.

One of the big issues about climatic change is however its constant potential to change. As explained by Gillings and Hagan-Lawson (2014), due to this dynamism of its nature, its potential distribution, frequency and impact are often a challenge in the sense that their occurrences are random in terms of magnitude, location and direction. A typical example given Rahmstorf (2000) pertains to how thermohaline circulation activities in the North Atlantic has an effect on the rainfall patterns of North West Europe. Similar typical cases are for instance how the El Niño activities in the South American coast around December bring devastating drought conditions to Southern Africa (Fauchereau, Trzaska, Rouault & Richard, 2003; Nash, 2017; Nicholson, Leposo & Grist, 2001; Rouault & Richard, 2003; Rouault & Richard, 2005; Thoithi, Blamey & Reason, 2021), often also causing the opposite effect of flooding and related diseases (Pascual, Rodó, Ellner, Colwell & Bouma, 2000). The phenomenon is reported to have an effect of bringing weather patterns that are opposite to the normal

weather and climate of the target areas. As a result, it brings excessive rainfall patterns to normally dry regions and drought to often wet regions (Chiew, Piechota, Dracup & McMahon, 1998).

The unpredictability of climatic change as a parameter also comes with consequent unpredictability of food supply. It is reported in the literature that the occurrence of extreme weather patterns has severe implications for food production in the affected areas (Lesk, Rowhani & Ramankutty, 2016; Rosenzweig et al., 2001). The shortage of food applies to both human and nonhuman organisms. With the predicted increment of extreme weather with time (Rahmstorf & Coumou, 2011), for instance the reported increased flooding in the last 100 years (Milly, Wetherald, Dunne & Delworth, 2002), the variability of the climatic patterns has the potential to cause widespread suffering to human and non-human ecosystems, especially those that are located in densely populated areas (Hess, Malilay & Parkinson, 2008; Maspataud, Ruz & Vanhée, 2013) as thermal expansion of ice caps cause widespread melting of the ice and rising of sea levels (Craft et al., 2009; Gilman, Ellison, Duke & Field, 2008; Hoegh-Guldberg, & Bruno, 2010). Alluding to this view, Wetzel, Kissling, Beissmann and Penn (2012) estimate that with time, up to 50 million people in South East Asia alone will become refugees of extreme weather patterns.

Nicholls and Tol (2006) have added another dimension that comes with extreme weather patterns. They comment that climatic unpredictability has the potential to encroach onto other planetary boundaries. They cited examples of how flooding has the potential to disrupt fresh water supplies and destruction of biodiversity (Gillings & Hagan-Lawson, 2014) and the causing of severe forest fires as a result of lightning during storms (Nash & Johnson, 1996). All these eventualities could potentially trigger the transgression of other planetary boundaries.

2.3.2 Acidification of oceans (water bodies)

Water covers approximately 71% of the total surface area of the earth (Williams, 2000). Despite this voluminous quantity, the earth's water bodies are under a severe threat from acidification. This makes the acidification of oceans and other water bodies a critical and worrisome planetary boundary. This planetary boundary is very much

related to the release of carbon dioxide into the atmosphere due to a multiplicity of human activities. However, the key problem is that up to a third of all the carbon dioxide produced by human activities is absorbed by the oceans (Cicerone et al., 2004; Le Quéré et al., 2007; Wiedmann & Minx, 2008; Yamasaki, 2003). This culminates into a process called ocean acidification during which the absorption of the carbon dioxide by the water leads to the lowering of the pH and chemical balance of the water, especially the carbonate content (Doney, Fabry, Feely & Kleypas, 2009). The issue of ocean acidification is succinctly summarised below by Rockstrom et al. (2009):

> Surface ocean pH has decreased by about 0.1 pH units (corresponding to a 30% increase in hydrogen ion concentration and a 16% decline in carbonate concentrations) since pre-industrial times (Guinotte et al. 2003, Feely et al. 2004, Orr et al. 2005, Guinotte and Fabry 2008, Doney et al. 2009). This rate of acidification is at least 100 times faster than at any other time in the last 20 million years. (p.12)

Commenting on the effect of the acidification of the oceans, Orr et al. (2005) reiterated that experimental evidence at hand indicates that if the acidification continues, it has the potential to affect very important oceanic organisms such as phytoplankton and corals whose calcium carbonate skeletons would be affected by the growing acidic conditions leading to skeletons getting dissolved, and in the process compromising the exchange of carbon between the atmosphere and the oceans (Rockström et al. 2009). This issue has been alluded to by Hönisch et al. (2012) when they lamented how the developing and continuing acidification of the oceans has accelerated in the last 300 million years. For instance, Barton, Hales, Waldbusser, Langdon and Feely (2012) describe how ocean acidification has for long been implicated in the adverse effects that it has on aqua-cultural industry of the west of the USA, leading to immense loss of revenue.

What makes the transgression of this planetary boundary critical is the historical observation noted by Benton and Twitchett (2003) that the greatest mass extinction on record (The Permian) which accounted for the extinction of approximately 95% of species was partly caused by the acidification of oceans. It is the link to this possibility that is scary. Moreover, the economic costs involved in the reversal processes such as decalcification processes are expensive and demanding to implement (Dove, Kline, Pantos, Angly, Tyson & Hoegh-Guldberg, 2013; Schlegel et al., 2012). As explained

by Gillings and Hagan-Lawson (2014) the shielding of the economic costs has to be met in order to avert the impending extinction of some of these keystone species. Should they go extinct the global ecosystems will suffer terribly. The cost implications are aptly summarised below by Narita, Rehdanz and Tol (2012):

> Ocean acidification is increasingly recognized as a major global problem. Yet economic assessments of its effects are currently almost absent. Unlike most other marine organisms, molluscs, which have significant commercial value worldwide, have relatively solid scientific evidence of biological impact of acidification and allow us to make such an economic evaluation. By performing a partial-equilibrium analysis, we estimate global and regional economic costs of production loss of molluscs due to ocean acidification. Our results show that the costs for the world as a whole could be over 100 billion USD with an assumption of increasing demand of molluscs with expected income growths combined with a business-as-usual emission trend towards the year 2100.(p.1)

In essence, ocean acidification is affecting the tourism potential of certain regions, leading to spectacular economic losses for fisheries as well. This view is alluded to by Hoegh-Guldberg et al. (2007) who further corroborates that in addition to the cost in revenue terms, there are also costs associated with protection of the vulnerable and target regions. The protection aspect is echoed by Steffen et al. (2011b) who explains that from a close analytical perspective, it would be more sensible to protect the oceans ahead of the atmosphere, given the oceans' carbon storage and the extent to which they influence both climatic variabilities and ecosystem stability.

2.3.3 Depletion of the ozone layer

In order to understand the issues regarding the consequences of the depletion of the ozone layer, it would be essential to first have an overview of the relationship between life on earth and the ozone layer. As explained by Gillings and Hagan-Lawson (2014) the original appearance of the ozone layer on the earth is the one that came with the emergence of life. They elaborate further that the ozone layer facilitated the emergence of life through its filtration of ultraviolet rays from the sun. These rays apparently had the potential to cause extensive radiation damage to life forms. This

view is alluded to by Shea (1988) who reiterates that based on the current rate of ozone depletion of 2% per annum, there will be approximately 15 million more cancer cases, close to 2.8 million cases of cataracts cases in the USA alone before 2075. If such astounding figures are only for one country, it is unfathomable to project the global figures to be affected by similar results. Moreover, this projection is only regarding human health.

The depletion of ozone due to anthropogenic activities was first observed and reported in 1974 (Molina & Rowland, 1974). The depletion of the ozone layer is associated with a multiplicity of human activities, mostly due to industrialisation. The most specified cause of ozone depletion is the release of chlorofluorocarbons (CFCs) into the stratosphere (Elkins,1999; Gillings & Hagan-Lawson, 2014; Rowland, 1990). To get a clearer understanding of what CFCs are, the following quotation has been taken from Elkins (1999):

> Chlorofluorocarbons (CFCs) are nontoxic, non-flammable chemicals containing atoms of carbon, chlorine, and fluorine. They are used in the manufacture of aerosol sprays, blowing agents for foams and packing materials, as solvents, and as refrigerants. CFCs are classified as halocarbons, a class of compounds that contain atoms of carbon and halogen atoms.(p.1)

While the foregoing statement explains what CFCs are, it fails to indicate how they influence the depletion of the ozone layer. The effect of CFCs is given by Molina and Rowland (1974). The duo explain that though CFCs remain inert for centuries, their inert tendencies are caused by the extreme stability of the carbon, chlorine and fluorine atoms that make up the CFCs. However, over time, the CFCs tend to undergo photodissociation in the stratosphere. It is this process that could lead to the production of considerable amounts of chlorine atoms that could potentially destroy the ozone layer (Rowland, 1990).

Apart from numerous diseases caused by the thinning and depletion of the ozone layer Portmann, Daniel and Ravishankara (2012) report that this depletion is attributed to the emergence of unpredictable atmospheric circulation patterns in the southern hemisphere. Such patterns have also been linked to the occurrence of heavy rainfall

and flooding in the southern hemisphere (Baldwin, Dameris & Shepherd, 2007; Robinson & Erickson, 2015; Son, Tandon, Polvani & Waugh, 2009).

The release of CFCs is also reported to affect the flying of planes negatively. There have been incidents where the accumulation of CFCs in the upper levels of the troposphere have almost caused air traffic accidents. Note the following information from Hayes (1991):

> Pacific Southwest Airlines (P.S.A.) Flight 350 was high above California en-route to San Diego when the pilot, Capt. Richard O'Harren, detected an odourless vapor spewing into his face. A system that normally beaded rain on the windshield had failed, filling the cockpit with what was later described as a CFC cocktail. Fearing for the plane's safety, O'Harren and his first officer, William Mulcaha, snapped on their oxygen masks and landed at their destination without further incident, but not before P.S.A. officials had assured them by radio that the rain-repellent chemicals were nontoxic and harmless.(p.1)

The foregoing scenario exemplifies how the release of CFCs was detrimental to the existence and sustenance of the ozone layer. It also indicates how this has become a direct threat to the continued existence of humanity.

Following the recognition of humanity's close footing towards the tipping point of the ozone layer depletion, an international agreement was signed in Canada. This treaty is code-named the Montreal Protocol (Wigley,1988). The protocol stands as an agreement for each signatory nation to reduce the release of CFCs into the atmosphere in a bid to avert the further transgression of the boundary. It was signed in 1987 by 24 countries and the then European Economic Community (EEC) (Andrady et al., 2012; Davidson,1987). The establishment of the Montreal Protocol has been highly regarded as a positive move that has seen improvements in the levels of CFCs being emitted into the atmosphere. Caution has however been given by other scholars that keeping all the focus on the elimination of CFCs may not totally solve the ozone layer destruction debacle since chemicals such as nitrous oxide which are also equally emitted have a similar effect of depleting the ozone layer (Portmann et al., 2012; Ravishankara, Daniel & Portmann, 2009; Wuebbles, 2009).

2.3.4 Atmospheric aerosol loading

The term aerosol is used to describe particles which may be of various types that are suspended in the atmosphere. This view is alluded to by Remer et al. (2009) when they describe atmospheric aerosols as suspensions of solid and or liquid particles in the air that are ubiquitous in nature and often seen as dust or smoke particles. The authors further mention that the sources of the aerosols are both human (e.g. from burning) and non-human (e.g. salt and dust) in nature. The description of atmospheric aerosols is aptly given below by Deleva & Grigorov (2011):

> The term atmospheric aerosol encompasses a wide range of particle types having different compositions, sizes, shapes, and optical properties. Aerosols may be liquid or solid particles suspended in the air with typical diameters ranging over four orders of magnitude (approximately from a few nanometres to a few tens of micrometres). They consist of inorganic and organic components and varying amounts of water.(p.1)

Contributing to the issue of aerosols and their effects in the atmosphere Tsigaridis et al. (2006) mention that a close analysis of the phenomenon has indicated that the concentration of aerosol has doubled since the industrial revolution. The effect of aerosols has been found to be quite diverse. For instance, because aerosols are often used in the formation of clouds (Li, Niu, Fan, Liu, Rosenfeld & Ding, 2011; Kazadzis, Amiridis, Kosmopoulos, Marinou & Tsekeri, 2013), they therefore influence rainfall distribution patterns and other weather patterns across the earth (Rockström, 2009). Related climatic influential patterns of aerosols have been reported regarding the manner in which atmospheric aerosol loading has interfered and changed the timing of rainfall in East Asia (Menon, Hansen, Nazarenko & Luo, 2002; Wang, Akimoto & Uno, 2002). A typical example of this that has been cited by Ramanathan, Crutzen, Kiehl and Rosenfeld (2001) pertains to how aerosols tend to increase the albedo of the earth's surface, in the process tending to scatter solar radiation. Consequently, there would be a corresponding intense heating of the atmosphere that would be accompanied by a dry adiabatic lapse rate (Peirce, Vesilind & Weiner, 1998). When such situations occur, incidences of global warming are initiated and consequent reduction in chances of precipitation. The dispersion of rainfall chances has been lamented by Gillings and Hagan-Lawson (2014) when they comment that there would

be a consequence that one of the most densely populated places on earth would become susceptible to both unreliable and unpredictable weather patterns. Such a trend could lead to predictions of economic liability for the affected regions. These views have also been alluded to by Nasurt (2011):

> Aerosols can affect solar radiation budget in two ways; by directly scattering and absorbing solar radiation (this is known as the direct radiative forcing), and also by acting as cloud condensation nuclei thereby influencing the optical properties and life-time of clouds (this is known as the indirect radiative forcing). Aerosols tend to cool the Earth's surface directly beneath them. As most aerosols reflect sunlight back into space, they have a direct cooling effect by reducing the amount of solar radiation reaching the Earth's surface.(p.1)

Based on the foregoing description of aerosols, it becomes clear that the phenomenon has a wide influence on weather patterns, particularly the way they affect both temperature and albedo on the earth's surface. Their influence could be linked to the global warming phenomenon. Nonetheless, they have even more influences.

Atmospheric aerosol loading has also been found to have negative effects on human health. For instance, the exposure to more than the recommended levels of aerosols has led to the negative heath experiences for 80% of populations on east Asia (Afroz, Hassan & Ibrahim, 2003). Major issues have been reported in China where excessive atmospheric loading has led to health complications (Tie & Cao, 2009). Similar findings have also been found regarding how dust particles cause many health issues including the manner in which the movement of the dust particles would be concurrent with the movement of pathogens, causing a lot of diseases (Griffin, 2007). A case in point cited by Griffin is the spreading of dust from the Sahara Desert in North Africa, and the Badain Jaran, Gobi and Takla Makan deserts of Asia. Commenting on the same issue of how aerosols affect human health Nel (2005) indicates that the phenomenon causes both cardiac and respiratory diseases claiming the lives of half a million people per annum, and costing around half a trillion dollars per annum globally (Selin, Paltsev, Wang, Donkelaar & Martin, 2011).

The process of precipitation scavenging is often responsible for the removal of aerosols from the atmosphere. The process of precipitation scavenging happens when

precipitation in its various forms takes with it to the ground particles of the aerosols (Loosmore & Cederwall, 2004; Loosmore, Hsieh & Grant, 2004). The process of precipitation scavenging is however one positive effect of precipitation as it happens in situ. However, the downside of precipitation scavenging is the formation of acid rain. Acid rain is formed when the various components floating in the atmosphere are dissolved in the water droplets forming acids in the process (Schindler, 1988). The effects of acid rain have been summarily stated by Likens, Driscoll and Buso (1996).

> Long-term data from the Hubbard Brook Experimental Forest, New Hampshire, suggest that although changes in stream pH have been relatively small, large quantities of calcium and magnesium have been lost from the soil complex and exported by drainage water because of inputs of acid rain and declines in atmospheric deposition of base cations. As a result, the recovery of soil and stream water chemistry in response to any decreases in acid deposition will be delayed significantly.(p.1)

The thesis of Likens et al. (1996) thus indicates acid rain negatively affects the water itself, the air and the soil. In the process related to the effect of ocean water acidification described above, acid rain poses a lot of threats to aquatic life and ecosystems (Paytan et al., 2009).

2.3.5 Biogeochemistry - Nitrogen - and Phosphorous cycles in nature

The nitrogen and phosphorous content in nature was balanced before humanity's interference. These elements are essential in the growth and development of living things including humans. Gillings and Hagan-Lawson (2014) have noted with concern how humanity has developed artificial ways of producing nitrogen and phosphorous content in nature in order to boost their agricultural production. They reiterate further that the consequence of this uninvited intervention was the reckless manipulation of the nutrient cycles in the process disrupting their natural cycles. Alluding to the same point, Gruber and Galloway (2008) have it that with the advancement of technology geared towards the mass production of crops, humans have by now overtaken all the natural processes combined in terms of the production and fixation of these elements.

Given that mankind has indulged in massive production of these nutrients, in addition to the nutrients that are still produced naturally, the planetary boundary of the nitrogen

cycle is reported to have been transgressed (De Vries, Kros, Kroeze & Seitzinger, 2013; Rockström et al. 2009; Running, 2012). The issues regarding the boundary of phosphorus has largely natural influences. For instance, a lot of the element is released from rocks during chemical weathering (Gillings & Hagan-Lawson, 2014). The issue with this element is the hyper-sensitivity of fresh water and coastal waters to it (Carpenter & Bennett, 2011) especially regarding to how it accelerates the process of eutrophication (Elser, 2012). The unregulated release of phosphorous into the soil is also reported to be a major concern due to its potential to lead to the acidification of soils and water sources, often leading to the growth of poisonous algal populations (Anderson et al., 2008) that would lead to the disruption of tourist activities. Apart from the excessive costs that come with eutrophication often leading to billions of dollars, the release of excess phosphorus is related to the development of oceanic anoxia which facilitates massive extinction (Barnosky et al., 2011).

2.3.6 Global freshwater usage

The demand for safe fresh water to use is a universal human right (Cominelli, Galbiati, Tonelli & Bowler, 2009; Füssel, Heinke, Popp, & Gerten, 2012; Gleick, 1998). This is because water is more than a vital aspect of life. The main issue is that human activities have tempered with the natural flow and availability of fresh water to the extent that there is now a need to ensure that its availability is under regulation (Gillings & Hagan-Lawson, 2014).

It is reported in the literature that humans have essentially tampered with the water cycle in many ways (Buytaert, et al. 2006; Kuchment, 2004) to the extent that the natural order of water has long ceased to follow its natural trends. For instance, due to human activities, the flow of run-off water into rivers and eventually into the sea has been largely manipulated and compromised to the extent that a lot of rivers dry up prematurely before they get to the sea (Brown, 2007). This problem which has been described by Cominelli et al. (2009) as an invisible problem has the potential to make life very unbearable on earth especially when it is compounded by related issues such as global warming. Nonetheless, all this is happening against a background of the demand for fresh water having trebled in the past half century (Brown, 2007).

As indicated by Meybeck (2003), human activities have caused some tremendous damage to the river systems and the water quality. He indicates for instance how industrial refuse dissolved in water is dumped into rivers, in the process increasing their salinity and absolutely upsetting their ecosystems therein. Water quality has been described by Arora et al. (2017) as relating to the water salinity, water temperature, water nutrient concentrations, and dissolved oxygen all of which have a direct influence on the general usability of the water within the environment. The alteration of the water quality has a serious negative impact on food availability. A typical example concerns how water issues in large agro-based economies such as China have strong and negative consequences for food throughout the world (Brown & Halweil, 1998).

All over the world, especially in the developing countries rivers are often affected by riverbank cultivation. In a study that looked at the effect of such practices along the Mississippi over the last 200 years, Turner and Rabalais (2003) has this to say:

> Two centuries of land use in the Mississippi River watershed are reflected in the water quality of its streams and in the continental shelf ecosystem receiving its discharge. The most recent influence on nutrient loading—intense and widespread farming and especially fertilizer use—has had a more significant effect on water quality than has land drainage or the conversion of native vegetation to cropland and grazing pastures.(p.1)

The implication from the above finding is that the quality of the water from the river has been negatively affected including the load that it receives from its many streams that tend to deposit chemical waste into the river. Farming inputs such as fertilisers are also being fingered in the manner in which they tend to negatively influence the water quality (Lijklema, 1995). As alluded to by Ruhi, Catford, Cross, Escoriza and Olden (2019) such interferences have led to significant impacts on the native species found within the ecosystems often leading to the promotion of sprouting of alien species within the ecosystems. They elaborate further that this causes significant disruption of the global freshwater availability.

The cost of water resources has always been associated with an increment in temperature on the globe. Small increases in temperatures are reported to lead to a surge in the cost of the water resources (Gillings & Hagan-Lawson, 2014). For

instance, it is estimated that the cost of water is around three billion dollars in the USA alone, and a staggering 84 billion for the whole world at a temperature of less than four degrees Celsius (Tol, 2002).

Various scholars and organisations have come up to suggest that there needs to be international co-operation with regard to the perseveration and provision of fresh water (Falkenmark & Lundqvist,1998). Such moves should be effected in order to improve the lives of hundreds of millions of people not getting safe water in the third world, especially accounting for the estimated 80% of the world's population that does not have safe water (Vorosmarty et al., 2010).

2.3.7 Change in Land Use

It is general knowledge that the hectarage of land on earth is fixed, yet it has been predicted long ago that the world population is increasing at an exponential rate (Cohen,1995; Whittaker & Likens, 1975). The exponential growth of the population within the context of a fixed area of land makes the use of land something that deserves attention. The key aspect that the global populations have to address, is the availability of food. As explained by Gillings and Hagan-Lawson (2014), there are two issues that increase the demand of land viz: industrialisation and agriculture. Industrialisation necessitates a growing need for land to suffice the expansionist tendencies of mankind effected by advances in technology. This has seen for instance, first world countries engaging in neo-colonial tendencies by developing multinational companies. These businesses are spreading across the third world acquiring vast tracts of land where they set up their industries (Boussebaa & Morgan, 2014; Martin, 1982). On the other hand, extended crop production is required to feed the world's ever-increasing population with major consequences exerted on the stability of ecosystems and natural cycles like the water cycle (Sterling, Ducharne & Polcher, 2013). The issue of land use directly interferes with other critical parameters of life such as the climatic patterns so that its effect is estimated to equal the emission of greenhouse gases into the atmosphere (Gillings & Hagan-Lawson, 2014). The most discussed issue of predatory land use relates to the clearing of the rainforest (Laurance,1999; Sears, Dávalos & Ferraz, 2001) whose presence is regarded to be under threat.

The planetary boundary for change in land use is pegged at 15% (Rockström et al., 2009), while the current usage is already estimated to be around 12% (Foley et al., 2005). This is a concerning prediction, that the threshold of the boundary is on the verge of being exceeded. Mankind is about to transgress the critical boundary to the extent that by around between 2020 and 2050 a shortage of arable land is expected (Lambin & Meyfroidt, 2011; Zhao, Luo, Deng & Yan, 2007). A close analysis of the foregoing statistics gives the impression that some steps will be taken towards the conversion of marginal lands into arable land to meet the growing food budget. Echoing the same sentiments, Gillings and Hagan-Lawson (2014) mention that moving into marginal lands and converting them to land use could trigger unforeseeable complications within the ecosystems and natural phenomena such as climate, and the associated climatic change. Marginal lands are regarded as areas that are of little ecological value due to their locations and adverse climatic conditions (Peterson & Galbraith, 1932; Post, 2013). Such lands include areas that are located near swamps, or characterised by waterlogging conditions or poor fertility, and those areas that are located on the fringes of deserts. What makes the situation even worse is what Foley et al. (2005) have found in their studying of the land use patterns within the Amazon; they have found that there appears to be a rapid negative change, for instance changing from rainforest to savannah climate, and thus driving the land towards marginal value as a result of unregulated land use. These changes on the other hand, come with tremendous changes and demands that are seldom anticipated.

There have been calls the world over for the sustainable use of land (Anderson,1990; Heineke et al., 1998) with some scholars suggesting that an effort should be made to ensure that land use, especially for agricultural purposes mimic the natural ecosystem patterns to maintain the stability of such areas (Ericksen, Ingram & Liverman, 2009). The whole idea is to try as much as possible not to transgress the land use planetary boundary.

2.3.8 Biodiversity loss and extinction

The loss of biodiversity is much related to the mass extinction periods that has taken place on the earth a number of times. This is explained by Jackson (2008) below:

> The great mass extinctions of the fossil record were a major creative force that provided entirely new kinds of opportunities for the subsequent explosive evolution and diversification of surviving clades. Today, the synergistic effects of human impacts are laying the groundwork for a comparably great Anthropocene mass extinction … with unknown ecological and evolutionary consequences.(p.11458)

Based on Jackson's views above, extinction removes some and paves the way for new communities to emerge. Its most troublesome concern is the level at which it does away with the species' domains leading into extreme extinction. This view is alluded to by Gillings and Hagan-Lawson (2014) who emphasise that the biodiversity loss catastrophe took place between the major geological epochs that have occurred on earth. The main term that is used under these epoch changes is *mass extinction*. Mass extinction is defined in the literature (Jablonski,1989) as a colossal loss of species, decreasing over 75% of the times at a given time of short duration. In the history of the earth, there have been five mass extinctions in the last half a million years (Droser, Bottjer, Sheehan & McGhee, 2000; Gillings & Hagan-Lawson, 2014). The last mass extinction took place over 252 million ago (Foster & Twitchett, 2014; Shen et al., 2011), and scholars and scientists critically observe that the earth is slowly but surely approaching the tipping point of another mass extinction. Butchart et al. (2010) report that little attention has been paid to this observation. However, scientists are basing their hypothesis on this pronouncement by commenting that the earth is gradually drifting into the Anthropocene, if it is not already within it. Scholars such as Barnosky et al. (2011) have however refuted the claims of the impending sixth mass extinction theory arguing that although there is a tremendous loss of species, it has not yet reached the level of being categorised as a mass extinction. They also allude to the position that species recovery is a slow process which might take millions of years.

In their analysis of loss of biodiversity and species, Gillings and Hagan-Lawson (2014) have mentioned that there is a need for clear recognition that humans are in the driving seat of accelerating mass extinction in the same manner that the previous non-human

catastrophes did. They refer to recent history when arguing that human transgressions on planetary boundaries could become equivalent to the effect imposed by such a phenomenon as climatic change. Their views are alluded to by Tol (2002) who estimates that the increase in temperature from human activities by approximately one degree Celsius would cost the fiscus approximately US$50 billion.

2.3.9 Chemical Pollution

Chemical pollution pertains to how chemicals that are used by humanity whether deliberately or inadvertently find their way into ecosystems and cause pollution. According to Rockström et al. (2009) humanity has become so dependent on chemicals that they appear to be indispensable to their lives. These chemicals are harmful to the environment and to life in general. Humanity is thus accused of manufacturing and distributing in excess of 80 000 chemicals according to Gillings and Hagan-Lawson (2014). They explain further that this excessive use of chemicals has left a signature on the geological record. Chemical pollution has led to depositional and disposal of heavy materials and radioactive chemicals often accompanied by extreme consequences (Gillings & Hagan-Lawson, 2014). What makes the issue of chemical pollution more disturbing is the finding by Rockström et al. (2009) that due to their diversity and multiplicity it is hard to predict and estimate their universal planetary boundary. Given the extent of chemical use due to modernisation, the boundary might be on the verge of being transgressed or even be transgressed already. The implication is that humanity is possibly cruising in the dark with regard to our safety from the catastrophes of chemical pollution. From a cost estimation perspective, it is estimated that the global costs of air pollution, for instance from the oxides of nitrogen and sulphur, run into tens of billions of dollars (Fankhauser, 1995, p.2009).

Another key concern that has been raised with the issue of chemical pollution pertains mostly to those that have the potential to cause extreme damage even at low concentrations. Such chemicals have the potential to cause the alteration of glands (Diamanti-Kandarakis et al., 2009) or the behaviour of populations, such as antibiotics (Gillings & Stokes, 2012).

2.4 TOWARDS LOCATING THE RESPONSIBILITY AND CONSEQUENCE OF THE ANTHROPOCENE

In my discussion of the Anthropocene so far, I have analysed how the phenomenon has come about as a result of mankind's abuse of both the human and the nonhuman entities within the collective. Such an analysis would be very important in this study; it has the potential to broaden the understanding of the Anthropocene from being generally viewed as an outcome of the interaction of the human and the nonhuman, to a view of it as an outcome of the dominant humans and the subalterns. These subalterns include the weakened, dominated and subjugated entities within the collective, both humans and nonhumans.

Having indicated in the foregoing paragraph that the interactions within the planetary boundaries are between the dominant and the subalterns, what follows now is to identify both the dominant and the subalterns, and how their interactions have led to the Anthropocene. In his analysis of power structures within society, Guess (2006) has mentioned that the dominant in society are always the white male Christian populace. It is implied that this group would be responsible for the means of production in society, and thus for the majority of transgressions of the planetary boundaries. This group is the one that regards the other group that is outside their group. The said group is associated with the Western Hemisphere, and they are also associated with the industrial revolution. As reiterated below by Steffen, Grinevald, Crutzen & McNeill (2011c:1), the period of the Industrial Revolution is pinpointed as the beginning of the Anthropocene as well.

> … we put forward the case for formally recognizing the Anthropocene as a new epoch in Earth history, arguing that the advent of the Industrial Revolution around 1800 provides a logical start date for the new epoch.

The implication would then be that the Industrial Revolution contributed immensely towards the onset of the Anthropocene. A further argument is that given that the industrial revolution took place in the West (Mohajan, 2019; Mohajan, 2020) and the industrial revolution is documented as the source of the Anthropocene, it becomes undeniable that the West is responsible for the onset of the Anthropocene. .As such, the activities of the West are responsible for the adverse transactions that take place

within the planetary boundaries. They regard the poor, people of colour and women as the subalterns that have to relate to them in a manner of servitude. In essence this dominant group is responsible for the Anthropocene.

Having identified the source of the Anthropocene above, including the responsible group, the group that forms the burden bearers of the Anthropocene must be explored next. The burden of the Anthropocene falls on the subalterns. The Anthropocene as a consequence of the adoption of technology and other mechanisms by the dominant groups is presented as something that is inevitable to the lives of the subalterns. For instance, a critical analysis of the Kyoto Protocol (Diniz, 2007) shows that dominant countries that greatly pollute the atmosphere, such as the United States of America, refused to be signatories of the treaty. The US refuses to reduce its pollution of the atmosphere while it expects the third world countries to do so. Of course, if the third world countries refuse to abide by these conditions, some economic sanctions might be declared. The implication of this section is that the rich are responsible for the Anthropocene while the subalterns pay the ultimate price.

2.5 CONCLUSION

In this chapter I have looked at the concept of the Anthropocene. The issue of the Anthropocene is the problem that has been identified with a view to this study. In order to explore the phenomenon widely and deeply, I have looked at the planetary boundaries. The planetary boundaries are regarded as the indicators of how human activities during the Holocene have transitioned into the Anthropocene. I discussed the planetary boundaries as a measure of how the interaction between the human and the nonhuman has led to the loss of the natural balance and equilibrium that existed between them during the Holocene. As such, planetary boundaries are examples of such interactions, including how this led to unforeseen and catastrophic circumstances. For instance, the interaction between the human and the nonhuman has led to climatic change, often with very adverse effects for both within the collective. I therefore explored each of the planetary boundaries and in the process explained how humans have related with their nonhuman neighbours and the respective boundaries to initiate the onset of the Anthropocene. As part of my methodology, I argue that in order for the teaching and learning of Life Sciences to address the

Anthropocene the pedagogical approach should look beyond the human, and thus also consider the nonhumans as equal partners within the collective. This would be a possible way to address each of the transgressed planetary boundaries, and either address or avoid their respective transgressions. Having realised that humans have caused so much damage, it would be ideal if the pedagogy in the Life Sciences could find an alternative approach to address the Anthropocene. It is this approach, a posthumanist approach, that I seek to develop in the forthcoming chapters.

CHAPTER 3: ACTOR-NETWORK THEORY (ANT)

3.1 INTRODUCTION

The problem that this study seeks to address is the issue of the Anthropocene that is threatening the existence of living and the non-living on earth. As such, the second chapter focuses on a discussion of the Anthropocene as a phenomenon. My intention is to synthesise and develop a critical posthumanist and democratic pedagogical theory that could be used in the teaching and learning of Life Sciences, in order to address the Anthropocene. The approach would replace the humanist way in which Life Sciences is being taught, which I argue works towards the promotion of the acceleration of the Anthropocene. I therefore intend to work with the following theories: Object Oriented Ontology (OOO), Actor-network Theory (ANT) and Critical Diffractive Pedagogy Theory (CDPT). Though I will work with OOO and ANT as they are given in the literature, when it comes to CDPT I am going to develop this theory by blending themes from Critical Pedagogy Theory and Diffractive Theory. In order to develop the critical posthumanist and democratic pedagogical theory, I am going to extract some relevant themes from each of the three theories and blend them into one theory. So far, I have worked on the OOO theory and singled out some relevant themes that I will use in chapter 6. In this chapter I am going to work on Actor-network Theory (ANT) and subsequently extract some relevant themes from it that I will use in chapter 6 too. Though there have been some criticism of both ANT and OOO from a critical posthumanist perspective (Braidotti, 2019, Van De Tuin, 2014), during my working with both theories, I shall be informed and motivated by the views of Braidotti (2019:1) which seek to see critical posthumanism as:

> The conceptual foundation I envisage for the critical posthumanities is a neo-Spinozist monistic ontology that assumes radical immanence, i.e. the primacy of intelligent and self-organizing matter. This implies that the posthuman knowing subject has to be understood as a relational embodied and embedded, affective and accountable entity and not only as a transcendental consciousness. Two related notions emerge from this claim: firstly, the mind-body continuum – i.e. the embrainment of the body and embodiment of the mind – and secondly, the nature-culture continuum – i.e. 'naturecultural' and 'humanimal' transversal bonding.

As I have indicated above, the use of ANT in this study is to provide a background against which a pedagogy may be derived from the extraction of themes that will be used to develop a critical posthumanist and democratic theory. Originally, ANT has developed as an offshoot within science, technology and society (STS) approach (Callon, 1986; Latour, 1986; Latour, 1987; Law, 1992; Michael, 2016). At the end of the chapter I am going to discuss how the themes I have extracted from the theory could contribute towards the development of a critical posthumanist and democratic pedagogy in the teaching and learning of Life Sciences, which would be based on a rational embodiment and embeddedness.

3.2 THE ORIGINS OF ACTOR-NETWORK THEORY

In this section, I give an elaborate discussion of how ANT originated and will also analyse how it has changed over time, focusing particularly on the critique that it has faced over time, and the emergence of the After-ANT perspective. Thereafter, I shall discuss ANT from a thematic perspective based on the themes that I find essential for this study. An analysis of the origins of ANT reveals that it started as an offshoot within the broad discipline of science, technology and sociology studies (STS) (Callon, 1986; Latour, 1986; Latour, 1987; Law, 1992; Michael, 2016; Rioux-Dubois & Perron, 2016; Vicsek, Kiraly & Konya, 2016; Watson, 2007). In his work on the origins and expansion of ANT, Storni (2015) mentions that the exit of ANT from the STS movement was caused by the former theory's emphasis on the issues that are associated and infused in daily life such as ecological and social issues.

The history and origins of ANT can be traced to the early 1980s in both the United Kingdom and France, particularly at the Centre de Sociologie de l'Innovation (CSI) of the École Nationale Supérieure des Mines de Paris (Callon & Law, 1982; Fayolle & Lamine, 2013; Meret, 2018; Michael, 2016; Vicsek et al. 2016). In the literature, the pioneers of ANT are Bruno Latour, Michael Callon and John Law (Callon, 1986; Callon & Latour, 1981; Michael, 2016; Rioux-Dubois & Perron, 2016). In a further analysis, Michael (2016) mentions that the roots of ANT are also traceable back to numerous traditions and lineages including the semiotics of Greimas, Foucault's analysis of power and the micro-history of Tarde. Apart from the origins above, ANT is regarded as having been heavily influenced by the philosophical work of Michel Serres on the

rejection of metalanguage (Brown, 2002) and Gilles Deleuze's material semiotic approach (Law & Singleton, 2006).

The origins of ANT are associated with questions that had been raised in research pertaining to how science and technology could be studied. As explained by Latour (1987), there was an argument among scholars regarding what they termed the sociology of scientific knowledge that focused on how scientific knowledge was socially constructed. Consequently, they realised that there was a need to study science and technology on the basis of the relationships that manifest from the dynamism that characterise their interaction and relationship with each other. The focus of ANT was therefore on the examination of actions and the proceeding actions that take place as entities associate with each other irrespective of the nature of those entities. As explained by Callon and Latour (1981) this development was an attempt to do away with the prevalent concepts of technological and social determinism which were based on binarism in society. Scholars envisioned an inclusive theory within which both the social and the technological are addressed. As such, they came up with a socio-technical account of society. In his analysis of the development of ANT Michael (2016) has mentioned that some of the seminal works on ANT include the Latour and Woolgar's 1987 work on the ethnography of Roger Guillemin's laboratory and its associated work at the Salk Institute (Latour & Woolgar, 2013); Latour's (1988) work on the Pasteurization of France. Callon's earlier work in 1986 focused on the work that biologists were doing to undertake scallop farming in the fishing community of St. Brieuc Bay. Michael mentions that the bulk of the vocabulary of ANT has been borrowed from the Electricité de France's (EDF) project that was promoting the electric vehicle. The common factor that links all these projects was the emphasis on how the human and the nonhuman possess unlimited potential to associate and engage with each other in processes that would lead to the formation of networks.

Since its introduction, ANT has been applied in a wide range of research arenas including information technology (Quattrone & Hopper, 2006), health care management (Broer, Nieboer, & Bal, 2010), economics (Bledin & Shewmake, 2004), design management (Storni, Binder, Linde, & Stuedah, 2015) and geographical studies (Rutherford & Holmes, 2008). The wide use of ANT is associated with its broad appeal to how nonhumans could be regarded as social and as such could also be

used as viable agents in the construction and development of knowledge in society (Michael, 2016). Michael mentions that the recognition of the potential sociability of the nonhuman has been borrowed from the philosophies of Michel Serres and Alfred North Whitehead, and is the basis of the flat ontological position of ANT. Of significance to this study is the analysis of how ANT could be used to address environmental issues. The use of ANT in dealing with environmental issues has been addressed by Holifield (2009). He mentions that due to its persistence on the removal of boundaries and the development of associations among the entities irrespective of their identities, ANT has the potential to be used in such a manner that it makes the achievement of democracy an attainable goal especially in the sciences. Holifield goes further to mention that the removal of boundaries by ANT comes with the recognition of political relevance to all the entities that are found within a collective in a manner that would make all the actors homogenously interrelated while maintaining their heterogeneity without prejudicing each other. This view is augmented by Syngedouw and Heynen (2003) when they describe the role of ANT as being invokable in a manner that presents collectives as hybridized assemblages where entities are entangled. In other words, ANT comes in as an attempt to examine the world without making use of hypothesising which it regards as a process of allocating outcomes before processes have been followed (Cowan, Morgan & McDermont, 2009; Whittle & Spicer 2008). In this study, ANT is going to be used in science education, particularly Life Sciences as one of many theories that are thematically blended to synthesise a Critical Posthumanist and Democratic Pedagogical Theory as indicated earlier. As a result, the chapter is driven by the following questions that have been asked by Fenwick and Edwards (2011, p.93) regarding ANT methodology:

(a) What are the different kinds of connections and associations created among things?
(b) Which different kinds and qualities of networks are produced through these networks?
(c) Which different ends are produced through these networks?

These three questions are of essence in this study. For instance, the author seeks to use ANT themes in Chapter 7 to explore the extent of democracy that exists among entities as presented by the Life Sciences curriculum, and the types and extent of

networks that may be built during the teaching and learning of the subject with particular respect to how they will lead to the manifestation of democracy. The three questions are centrally linked by the concept of agency that Latour believes to be the key aspect that characterises the potential of actors to affect and also to be affected. It is these two that allow entities to be open to each other leading to interaction and formation of networks in-situ.

Having discussed the origins of ANT in the section above, I have managed to lay a foundation of how the approach began. In the following section I am going to undertake an overview of ANT after which I will narrow down the discussion to particular themes that I will use in Chapter 6. In the ANT overview, I am going to look at the following aspects:

(a) Towards understanding the actor in ANT
(b) Towards a comprehension of the actor-network
(c) The role of the non-human in the actor-network
(d) Power and actor-networks
(e) Towards an understanding the concept of translation in ANT

3.3 THE ACTOR-NETWORK

3.3.1 The role of the non-human in the actor-network

One of the key themes of ANT that I am going to discuss relates to hybridisation. The concept of hybridisation relates to how within the collective, entities tend to co-constitute each other. The theme is closely related to that of heterogeneity that I have discussed above. It differs from hybridisation as the emphasis is on how through interaction, human and nonhuman entities tend to alter each other. In the process, the nonhuman entities within the collective are regarded as equally important to the human entities therein. In that case, as they interact within the various networks that they form, they do so on par with each other, and thus in the process hybridise each other. As explained by Sayes (2014) the term nonhuman refers to entities ranging from animals, natural phenomena, texts and other living and non-living entities that are not human. Sayes justifies why non-humans should be included within networks. He thus

came up with four reasons why they are important. These justifications are important as they unequivocally also justify the use of the ANT in this study.

(a) Non-humans make the sustenance of a human society possible

In his explanation of how the human should talk to the non-human Sayes argues that the presence of non-humans within networks allows the proper functioning and sustenance of the humans and the collectives at large. He elaborates further that the non-human possesses inherent affordances that work to advance the success of the human. Latour (1996) refers to this as inter-objectivity. He gave examples of non-humans such as machines and how they work towards the successful development and maintenance of the human society.

(b) Non-humans act as mediators

Sayes argues that non-humans act as what he referred to as stable relays. In this way, the non-humans act as mediators and according to Law (1999) they are capable of transmitting and transforming relations and effects within networks. In that manner, they assume equivalent status to human actors within networks. It would therefore be prudent to regard them as equal partners within the collective.

(c) Non-humans are members of moral and political associations

In a further analysis, Sayes argues that the importance of non-human actors is also prevalent in the manner in which they belong to and are members of moral and political associations. They therefore possess agency that is of importance in the running of networks. Sayes' views are alluded to by Latour (1986) when he gave examples of items such as seatbelts and how they possess both moral and political functions in the manner in which they function. Latour further explains nonetheless that though it may seem superfluous to assume that objects have morality on their own, it is logical to look at the morality and politicality with particular reference to how the objects are used and which concurrent roles and affordances prevail consequently.

(d) Non-humans form essential gatherings

The gathering nature of non-humans is palpable in the way in which they perform their duties within networks (Callon, 1991). This view is corroborated by Sayes (2014) when he comments that non-humans form essential gatherings as they connect actors

across spaces and times. By being capable of creating gatherings, nonhumans could therefore be regarded as social.

3.3.2 Power and Actor-networks

The issue of control is based mostly on the development of strategic moves that would be essential to convince the others for them to align themselves and play certain designated roles (Law,1992). This would be the primary way through which the goals and aims of the networks would be achieved. In that manner, control is a paramount role within actor-networks. Law explains that the system of control would not be monopolised and centralised by the controlling actor. He says that the controlling actor strategically shares his controlling influence with selected others, in order to make the system more efficient. Law (1986) summarised this situation as follows:

> Texts of all sorts, machines or other physical objects, and people, sometimes separately but more frequently in combination, these seem to be the obvious raw materials for the actor who seeks to control others at distance.(p.255)

Law nonetheless, mentions another aspect that is associated with the control system. He explains further that the process of control and regulation is associated very often with resistance and struggle. The struggle and the resistance originate from the process of translation during the interest of the enrolled actors have to be aligned with those of the actor-network (McLean & Hassard, 2004).

3.3.3 Envoys and Inscriptions

In his descriptions of how controlling actors achieve their intended levels of control, (Law, 1986) talks about the dual roles of envoys and inscriptions. The concept of inscriptions in ANT has been widely used. For instance, Stockbruegger and Bueger (2017) have the following to say about it:

> The concept of inscription describes a stable relationship between two (heterogeneous) actors in which their roles are clearly defined, their behaviours are attuned to each other and their patterns of interactions are well established. A successful inscription can turn a complex technology, like a door, into a black box that functions like a single unit. The concept of inscriptions is particularly useful to think about how technologies have become part of everyday practices and how they dominate the way that things are done.(p.53)

This definition of what inscription entails gives an indication of a relationship that is equitably enjoyed among the entities. The last sentence leans towards the other dimension of inscription. According to this dimension, inscription is more about one entity dominating the others. An interesting aspect comes from a situation whereby the dependency of one entity on the other could actually be attuned into dominance by the entity depended on. A typical example has been given by Latour (2007) when he talks about how humans become dependent on the services that are rendered by a door-stopper. In this example, though it appears quite absurd to suggest that the human becomes dominated by the door-stopper, in reality, the door-stopper assumes powers of inscription and becomes a dominant partner to the human. As explained by Stockbruegger and Bueger, the dominant dimension of inscription indicates how one entity influences the behaviour of another entity. It must be realised, though, that these processes occur among human and nonhuman entities.

Stockbruegger and Bueger however bring in another critical dimension of inscription. They argue that the success of inscription is not automatic: rather, it is dependent on the reaction of the dominated actor. Their views are clear from the following quote:

> …inscriptions need to be understood as relationships of power that go both ways. The power of the dominant actor is limited, and it relies, at least to some degree, on the dominated actor and whether it accepts and is able to execute the script imposed on it. Resistance is an option, power and domination are fragile and inscriptions can fail (Stockbruegger & Bueger, 2017, p.53)

This view of inscription makes it clear that inscription is dependent on the context wherein the dominated actors find themselves. While it is important for the function of actor-networks, it is nonetheless not an obvious outcome. Such a possibility however

brings in an aspect of democracy within actor-networks. Due to the possibility of resistance by the dominated actors, the dominant actors would not take the dominated actors for granted. Stockbruegger and Bueger conclude by explaining how the concept of inscription is important in the analysis of power relations within networks.

Though she agrees with the general implication of the concept of inscription, González's (2013) view of the concept is wider than the way many others regard it. González concedes that the concept of inscription pertains to how controlling actors have to rely on the effect and performance of other actors for them to achieve their goals. She however goes on to explain that inscriptions often take place at a distance, a tendency that van House (2003) describes as the assumption of emissary status by the inscription actors. In other words, the inscription actors assume a role designated to them by the control actors. Alluding to the same tendency by the inscriptions, Law (1984) explains that often the inscriptions operate in the same manner that devices act, in a process where they appear as durable entities that work as envoys. Law (1984) continues that upon their assumption of envoy roles, the inscription actors become very usable for a distance from which they can exert control of other targeted actors within the network. In their processes of exerting control, Law (1984) says they may be used under prescriptive conditions or even as a mechanism to enforce the interests of the controlling actor upon all the other actors.

In a further analysis of the operations of inscriptions, Law has maintained that the effectiveness of the inscription as a tool of enforcement is neither guaranteed nor automatic. He elaborates that the context that surrounds the inscription has a direct influence over the manner in which it achieved its designated roles. All this would also be jointly influenced by the level and extent of the inscription's durability and mobility (Khan, 2013; Law, 1984; Sidle & Warzynski, 2003). Law introduces the concept of the envelope. He describes an envelope as the context that surrounds the inscription. The success of the inscription is directly influenced by the firmness and strength of the envelope that surrounds it. Law argues further that the strength of the envelope has a direct influence on how much the inscription would be able to face off competition and challenges from other actors within the network.

González (2013) has described how the aspects of mobility and durability work with inscription actors. She explains that the durability of an inscription is determined by the extent to which it sustains its patterns of relationships with other actors. She goes on to mention that the inscription actor has to maintain very cordial relations with both the controlling actor and the other actors. It is the warmness of these relations that determine the extent of mobility of the inscription actor (González, 2013). This view is alluded to by Latour (1987, p.227) who goes further to explain that with enhanced and adequate mobility and durability the inscription actor becomes a “black box”. He describes a black box as an actor that systematically coordinates work of networks and other actors. The key essence of a black box however, lies in its unquestionable acceptance within networks. In other words, the black box could be regarded as being taken for granted or rather familiarized. All the other actors within the network would have accepted the nature and role of the black box to the extent that there is no need to question it further. The black box may be any form of an actor, physical or non-physical, human or non-human; the key aspect is that its status is beyond reproach and well-accepted. In the teaching and learning of Life Sciences, black boxes could be regarded as theories like social constructivism that determine how the learning of concepts should be addressed. The power of ANT as a theory is to identify these black boxes and open them. The prevalence of incidences such as the Anthropocene might be argued to be related to the various black boxes that are found in the pedagogical beliefs and approaches used in the teaching and learning of subjects such as Life Sciences. The importance of ANT would therefore be to allow the platform for the opening of such boxes and address the often taken for granted issues behind which might be lying the promotion and acceleration of the Anthropocene.

Doing further work on actors and actor-networks, Latour came up with a number of characteristics of inscription actors. In his work in 1990, Latour came to the conclusion that inscription actors reach a point of irreversibility at which it would be not be possible to go back to earlier condition and states (Latour, 1990, p.40). Latour also talks about the loss of trustworthiness and loyalty of the inscription actors to the controlling actors. He describes this as inscription actor “double-agenthood” (Law,1986, p.256). He continues to explain how the supporting of inscription actors with strong envelopes is effected as a strategy to overcome the loss of loyalty to the controlling actor.

3.3.4 Envelopes

The concept of envelopes as described by Law (1984) gives an overview of the relationship that exists between inscriptions and other actors within a network. These actors as further explained by Law could be human, non-human and other inscriptions. The implication is that the level of how inscriptions participate in the control processes is a shared phenomenon whose operations are multi-focal and multifaceted. This view is alluded to by González (2013) below:

> The relationships maintained between inscriptions, their components and other actors will influence the ability of inscriptions to take specific actions. In general, envelopes can influence the capacity of the inscription to act in two different ways. Firstly, actors included in the envelope can assist the inscription's ability to take specific actions. Secondly, actors of the envelope might undermine the inscription's capacity to exercise control on others by imposing some limits in its actions.(p.69)

González's views above give an implication that envelopes possess both a facilitative and a restrictive function on the operations of the inscriptions. This has been described by Law (1984) as the envelopes' affordances on the durability and fidelity of the work of the envelopes. Law explains that a key requirement of the inscription would influence their ability to embody heterogeneous actors into their networks. This would essentially improve their durability.

3.4 TOWARDS UNDERSTANDING THE CONCEPT OF TRANSLATION

The concept of translation refers to how actants, human and nonhuman, animate and inanimate relate to each other as a result of their association and interactions within networks. As is alluded to by Murris and Bozalek (2019:5):

> …..we also understand the philosophies of Barad and Deleuze as being located in a relational ontology, which holds that entities do not ontologically pre-exist relationships, but rather that entities come into being through human and more than human relationships. Their relational ontology disrupts the idea that the world consists of substances that exist ontologically ('substance ontology') and prior to bodies inhabiting the world.

It is important to emphasise at this point that the word *relate* is not used in a humanist way. The implication of a relationship here is that it is an agential outcome of a transaction that takes place between entities. Specifically, the process of translation looks at how processes such as displacement and transformation take place within a network during the association of actors. Translation is thus regarded as all the negotiations, persuasions and violence among other things that happen when an actant undergoes the process of change in order to fit within a network (Callon, 1986). The process is very important in this study due to the manner in which it presents the heterogenous manner in which networks are formed and deformed as well. The process also clarifies the contingent characteristic of heterogeneous interactions that are found within networks.

As explained by Callon (1986) translation is a "geography of obligatory points of passage" (OPP) with an OPP being defined by Gonçalves and Figueiredo (2012, p.2) as "the first component of translation, the translator: an entity (a thing) in an actors-world that intent to speak on behalf of other actors of that world translating in a way that fits together their interests and behaviours". Due to the manner in which it relates to how actors engage with each other within networks, the process of translation has come to be regarded as a *sociology of translation* which Cressman (2009) also describes as an approach that is generally interpretive yet analysing ideas from a sociotechnical perspective. According to Callon (1986), the concept of translation gives an overview of how networks emerge, and with time get transformed. He mentions also that translation has four key processes that are associated with it viz:

(i) problematisation
(ii) interessement
(iii) enrolment
(iv) mobilisation

The role of translation within networks has been described elaborately in the literature. For instance, translation is regarded as being behind the temporary nature of networks which progressively change with time, causing the emergence of actors that might control others (Callon, 1986).

Callon (1986) has gone further to explain how the concept of translation works. He describes how certain actors assume spokesmanship of others during the process of

translation. In this regard, the spokesmen use their own language to express the interests of other actors (Callon, 1986). The concept of language is used in this context to be inclusive of both the animate and the inanimate actors within the collective. It should not be confused with the general meaning of language which is restricted to the humans. The term language is thus an act of association and interaction among the entities which is not premeditated. With translation, as in any other situations where one entity represents or claim to represent the interests of others, there is bound to be resistance on the part of the represented entity. Under those circumstances, Callon describes it as a failure of the translation process. Callon's views resonate with the argument that aligns with the prevalence of conflict and resistance in cases where one entity represents the other. Callon explains that under circumstances of failure, where the represented actors become resistant, a tendency of dissidence ensues, and the represented actors refuse to accept the roles that are designated to them by the controlling actor. Having described the process of translation in general, in the following section, I am giving an overview of the four processes of translation: problematisation, interessement, enrolment and mobilisation as given by Callon (1986).

3.4.1 Problematisation

The problematisation stage is associated with situations where some actors attempt to address prevalent problems by using their terms as reference points (Sarker & Sidorova, 2006). As further elaborated by Tatnall and Burgess (2002) such actors also try to lay out a problem-solving network by luring those actors that have the potential to address the problems. In their analysis of problematisation Linde, Linderoth and Räisänen (2003) mention that part of the mandatory aspects of the process of problematisation is the need to have all the identities of the actors defined following which the problems themselves would be identified. As mentioned earlier, the problem would be defined according to the terms of the controlling actors. Such a tendency is achieved through the establishment of what Callon (1986) refers to as the Obligatory Passage Point (OPP). The OPP is regarded as a declarative tendency of the controlling actor who creates an impression that its own presence is totally indispensable. In the declaration, the controlling actor gives the impression that

problems being faced by the other actors could only be solved by passing the OPP (Law, 1986). Law explains that the other issue with the OPP is that the controlling actor demands that if the other actors would wish to pass through the OPP, they have to streamline their own interests to meet those of the controlling actor. This would as such be regarded as a demand for loyalty and a declaration of control.

3.4.2 Interessement

The process of interessement is associated with the fixation of the roles that actors have to play within a network, a process that Callon (1984) describes as the strategic locking actors into place. As explained by Sarker and Sidorova (2006) key actors have a number of strategies that they use to ensure that their interessement is successful. Michael (2016) has described the interessement process as a process where the key actor strategically interest the other actors within the network. The main approach wants to achieve the process of interesting the others, including the removal and elimination of alternative roles for the other actors. This leaves the actors with no option but to follow the key actor's direction (Callon 1986). Alluding to the use of similar approaches, González (2013) says that:

> A common strategy is to build devices and place them between the controlling actor and those being interested. The use of representatives is another strategy, in which the controlling actor negotiates interessement with those who speak in the name of the others.(p.71)

Nonetheless, it is agreed in the literature that the strategies could either take a seductive approach (Magnani, 2012) or a force approach (Callon 1986). Callon goes further to explain that the logic of interessement is to ensure that that through imposition, there is stability of the assumed identities and roles for the interessed actors. During interessement, as mentioned above, fixed roles are assumed by the actors that show loyalty to the key actor. They are therefore given fixed places (Tatnall & Burgess, 2002), while those that show resistance are neutralised through weakening, so that their influence may be minimized (Linde et al., 2003). As alluded to by Callon (1984):

> Interessement is the group of actions by which an entity [a controlling actor] attempts to impose and stabilise the identity of the other actors it defines through its problematisation…to interest other actors is to build devices that can be placed between them and all other entities who want to define their identities otherwise. A interests B by cutting or weakening all the links between B and the invisible (or at times quite visible) groups of other entities C, D, E, etc. who may want to link themselves to B. (p.207-208)

As Callon says, in order to achieve the tremendous role of convincing all the actors by themselves, the key actor may decide to appoint a spokesactor. These will be loyal actors who the key actor knows are responsible in terms of carrying and transmitting his word to all the actors. He goes further to explain that the spokesactor is also given the authority to eliminate those actors that offer resistance by refusing to be loyal to the OPP. When this elimination is achieved the next level of translation would be to undergo enrolment.

3.4.3 Enrolment

According to Callon (1986), the successful implementation of translation is not necessarily dependent on the success of the interessement alone. He explains that following successful interessement, there needs to be successful enrolment. Enrolment has been described by Callon (1986) as:

> …negotiations, trials of strength and tricks that accompany the interessement and enable them to succeed. (p.211)

The aspect of negotiations which is a heterogenous process involving both the human and the nonhumans plays a primary role in the way control is asserted within a network. It is through negotiations that roles are planned and designated as informed by the OPP scheme (Callon & Law, 1982; Law, 1986; Linde et al., 2003). The assertive role of negotiations is further described in the manner in which the negotiation process further focuses on those actors that have the potential to disrupt the stability of the network. In her analysis of the importance of negotiation in the process of enrolment, González (2013) brings in a further dimension of negotiation, which underscores that negotiation though important is not indispensable. She elaborates that there are certain cases where the actors do not offer any resistance to the process of enrolment

to the extent that there would be no need for negotiation processes. This view is however contrary to the view of Callon (1986) who outlines a number of processes through which negotiation may be done. He elaborates that negotiation may take the form of physical violence especially against those actors that may be regarded as predators to the enrolment, through seduction and forthright consent.

3.4.4 Mobilisation

The mobilisation of allies is the last stage of translation. The process of mobilisation is characterised by the accumulation of sufficient allied actors in places where they would be able to influence the others (Latour, 1990). As alluded to by Law (1984) during the process of mobilisation, the key actor assumes full spokesactorship of the actors that it regards as passive, often those that have been subjugated. This would consequently lead to the construction and development of a wider network that Tatnall and Burgess (2002) describe as often having some absent members whose agency has been usurped by the key actor. Tatnall and Burgess explain that during enrolment, the key actor keeps a close association with the spokesactors to whom it has designated authority. The necessity of maintaining such a relationship would be to give the impression that the spokesactors are real representatives of the masses.

Callon (1986) has mentioned that the role of the spokesactors is nonetheless not without challenges. He says that in some cases, some actors may decide to disagree with the spokesactors, and disregard the directives of the OPP. When this happens, the often-loyal actors may become distracted and thus the equilibrium of the entire network is severed. Under those circumstances new forces of translation begin to take place, often in opposition to the originally intended translation.

3.5 ANT CRITIQUE AND THE EMERGENCE OF ALTERNATIVE APPROACH: AFTER ANT

Having discussed the origins of ANT up to thematically exploring it, this section looks at what is generally referred to as the critique of ANT. The critique of ANT has expanded the dimensions of ANT to include new aspects that were not included in the

original formulation of the theory. In his explanation of the post-ANT work, Watson (2007) has explained that one of the key criticisms that ANT faces is its categorisation of all entities into only human and nonhuman entities. Watson found the categories to be too broad to that extent that a lot of information is lost in the process. Watson's argument bears credence especially regarding how generalised nonhuman entities are during research. For instance, in the analysis of hybridised spaces, nonhuman actors such as door keys (Latour, 1991), firearms (Latour, 1993) and voyaging ships (Law, 1986) are given equal significance to human actors. This approach of ANT has been widely criticized in the literature (Alaimo, 2014; Braidotti, 2019; van der Tuin, 2014) as it is argued that posthumanism does not begin with things or discrete objects which are separated from the human subject, but from a relational ontology where relationships precede things, where subjects are part of substances and the world. This is alluded to by Haraway (2004) as she disagrees with the implications of such narrowing of the collective. She has this to say:

> …too narrow a concept of the 'collective', one built up out of only machines and scientists, who are considered in a very narrow time and space frame. (p.115)

Agreeing with Haraway, Watson (2007) has also disagreed with ANT especially on the accordance and assigning of value on the simple basis of difference. He complains about the uncritical homogenization of everything that lies within the collective, a tendency that has the potential to undo the gains of heterogeneity and diversity which are crucial components of the collective.

The other disagreeable aspect regarding ANT according to Watson (2007) is the issue of how ANT tend to emphasise the symmetricity of all the entities within the collective. He criticizes the following view of Latour (1999) as tending to convolute the relationship between the human and the nonhuman:

> …the modern collective is the one in which the relations of humans and nonhumans are so intimate, the transactions so many, the mediations so convoluted, that there is no plausible sense in which artefact, corporate body, and subject can be distinguished. (p.197)

Watson's views are corroborated by the views of Lee and Brown (1994) who also disagree with the tendency of uncritically applying the principal of equality within the collective. They mention that:

> In the context Latour provides (a discourse of liberal democracy), a challenge to the reasoning behind the enfranchisement of the nonhuman is rather risky, because if we endorse the principal of equality (and who would not dare to, in principle), we must then be prepared to apply it with fear or favour [sic], or accept that we are prejudiced. (p.776)

In the foregoing section, I have discussed some of the critiques that are levelled against ANT as a methodological approach. In the next section I am going to explore what has been suggested as an alternative to ANT. This approach is described in the literature as the After-ANT (Watson, 2007). The basis of the After-ANT approach is based on what Law and Singleton (2005) refer to as the problem of difference. The problem of difference is based on the principle that ANT as a methodological approach should focus more on the uncertainty of specific relations between objects within the collective. In that case, as explained by Mol (2002), the problem of difference rejects the assumption of singularity, independent and objective reality within the collective. She argues that there exists:

> …different and valid knowledges that can be neither entirely reconciled nor dismissed, and suggests that knowing is or might properly be, a process that is also decentred, distributed, but also partially connected. The logic of juxtaposition renders it inappropriate, even impossible, to draw things together into singularity. (p.197)

The implication of Law's view is that After-ANT should come with the recognition of the fluidity within which actors are found. This fluidity is influenced by the context. In that case, Law advocates for the recognition of multiplicities of realities that are found within the collective. These multiplicities are indeed beyond the ANT categorisations of the human and the nonhuman. These multiplicities that are emphasised by After ANT, recognise each network as a tip of an iceberg (Law & Singleton, 2005). They argue that what is generally observable within networks are just a tip of the iceberg, and that a lot of interactions beyond the categorisation of human and nonhuman are found buried in the water within which the majority of the iceberg lies.

3.6 EMERGING THEMES

In the section above I have looked at both the origins and the overview of ANT. In this section, I am going to undertake a discussion of what has emerged as the key themes of ANT. The selection of the themes has been based on how they fit into the overall argument of the study. For instance, the theme of relationality is important in the overall study due to its emphasis on the extent to which all entities within the collective be they human or nonhuman, are related. This matches the flat ontology perspective that seeks to remove all boundaries among themes previously regarded as different. Relationality therefore lays the foundation that would allow all the entities to connect with each other and form heterogeneous networks. The formation of such networks is paramount in the manner in which the human would no longer be regarded as the centre of the collective. This explains the emphasis that all the entities within the collective would share agency symmetrically and thus be able to associate in a more discursive manner that transcends all the boundaries. In addition to that, the formation of heterogenous networks would be important in critical posthumanism in the manner in which it fosters the development of hybridisation among the different entities. Overall, the themes of democracy and ethics are of importance in the study in the sense that they allow for the manifestation of morality among the entities to the extent that all entities would recognise the importance of the other. I will use these themes together with those from the other theories in Chapter 6. The following themes will be focused on in my discussion:

(1) Relational techno-socio materiality
(2) Network
(3) Agency
(4) Ethics and democracy
(5) Free association

3.6.1 Relational techno-socio materiality

The first theme to be discussed shall be on how ANT is an expression of the prevalence of relational techno-socio materiality. Callon and Latour (1981) argue that there exists a convergence zone that is characterised by relational materiality between the technological and the social in society, to the extent that the two are interlinked in a very complex manner (Murdoch, 2001) that would not allow their binary separation.

This view is alluded to by Vicsek et al. (2016) who have described the basis of ANT as the realization that reality may not be separated into pre-ordained categories of “the social” and “the technical” per se, but should rather be regarded as comprising of a multiplicity of natures flowing from both the social and the technical sanctuaries and reserves within networks. This is regarded as the source of the principle of heterogeneity which is used to describe actor-networks (Cressman, 2009; Law, 1992; Murdoch, 1997, 1998; Walsham,1997). The concept of heterogeneity is alluded to by Latour (2005, p.7) where he defines the social and the technical as “a very peculiar movement of re-association and reassembling”.

As explained by Law (1991), the social and the technical share a common fundamental to the extent that entities that appear to be specifically social are also in a way technical, and those that appear to be specifically technical are also social in another way. No entity therefore belongs to one without belonging to another. All the entities are hybridized. This view aligns well with Latour’s (1991, 1992) description of the concept of sociology of translation which argues to be the key operator in the definition of the relationship between the social and the technical and how they tend to co-constitute each other. The concept of sociology of translation which seeks to make explicit the aspect that the roles that the social and the technical represent are simply delegated to them. The roles have no significant implication towards their individual identities, but rather only make sense within the perspective of the interactions that produce them. This agrees with what I have discussed earlier when what is social has some technical parameters (meaning) and what is technical also has some social parameters. In that way, the social and the technical are co-constituted.

It may be sound to argue that ANT as an approach disagrees with the binary and dichotomous classification of aspects for instance into technical and social, and many other such categorisations. Augmenting the same argument in his notes on ANT in 1992, Law has it that:

> ..knowledge is a social product rather than something generated through the operation of a privileged scientific method. (p.2)

This view has also been mentioned to by Langlitz and Strum (2017) when they summarise Latour’s views of ANT thus:

> Latour had learned from ethnomethodology that social structures were not written in stone and did not predetermine what people could do but emerged flexibly from a multitude of small-scale negotiations between actors. (p.159)

ANT's relational techno-socio materiality could also be discussed from a heterogeneity perspective. The views of Fenwick and Edwards (2011) also add momentum to ANT as a heterogeneity-promoting approach in society. They describe ANT as a methodology that seeks to explore the relationship and interconnections between human and non-human entities within a community. By establishing ANT as a relationship between the human and the non-human, Fenwick and Edwards have in that way brought homogeneity within the collective. This is the second theme that I am going to focus on. They explain that the approach tends to adopt a non-foundational and decentralizing tendency in which the performance of things precedes their presence and being. They believe that 'nothing exists prior to its performance or enactment' (p2); and its being may not be prejudiced. The approach according to Fenwick and Edwards (2011) decentres human intention and action (from its pro-humanistic closet) and in the process, accords equal status and importance to all the entities (human and non-human) as they exist within what Latour (2004) referred to as the collective. In this way, I would say that the approach as described by these two authors removes the boundaries that encapsulate the various types of entities as they lie within the collective. In the process, all the entities within the collective share their heterogeneity. These views have also been shared by Gherardi and Nicolini (2005) when they argue for heterogeneity as a primary principle of ANT. They put forward the following views in support of the recognition of heterogeneity as a source of complementarity within the collective:

(i) ANT does not suggest that there are no divisions within the collective, but rather, such divisions are outcomes of interactions that happen within networks, among the heterogenous actors. The outcomes are both discursive and material, to the extent that they are discoverable using empirical methods.

(ii) The material semiotic approach transcends the human realm and resists the influence of language which is a domain of the human and their proxies. The approach proposes for the accordance and recognition of equal citizenship

to all entities irrespective of their heterogeneity within the collective. By extension, activity is not restricted to the human but is a sharable attribute accessible to all entities.

(iii) Ontological performativity as a principle is based on the assumption that entities do not have prerogative agency, but rather only assume a becoming as a result of being performed during the various interactions that take place within networks. In essence, all entities are reversible and uncertain outcomes that hail from performances in time (Gherardi & Nicolini (2005, p. 2).

The three aspects described by Gherardi and Nicolini imply that the heterogeneity emphasis of ANT is underwritten by both material relationalism and ontological performativity.

John Law's work has also contributed tremendously to how heterogeneity is a critical perspective in ANT. In his thesis on ANT in 1992, Law argues that ANT which is also regarded as the sociology of translations (Callon, 2007; Law, 1992) focuses on the heterogeneity of networks with particular respect to how they are constructed and transformed. This perhaps comes from the approach's refusal to recognise binary classifications of entities. The heterogeneity of the networks is constituted of diverse entities among them humans and non-humans in a general sense. The recognition of non-humans as recognisable entities with agential capabilities is what makes ANT quite different from many other theories within its domain (Ashmore, Wooffitt & Harding,1994; Fenwick, 2010) and as explained by Conty (2018), this is a tremendous move taken by Latour to do away with what he calls the "infatuation of modernity" (p73). As explained by Latour (2007), the recognition of non-humans as actors is paramount in the understanding of how societies operate. As he explains further, non-humans have to be recognised beyond the pre-meditated view of them being only symbols, and projections of human views. It would be important to realise and acknowledge that they exercise their own agential capabilities (Ashmore et al., 1994; Nash, 2005; Sayes, 2014). Due to the recognition of the agential potential of non-humans, ANT focuses on how such characteristics would lead to the development, convergence, divergence and transformations of networks within the collective. The collective has indeed been described by Latour (2007) as a community of human and non-human entities. Latour (2007) further explains that ANT looks at how networks

become durable and, in another way, how that durability may be lost. His overall argument is centred on the recognition of human and non-human actors, and how during interaction, these human and non-human actors co-operate with each other, and in the process, create various forms of networking that may work along each other or even compete with each other. Latour (1996) argues that during these interactions actors have the potential to enlist each other into their various networks, a process that leads to the expansion of some and the disappearance of other networks.

The work of Thrift (2000) has also contributed to the significance of heterogeneity as a theme in ANT. Thrift however sees ANT as a performance of heterogenous engineering. He views heterogenous engineering as being responsible for what the entities eventually become. In that way, heterogenous engineering pre-exist entities, and by that measure it follows a relational ontology. Thrift (2000) describes ANT as follows:

> It is the study of heterogeneous engineering: heterogeneous because it is concerned with a vision of the world as a multiplicity of different connections; and engineering because it sees these connections as fabricated out of a diverse range of materials. (p.4)

The description of ANT given by Thrift above, especially the heterogeneity engineering implies that indeed ANT looks at the multiplicity and variety of the entities with particular respect to the multilateral entanglements that connect them without any prejudice towards each other. In this manner, ANT is regarded as closely related to post-structuralism (Ritzer, 2008:656; Vicsek et al., 2016), especially the ways in which it emphasises relationality. It must be stated early enough that the engineering that is being discussed here would not be pre-determined. In essence it would be random and contingent upon the interactive patterns of the entities which in themselves would also be random. The essence of the engineering that is emphasised here is that Relationality is the next theme that I am going to discuss below.

By emphasising relational techno-socio materiality, ANT tends to disagree with the pre-ordainment of essence to entities outside their performance within networks. As such, ANT presents the relationality of entities as being contingent upon their interactions within networks. This understanding of relationality has been described

elsewhere in the literature. For instance, Vicsek et al. (2016) regard relationality as an outcome of the interactions that take place among entities within networks, while Rioux-Dubois and Perron (2016) talk about the essence of any actor or even of the network itself, as only an outcome of the relational dynamics within the networks. Elsewhere in the literature (Knorr-Cetina & Mulkay, 1983), ANT has been discussed as being responsible for presenting the world as an outcome of various processes of relational inquiry which strategically avoids epistemological approaches and follows a pattern that is both generative and ontological. The recognition of the world as a relational outcome is also related to the views expressed by Blok and Jensen (2011) when they argue that due to the interactives of the world, actors within the world are themselves engineered in a relational manner. They elaborate further that due to this engineering trend, there is always some relational reconfigurations and repositioning of conventional understanding of entities. Following the argument of Blok and Jensen, it implies that outcomes are engineered as well, and so are views. It is this aspect of engineering that I find appealing to this study; due to the perceived engineerability of outcomes, it is implied that democracy within the collective may equally be engineered. All this engineering is indeed underwritten by the principle of relationality that governs the relationship among the actors within a network. In other words, heterogenous engineering is contingent upon the interaction of entities within the networks and is not dependent on a priori characteristics of the entities.

One of the key attributes of ANT is based on its rejection of cause and effect as disparity aspects. As described by Ritzer (2008), by advocating for relationalism, ANT rejects the principle of cause-and-effect as a primary analytic tool to describe social relations and interactions. ANT approaches effects not necessarily as direct products of a linear process, but as outcomes that happen as entities network and entangle with each other. The process of engaging and entangling with each other consequently removes the boundaries that encapsulate entities.

3.6.2 Network

The other critical theme of ANT is the concept of the network itself. The concept of the network is critical in the manner in which it establishes the possibilities of relationship

between the human and the nonhuman. According to Latour (2004) the major intention of ANT is to explore and interpret how human and non-human entities become as a result of the formation of relations between them. As a result of coming together and formation of relationships, networks eventually form and they too become entities. When they come together, they form networks. In that manner, ANT studies how entities manage to come together, hold together and in the process, end up in networks that produce forces and effects (Fenwick & Edwards, 2011). This view has earlier been explored by Latour (1999) when he mentions that the main aim of ANT is to investigate the extent to which objects participate in the creation of networks that abound with relations, within communities and collectives. It is important at this point to note that by referring to “objects” Latour was trying to do away with the dichotomy between objects and subjects which is a prime driver of humanism. He is thus attempting to accord and distribute agency to both the human and the nonhuman without bias or discrimination. Nevertheless, it should be understood that the agency in question is not an essence but rather an outcome of the interactions taking place within networks. Both the human and the nonhuman entities only access agency through the various interactions that they get involved with within the networks. As such, they do not have inherent agency particular to their individuality. That is perhaps the reason why Latour believes that agency should be openly accessible to all the entities in the same manner that they could openly be part of any networks.

3.6.3 Agency

I also want to discuss another critical ANT theme of agency. As discussed by Sommerville (1999) ANT emphasises agency as a key theme that seeks to help with how entities tend to co-operate during the process of translation. He goes further to mention that the central aspect of ANT that lays a foundation for the recognition of agency is the assumption that within the collective, all actors are active and thus no actor is passive. To that extent, no actor may be taken for granted in terms of how it relates to the other actor. This view alludes to Callon’s (1993) view that all actors exude some agential capabilities as a result of their interactions within networks. Callon goes further to explain that the potential to be agential applies to all actors, human and nonhuman, living and non-living, and that the potential does not precede the existence

of the entity but would rather feature during the process of interactions. This view confirms what has been mentioned by Callon and Latour (1981) when they emphasise that irrespective of the actors being categorised into macro-actors and micro-actors, they nonetheless have an equal footing regarding their potential to possess agency. The classification of the actors by Callon and Latour should not be misunderstood to be a latent move towards the re-establishment of the binarisation of matter. Rather, their intention is to illustrate that though actors may possibly seem to be of divergent origins, they however, have equal potential when it comes to agency. As Callon and Latour (1981) mention:

> The difference between [micro- and macro-actors] is brought about by power relations and the constructions of networks that will elude analysis if we assume a priori that macro-actors are bigger than micro-actors...[A]ll actors are isomorphic...[which] does not mean that all actors have the same size but that a priori there is no way to decide the size since it is the consequence of a long struggle. (p.280)

The argument put forward by Callon and Latour above imply that there is a need for an epistemological refocusing in the analysis of actors. In essence, such a refocusing should focus on how the identity of actors should not be used as a measure of their presence within the networking processes of the collective. Instead, what should count is the agency that they should all be understood to have the potential to possess. I emphasise the possession of agency from a potential perspective to illustrate that the agency of the actors is not based on their a priori status, but rather on their interactions with other actors as they form and deform networks. I am going to use the concept of epistemological refocusing as a key approach of how to emphasise the importance of agency as the key factor that opens all the actors to interact with each other. This view agrees with what Somerville (1999) mentions when he says that the prime role of agency with ANT methodology lies on the concept's emphasis that what matters is not necessarily the natural state of the individual actors, but rather the potential that they have to form relations with other actors within the collective. As a result, agency plays a crucial role in the manner in which it makes it possible for human and nonhuman entities to perform tasks alongside each other for the benefit of each other within the networks. Agency would in that case work like a buffer solution that connects and nourish diverse entities as they interact. In that case, it bridges the gap between the

human and the nonhuman entities as mentioned by Latour (1994) when he says that agency completes the missing element of the nonhuman input within the collective. As such he regards the nonhuman entities as:

> …the missing masses who knock insistently at the doors of sociology...[and]...[t]o neglect to analyse them and observe only human action is like limiting one's gaze to half of the court during a tennis match: the observed movements seem to have no meaning. (p.568)

Another key theme that has to be discussed alongside the agency theme is ethics. In the foregoing section I discussed the critical importance of the theme of agency. I explained that agency cuts across the individual identities of the entities within the collective. To that extent, it allows for the association of entities that would often be regarded as incompatible. A typical example of such entities would include the human and the nonhuman. Agency comes in with a potential to link these different entities and thus form sustainable actor-networks. Be that as it is, it would remain incomplete if I ended the discussion of agency without having explored what might be lying behind the agency that allows the potential for the entities to associate and interact irrespective of their natural states. I argue that behind agency lies ethics as the driving force. Ethics I believe remove the boundaries that tend to encapsulate the natural states of the entities. The ethics achieve this through a process of non-discrimination where all the entities would be available for interaction with each other in a manner response-able manner (Bozalek & Zembylas, 2017; Murris & Bozalek, 2019) . By doing that, it opens the space for all the entities to associate and interact unconditionally forming actor-networks in the process. As such, I regard ethics as a theme that transcends the entire collective. It is the one that ensures the actors within the network are open to interaction with each other collectively. During the discussion on agency above, I mentioned that Callon and Latour (1981) have discussed the unfortunate presence of macro-actors and micro-actors within the collective and how the gap that separates them is bridged by agency. That agency that bridges the gap is indeed informed by the posthuman ethics. It is the posthuman ethics that allow diverse actors to associate with each other in a manner that would be democratic, and the platform where the voices of all the entities would be heard.

3.6.4 Ethics and democracy

Ethics and democracy form a critical theme under ANT studies. For instance, the critical role of ethics within networks is to provide a buffer zone of morality within which all interactions take place leading to the formation of relations. As explained by Koopman (2013) ethics are responsible for the provision of moral codes that inform the nature of interaction among entities. Within actor-networks for instance, ethics make it possible for entanglement to take place amongst various entities irrespective of their similarities or differences. By doing that, ethics open frontiers of association among the entities within the collective, and thus promote the entanglement of entities which leads to the formation of heterogeneous networks. In that case, as mentioned by Koopman above, the ethics provide universal moral codes that make interaction possible. The moral codes allows for the conflation of the differences that might be between any entities (Bengtsson, 2018).This agrees with what Latour (2004) discusses in his work on the Politics of Nature, where he emphasises the need for the development of a parliament of things within which all entities irrespective of their identity would be entangled. Ethics I would argue, are responsible for the rejection of the a priori status of actors within and without actor-networks. Within actor-networks thus, ethics would allow the actors to freely associate. On the other hand, outside of the networks, ethics make it feasible for the formation of networks as various actors possibly combine and come together. In that way, ethics make the actors commit to working together for the common good of all. In that process, ethics promote a tendency whereby actors take care of their own well-being and the well-being of the other. The other include other actors and also the network itself (Wellner, 2017). In essence, this would lead to the development of reciprocal relations within the collective. This reciprocity is based on the need to do good for oneself and also for the other. On the other hand, it is also informed by the need for relationality, collective autonomy and volition. As a result, the presence of ethics as a theme in this study is prominent. It charts the way for the development of an egalitarian critical posthumanist collective.

Adding to the importance of ethics, democracy would be a co-theme within the collective. Democracy manifests within the actor-networks in a number of ways that have already been discussed above. It must be emphasised that the role of democracy

within the networks would be to ensure that all the entities are given a voice regarding the operations of the networks. For instance, through the removal of boundaries (Latour,1996) that tend to separate entities within the collective, all the entities are placed on the same level. The placement of entities at the same level of recognition irrespective of their individual and natural differences has been described by Lee and Brown (1994) as the ontological perspective of ANT. Lee and Brown have elaborated that the power of this perspective is that it is based on a liberal-democratic framework that rejects the discrimination against any entities within the collective. Such a placement of the entities makes the relationship among the entities democratic in the sense that the placement does not allow any kind of hierarchisation, be it lateral or horizontal. A key aspect to note is that the hierarchisation in question is more to do with the value systems within the collective. It is about the categorisation of what should be regarded as more important, both in terms of the values and the entities themselves. In that case, democracy comes in as a pacifier that seeks to include all the voices within the collective.

In essence, the democratic orientation of the entities towards each other paves the way for them to bring more diversity, depth and strength to the network. A critical aspect to realise also is that the interaction of the entities is not selective in any manner. This implies that the entities within the collective do interact without premeditation. As a result, the interaction patterns within the collective would allow the entities to associate, connect and re-connect freely. In that case, the human and the nonhuman would be in a position to associate and interact and form heterogenous networks within the collective. I argue that the association of the human and the nonhuman would only imply that the nonhumans have been given a voice. Such an accordance of a voice to the subalterns is a typical case of the promotion and manifestation of democracy within the collective. Such patterns of interaction imply that there would be democracy within the collective since all entities would be open to associate and interact with any other entities. As such, democracy would be co-created (Faraon, 2018) and sustained by the various entities within the collective. It will manifest as a common good for all the entities within the collective. In the same way, there would be a promotion of heterogeneity within the collective due to the random interaction and association of the various entities forming networks. When the

entities accept each other's heterogeneity within the collective, it is imperative that democracy would be in such a collective.

The democracy in ANT is also implied in the manner in which it acts as an intermediary that lies at the confluence of technological-determinism and socio-constructivism through its eradication of the tendency of dualism and binarism. All attention is directed towards processes that tend to focus on networks that are more diverse and characterised by socio-technicity (Bloomfield & Vurdubakis, 1997; Knights, Coombs, & Bloomfield, 1997). This is emphasised by the principle of generalised symmetry (Walsham,1997) which looks at entities in terms of them being either human or nonhuman, and in the process not discriminating against the nonhumans. By treating entities as being potentially human and nonhuman, ANT would then be in a position to trace the sources of inequalities that might be found within networks. In other words, ANT promotes democracy by tracing how inequalities are continually generated and maintained within networks and communities. It attempts to find a way to make democracy more inclusive. It manages this through the emphasis on the need for all the entities within the collective to have an equal voice. As such, by acting as an intermediary, ANT closes down all dualisms and offers more a democratic space through collective belonging and collaboration of all the entities within the collective. In other words, ANT prevails in the situation where both entity and network are prone to engage in associations that are free from control. In that way, it promotes the diversity within the collective. By prevailing in a situation where the being of an entity is subject to, and contingent upon the interactions that take place among the entities within the collective, ANT in that way makes it clear that no entity would be more important than other entities and the network at large. In that way, the wellbeing and sustenance of the network would be a primary goal of all the entities within the collective. When that is achieved, it would be then be prudent to mention that democracy would have been achieved within the collective.

3.6.5 Free association

The other ANT theme that I am going to discuss is free association. As explained by Law (1999), the principle of free association is the one that calls for the outright removal of predefined boundaries across entities in whatever forms they may be. This is a precursor to the recognition of generalised symmetry. He explains further that though there may be possible sprouting of differences across the entities, this should however come along as a result of the interaction that takes place within the various networks they are engaged in. Such an assumption is the one that sees to the point that there is no a priori accordance of agency within the entities (Hamilton, 2009), an aspect that Rioux-Dubois and Perron (2016) regard as non-essentialism. Agency therefore, is brought about as an outcome of the free association of actors without any premeditation. This view has been hailed by Callon (1999) in his explanation of the essence of ANT. He explains that:

> ANT was developed to analyse situations in which it is difficult to separate human and non-humans, and in which actors have variable forms and competencies. (p.183)

Latour however also indicated that irrespective of the interaction of the different actors, the actors remain irreducible to each other's state (Latour,1993).

In the foregoing statement Callon gives clarity on the situations under which ANT may be used. He emphasises the issue of the use of the approach to deal with the removal of boundaries, a process that may be difficult due to the multiplicity of the forms of the entities. The implication of Callon's views is that differences should not be used to separate entities within the collective. Difference should rather be used as a need to appreciate and accept the complexity and reality of diversity that is found within networks. Differences should therefore be used as a motivation for the networking of various entities within the collective, and as such should be regarded as a source of strength and depth of the relationship among the entities. His views are alluded to by Latour (2007) who regards the removal of boundaries as the basis of his philosophy of flat ontology. ANT as such studies how entities manage to come together, hold together and in the process, end up in networks that produce forces and effects (Latour, 1999; Fenwick & Edwards, 2011). This view has been explored by Latour (1999) when he mentions that the main aim of ANT is to investigate the extent to which

objects participate in the creation of networks that abound with relations within communities and collectives. It is important at this point to note that by referring to "objects" Latour was trying to do away with the dichotomy between objects and subjects which is a prime drive of humanism. He is thus attempting to accord agency to the nonhuman through referring to both the human and the nonhuman as objects.

3.7 TOWARDS WORKING TOGETHER WITH BOTH ANT AND OOO IN A CRITICAL POSTHUMANIST STUDY

The importance of working with the two theories is based on the need to interweave their tenets in a way that would befit a critical posthumanist and democratic pedagogy. Both ANT and OOO are inclined towards a democratic orientation. This is because both of them are based on the need to observe a flat ontology that recognises the relationship between all entities within a collective. In that case, they regard all entities as being on par with each other in terms of the ethics and morality that would characterise their relationship. The application of a flat ontology needs however to be applied with care so that issues of power relations are addressed sufficiently. For instance, Braidotti (2019) is highly critical of a flat ontology, because in flattening out the power relations, ANT and OOO relinquish the subject altogether in terms of gender, race, class and age relation.

However, on the other hand, these two theories have individual characteristics that if brought to work through each other in a diffractive manner, would bring about the manifestation of a critical posthumanist and democratic situation within the collective. In this study, the meaning of diffraction is borrowed from Bozalek and Zembylas (2017:1) who conceptualised it from authors including Haraway Barad viz:

> The notion of diffraction has been taken forward in the work of Barad (2007, 2010, 2014, 2015) who does not only regard diffraction as an optical metaphor, but also as a *method* and a *practice* that pays attention to material engagement with data and the 'relations of difference and how they matter' (Barad, 2007, p. 71). Diffraction is understood by both Barad and Haraway as a process of being attentive to how differences get made and what the effects of these differences are. Barad's notion of diffraction is derived from the physical phenomenon of diffraction which she extends

> to other forms of knowledge production.1 Diffraction from her perspective can be used to acknowledge the influential role of the knower in knowledge production and particularly how we learn about 'material configurations of the world's becoming'(p. 91). For Barad, diffraction is a useful tool highlighting the entanglement of material-discursive phenomena in the world. Diffraction is thus predicated on a *relational ontology*, an ongoing process in which matter and meaning are co-constituted.

For instance, ANT's emphasis on the importance of relationships, networks and entanglement as the determinant of the identity of all entities is critical if it would be worked along OOO's thesis that all entities are simply identifiable as objects. In such a case, OOO would lay the foundation that allows for the recognition of critical posthumanism through its assertion that all entities are ontologically just objects in one way or the other. The power of this assertion is that the dichotomous relationship characterising the human and the nonhuman is technically removed since all entities become objects, capable of associating with each other, and to form heterogeneous networks. In addition to that, by regarding all of the entities as objects that share objecthood, avenues are then opened for all of the entities to associate with each other, and thus share materiality among them. This connects well with the ANT emphasis on the prominence of relationships as the founding principle that determines the nature and extent of networks. That means, building on the objectification of the entire collective allows for the recognition of what Latour's parliament of things, where being a thing would be contingent upon the relationships among the various things. In another way, the working together with, between ANT and OOO would be facilitated by OOO's ontology that is based on a non-exclusionary manner regarding the relationship among the entities. This greatly impacts the manner in which it would forecast the direction of the study towards a democratic outcome. Due to the non-exclusionary manner, the implication would be that all entities within the collective would be regarded as friends that share materiality and would be capable of entangling and forming heterogeneous networks.

3.8 CONCLUSION

In this chapter I have first looked at the origins of ANT as the basis of how it came to be what it is today. I then proceeded to do an overview of the theory. The overview

ended with an examination of the critique of ANT and the emergence of the After-ANT theoretical perspective that tend to disagree with some of the views of ANT. I went further to give an overview of the key themes of ANT that I seek to use in Chapter 6 in the synthesis and development of a Critical Posthumanist and Democratic Pedagogical Theory. I concluded the chapter by discussing the affordances of working together with ANT and OOO in this study.

The integration of ANT in this study has the potential to bring tremendous affordances to the re-conceptualisation and transformation of pedagogy in the teaching and learning of Life Sciences. This is discernible from the themes that I have singled out. For instance, relational techno-socio-materiality as a theme is very crucial in the discussions pertaining to how the binarisation of the human and the nonhuman could be sustainably replaced by the recognition of materiality between them. It is this recognition of materiality as a common denominator between the human and the nonhuman that has the potential to lay a foundation for the manifestation of hybridity and heterogeneity within the collective. The hybridity and the heterogeneity in their own ways work closely towards the formation and sustenance of networks within the collective. These networks point towards the promotion of democracy as the different entities within the collective work alongside with each other, sharing agency. The hybridisation of the collective has the potential to bring the human and the nonhuman close to each other in such a way that their complementarity in the development of the collective would be indispensable.

Themes such as ethics and democracy are an intrinsic part of the overall direction of the study. For instance, a reconceptualisation of how ethics could be integrated into the teaching and learning of Life Sciences may offer new insights regarding how the human and the nonhuman should be understood in terms of their interactions within the environment, and the effect of such interactions. Ethics thus bears importance towards the entire study in the sense that it brings to the surface the importance of recognising morality between the human and the nonhuman.

Just like the contribution of ethics discussed above, democracy also contributes tremendously towards the achievement of a critical posthumanist and democratic pedagogy. Democracy as theme within the posthumanist sense wants to promote

ways not to be regarded as being only applicable to the human, but also to the nonhuman. Democracy as a theme, like ethics, searches for fairness to prevail across the human and nonhuman divides to the extent that the presence of the boundaries would make no sense since all the entities would be co-existing without undermining each other based on identity. The unimpeded co-existence would also be influenced by another theme from this chapter: free association. Free association essentially opens all avenues of interaction to all the human and the nonhuman to freely exist together with and alongside each other for the good of the collective. This would be of tremendous importance if applied in re-conceptualisation of how the Life Sciences pedagogy could be of use in addressing the Anthropocene.

CHAPTER 4: OBJECT ORIENTED ONTOLOGY (OOO)

4.1 INTRODUCTION

In the last chapter, I looked at the Actor Network Theory. An exploration of the Anthropocene is important in the sense that the acceleration of the phenomenon could also be related to the pedagogical approaches used in the teaching and learning of Life Sciences, including the manner in which the curricula are organised. The focus of the chapter was on the exploration of how the earth as a habitat that is characterised by sets of systems gradually descended into the Anthropocene. Having isolated the planetary boundaries as the study units of the Anthropocene, I am now going forward to explore how I can come up with a critical posthumanist and democratic pedagogical approach that would address the Anthropocene in the teaching and learning of Life Sciences. The theory that I wish to elaborate shall be based on the themes that I am going to extract from the selected theoretical traditions of Object Oriented Ontology, Actor-network Theory and Critical Diffractive Pedagogy. the Diffractive methodology is generally regarded as belonging to critical theory (Taguchi, 2012; Ulmer, 2016), in the case of critical diffractive pedagogy, the critical aspect emphasises how the pedagogy would focus on the establishment of relations between the human and the nonhumans. It is these relations that are important in the establishment of democracy in the teaching and learning of Life Sciences, while steering the pedagogy towards a solution that could address the Anthropocene. In this chapter I am going to focus on Object Oriented Ontology and conclude the chapter by giving a concise outline of the themes that I am going to use later.

The essentiality of OOO in this study lies on its demands and emphasis on the placement of all objects at an equal ontological level. This level of argument is very important in the sense that it provides an egalitarian platform whereby the human-oriented dichotomization of subject-object is done away with. OOO comes with the categorization of all entities as objects, are ontologically equated irrespective of their identities, and hence placed within a flat ontology. In this way, OOO therefore brings to the forefront issues related to the development of a common hybrid world within which all the boundaries are in a process of continuous making and re-making. The analysis of the OOO philosophy is very important in this study in the addressing of

how different entities could relate to each other in a manner that would lead to the development of a common world to which all of them would belong.

Towards the overall position of this study, the use of OOO adds the contribution of Actor-network Theory. The common world as a concept lays out an ideal foundation for the formation of relational heterogenous networks emphasized by ANT. The use of ANT in addition to contributing towards a heterogenous common world, also brings about the view that such a common world would also be characterised by hybridity. It is in essence a heterogenous and hybridised common world within which the human and the nonhuman entities freely associate. This chapter therefore contributes information that would be used in the reconceptualisation of both critical posthumanism and democracy from a Life Sciences pedagogical perspective. Towards critical posthumanism OOO adds aspects related to the development of assemblages between the human and the nonhuman typically leading to a critical posthumanist outlook. Concerning democracy, OOO brings around the view that the removal of boundaries between the human and the nonhuman would lead to situations where there would be both morality and ethicality in the manner in which all the entities would relate to each other. This is the basis of democracy.

The further argument is that through the ontological equation of all entities within the collective, in the process regarding all of them as objects, OOO opens the avenues for the inclusion of all kinds of entities into a common world. The creation of such a common world I argue brings with it an equally hybrid world. A further argument would be that a hybrid world would be built on the premises of a reconceptualized notion of democracy. As I argued in the chapters on posthumanism and ANT, the prevalence and expanded notion of democracy would terminate the human tendency to monopolise the centre of the collective. Such termination through the decentring of humanity, would lead to upholding mutual relations based on performative ethicality. When this happens, the opportunities to curb the encroachment of the Anthropocene might become possible. The chapter therefore follows an exploration of OOO with a particular focus on how its tenets address the above stated sub-question. A special emphasis is on how the adoption of OOO would lead to addressing the issues of the Anthropocene.

To achieve this, I will examine the OOO theory while focusing mainly on the following themes:

a. Principle of reductionism /irreductionism
b. Principle of flat ontology
c. Withdrawing of objects
d. Univocality
e. Alien phenomenology

The above-mentioned themes which form the central nerve of my discussion of OOO come from the work of Graham Harman, Levi Bryant, Ian Bogost and Timothy Morton. Though there are several others who have also contributed a lot to OOO, I have found Harman, Bryant, Bogost and Morton to be more relevant to this study. The origins of OOO have for the most part been contributed by Harman, with the other four alluding to his views in their own versions of OOO. I have therefore extracted what I regard as the crucial parts of their individual views of OOO suitable for my study. An analysis of the aforementioned themes would however only be achievable if I begin by giving a general overview of OOO. Before I probe into the individual philosophers' views regarding OOO, I will first discuss how OOO emerged from the ashes of correlationism. During this discussion, issues related to speculative realism will also be discussed.

4.2 HITHER CORRELATIONISM

This section deals with the background of OOO. The background includes how OOO as a philosophy metamorphised from correlationism. The section departs on a journey of tracing this development. Though the trajectory of the development is not linear, it appears to be more desirable to follow the primary route that the development has followed. In a nutshell, the discussion shall focus first on how the influence of idealism with correlationism as its front runner has led to the re-development and emergence of realism using speculative realism as its interfaces in a counter deployment manner. OOO then emerged as a collective and inclusive form of speculative realism. Speculative realism is a loose collection of philosophies that are generally linked by their opposition to correlationism (Galloway, 2013, p.353). Commenting on the origins

of the concept of speculative realism, Harman (2010) mentions that credit for the promotion of the concept of speculative realism is generally given to Brassier, though it has featured in the work of Meillassoux earlier.

Correlationism has been defined by Meillassoux (2012) as:

> ..the idea that we only ever have access to the correlation between thinking and being, and never to either term considered apart from the other. (p.5)

It has also been defined by Zahavi (2016) as:

> … the view that subjectivity and objectivity cannot be understood or analysed apart from one another because both are always already intertwined or internally related. It is the view that we only ever have access to the correlation between thinking (theory) and being (reality) and never to either in isolation from or independently of the other. On this view, thought cannot get outside itself in order to compare the world as it is 'in itself' with the world as it is 'for us'. Indeed, we can neither think nor grasp the 'in itself' in isolation from its relation to the subject, nor can we ever grasp a subject that would not always-already be related to an object. (p.4)

Heft (2016) defines it as:

> ..the view and or belief that humans cannot have access to anything outside of thought and thus any truth claims we make about the world must involve a human subject looking at an object - in a word, thought and Being are co-dependent. (p.12)

All three definitions give the impression that correlationism is all about throwing the human mind into the fold of everything else. It puts everything within the locus of the human mind, since the failure of that occurrence would essentially make things either insignificant or immaterial. Correlationism it is arguable, is backed by both idealism and humanism, and thus puts epistemology ahead of ontology and in the process, as described by Bryant (2011), subordinates the questions of being to the questions of epistemology. This view is idealistic and as a matter of fact, Meillassoux refers to it as extremely idealistic (Meillassoux, 2012). Heft (2016) has traced this subordination of ontology to epistemology, back to the time of Socrates. He goes further to mention that the subordination of ontology by epistemology has led to a tendency whereby the centrality of philosophy is centred on the extent to which humanity had access to the

world. In agreement with both Meillassoux and Heft, Golumbia (2016, p.7) posited that correlationism is simply another term for idealism.

In his work on the Democracy of objects, Bryant (2011) has lamented how the correlationist relationship characterising the human-world column has tended to humanize philosophy and, in the process, compromise the non-human status and parameters of ontology. Ontology in that way was infiltrated by humanism and lost its original spectrum It may be very reasonable to argue that correlationism forms the basis of science as a subject. The discussion of correlationism in this study is also essential in the sense that science subjects are humanistic (Aikenhead, 2006) and apparently also correlationistic. For instance, the manner in which science teaching and learning are conducted emphasises constructivism, which emphasises the link between the human mind and objects. This is alluded to by Heft (2016) below:

> …the truth of any scientific statement, for the correlationist, must not rest on any appeals to the nature of a piece of evidence in and of itself, but rest on the validity of evidence garnered from experiments conducted in the present that can, in theory, be verified by other scientists within the present. (p.16)

Heft's views in the above statement confirms that the scientific method is correlationistic. In other words, correlationism is a variation of humanism. This is due to its insistence on human centrality (Aikenhead, 2006). This places science at a very subjective junction, where its evidence would only be regarded as authentic if they only have a human confirmation. In that manner, along with its accomplice in correlationism, science lacks democracy, since it only takes cognizance of humanity among the innumerable number of entities that exist within the collective. While the issue of the import of correlationistic science deserves to be touched upon, the current discussion should focus on how OOO departs from correlationism.

Having noticed this shortfall of science and, the associated subjugation of ontology by epistemology, it becomes necessary to explore the next aspect in line. The desire all along is to trace the development of OOO. I argue that the deficiencies of correlationism and its ideals might fail to provide justice and democracy to all the entities within the collective. Based on one of the primary tenets of correlationism, namely that reality correlates with human thought as explained by Golumbia (2016), an opportunity arises that would usher in OOO with a new assortment of views.

Primary among those views would be the emphasis on the need to bypass rationalism which by itself is fundamentally humanistic. OOO brings the relief that focuses not only on the human mind, but on the existence of relations among all entities within the collective. The terrain within which these relations manifest would be regarded as flattened and beholden of equivocality. In that manner, there is an emergence of relations that assume pre-rational nature. In that way, rationality ceases to become the yardstick for the determination of being. Every other entity would then qualify as an object. This is how OOO overtakes and supersedes correlationism and is of profound importance in this study where the need for the existence of democracy among all the entities within the collective is paramount.

4.3 THE BIRTH OF OOO

OOO as a philosophy is generally profiled as the work of Graham Harman. Harman himself however says that he actually uses the term as Object Oriented Philosophy (OOP) though he does not mind the use of OOO when representing OOP (Harman, 2011). The term Object Oriented Ontology is quite recent. It was first coined by Levi Bryant in 2009 as a compromise to the different views that they held together with Harman and Bogost (Harman, 2015). This view which is given by Harman in his outline of the origins of OOO, is also linked to his explanation that apart from the more publicised proclamation of the term by Bryant, he had already used it back in 1997 at a speculative realism conference at the University of London. This explanation perhaps works as an antidote to the often-confused relationship between OOO and speculative realism which I will address later on. Currently, I am focusing on the general overview of OOO.

I have mentioned at the beginning that OOO is mostly attributed to Graham Harman. As explained by Heft (2016), Harman's views were indeed influenced by his reworking of Heidegger's theory into his popular theory of tool-being, and also borrowing some elements from the works of Husserl. Harman's argument was that it is essentially worthwhile to envisage a world that is fundamentally characterised by the ubiquitous presence of objects. Harman goes further to explain that in this world, there would also be some object to object interactions that are completely independent of human thought and involvement. This argument essentially puts correlationism to rest.

Harman advocates for the observance of realism as the yardstick to examine the relationships existing among objects. The baseline view of OOO is therefore based on the view that objects exist in nature irrespective of the presence of the humans. In this way, humans are regarded as merely one of the object categories.

In order to develop a thorough and coherent theory of OOO, it would essentially be most proper to first explore what an object itself is. The rationale for this suggestion is based on the view that the object indeed is regarded as the fundamental element of being within OOO. Following this line of argument, Harman (2015) has defined an object as “a real thing considered apart from any of its relations with other such things”. (p.19). Though his definition appears to isolate objects and disregard their relations, the aspect that he defines objects in such a way confirms the presence of the relations.

Harman’s definition means that an object is standalone and non-reducible to anything except itself. His emphasis of how the relations that an object has with other objects has no bearing on the identity of the object seems to suggest that the object is independent, characterised by an independent reality and is not a product of any other object. Neither may the object itself be a source of another object. In his previous work on objects in 2011, Harman has mentioned that the existence of objects as independent entities implies that they have a unified reality that is definable by their own existence, and that is autonomous to the environment to which they belong. He argues further that the autonomy and independence of objects is the one that fosters the development of a flat ontology wherein all objects have a fundamentally equivalent existence at least ontologically. A close analysis of Harman’s views gives the impression that objects are not comparable to any other objects nor even to themselves. This gives the starting point of the philosophy of object undermining and overmining that shall be briefly discussed subsequently in the chapter. Harman’s views about objects so far seems orthogonal to the views of other OOO philosophers such as Latour who emphasise the relationality of objects and how they shape and determine the destiny and nature of the object. However, Harman also agrees with the view of the existence of relations between and among objects. He critically emphasises that though objects are not necessarily products of the relations that they have with other objects, they nonetheless in a way also form relations with other objects. But these are independent relations. They are not dependent relations like generally portrayed in relationalism. In this paragraph, I have defined what an object

is and will give a description of how an object is constituted. I am going to investigate the characteristics of objects when I look at the Principle of Reductionism. In the next section, I am going to explore the main themes that characterise objects, which I find essential for my study.

The first theme that I shall look at is the Principle of Withdrawalism of objects. Though some OOO scholars call it the principal of withdrawal, I will use the term Withdrawalism that I view as being more representative of the manner in which the process of withdrawing continually takes place. This principle is derived directly from Heidegger's philosophy of how objects operate. As elaborated by Harman, this principle mentions that no matter to which extent we use an object, a tool for instance, there is no point where we exhaustively understand the nature of the object in its totality. In essence, the principle posits that objects always withdraw some of their characteristics and features from the individual using them. The Principle of Withdrawalism is coupled with the Principle of Inexhaustibility. The Principle of Inexhaustibility mentions that due to the autonomous nature of their beings and the independence of their operations, object qualities are verily inexhaustible. This implies that the way objects operate are innumerable and depend on the other object that they relate to. The Principle of Inexhaustibility generally makes objects very diverse in their operations, and when described collaboratively with the Principle of Withdrawalism, the two of them explain how objects through withdrawing some of their features in different situations remain undiscoverable and are only knowable in some ways, yet not others. Understanding the nature of an object becomes an on-going task which is characterised by repeated episodes of disclosures and concealment characteristics (Harman, 2011).

The other important principle of OOO is the Principle of Reductionism/Irreductionism (Harman, 2011). This principle is closely related to Principle of Withdrawalism. The two are linked by the central aspect that the totality of an object is never knowable since it only reveals certain aspects to certain objects and not others. This principle should not be confused with the Principle of Inexhaustibility, though they are related. This view is lucid from Harman's elucidation of Heidegger's tool being theory. Harman quotes Heidegger's statement that in whatever the level of interaction, an object would never be used, but would simply be what it is. The argument is that there is a need to watch the way we comprehend objects so that we do not come to categorise them by their use, a situation that Harman calls caricaturisation. Such categorization would

indeed be very much inadequate given that objects tend to withdraw their beings in certain manners. As such, our current view of the object is only part of a totality of potential views that may describe the same object. The multifaceted extent to which any object could interact with different objects is what Harman regards as the process through which objects objectify each other. This is a very crucial characteristic of the Principle of Reductionism. It is attributable to the view that each object interacts with another object in a different manner. Harman argues that those interactions are not reducible to anything other than what they are. Posing a further argument about reductionism, Harman (2002) has reiterated that reductionism is not restricted to sentient objects. The concept of sentiency is generally associated with living objects, since it implies the presence of feelings and perceptions. Harman's argument is therefore based on the view that all kinds of objects are prone to being reductionist. This view occupies a central place in the progress made in OOO. It is the one that opens avenues and breaks boundaries among objects to the extent of suggesting that human and non-human objects regardless of the sentience parameter, are irreducible to each other. For instance, when teaching learners about global warming as an aspect of the Anthropocene, the teacher may not reduce the Anthropocene to global warming or in the reverse order, expand global warming to the level of the Anthropocene. Being an aspect of the Anthropocene does not make global warming the Anthropocene itself. They are related, but simply irreducible to each other. From an ontological perspective, everything is an object irrespective of its nature. For instance, phenomena such as the Anthropocene are objects similar to temperature and rain. In that way, being an object is not necessarily tied to the state of the object. It is just an ontological categorisation which brings everything together under the same general umbrella. The intention is to avoid dichotomization of matter. I would therefore propose that the concept of object is based on an advanced form of materialism that includes not only everything that has mass and volume as matter is generally regarded, but everything that is perceptual too. In that case, ideas are material since they are perceptual. According to this categorisation, knowledge is materialistic, and so are other physical things.

Harman also postulates another crucial aspect that involves reductionism; he mentions that objects cannot be described qualitatively. Thus, as he maintains, objects cannot be described by their qualities. The utmost part of his argument is that qualities

are only part of the object, and thus an object would not be described by using only some element of it. In another way, qualities may not be absolute; they are only determinable to the extent of the other object that is discerning them. They may in that case be regarded as subjective. This is the foundation of the Principle of Mining of objects as described by Harman. The Principle of Object Mining states that objects should not be characterised by either by their components (under-mining) or by their totality (over-mining) (Harman, 2010). Harman's argument regarding the Principle of Object Mining is that objects should be regarded as what they are without under-representation or over-representation since this will have the effect of distorting their real nature. This Principle can be regarded as a component of the Principle of Reductionism and is very important in the teaching and learning of Life Sciences. In order to avoid undermining, teachers should use experiments to convey the concept under investigation adequately beyond the individual importance of the experiment and its components. On the other hand, the learners should be able to understand the intended outcomes of the lesson without having to go into the details of the importance of each phase of it. Moreover, objects as per the Principle of Withdrawalism would only exhibit some qualities and not others depending on the communicable situation. This might then imply that neither undermining nor overmining is understated, but rather occur in accordance with the withdrawal tendency of objects. Going back to the example of the teacher and his learners in a Life Sciences lesson, their interaction during that period may not be reduced to give an accurate view of their interactions before or after the lesson. It may not be reducible to the performance of the learners in the forthcoming end of term test, either. It is just an interaction there and then, bound by the parameters of time and many other withdrawn parameters of both the teacher and the learners. The interaction thus does not cater for various qualitative aspects that are found in their individual beings.

Based on his work on the Principle of Reductionism, Harman has then found himself in a position to define what he calls an object. It might appear somewhat absurd that there has been mention of objects, yet the definition of the object is not known. The definition it appears has developed alongside the principles that guide OOO. Harman in his work on OOO in 2010 has come to define an object as "anything with some sort of unitary reality" (p.147).

This definition might be regarded as very composite. It links backwards with what has been cited above as what Harman means when he says that objects are not used but rather are what they are. Being what they are is an implication of unitary reality, implying that they have a completeness no matter how they are seen or perceived. Having come up with the definition of an object, Harman (2010, p.116) then states what he regards as the five rules that make an object an object.

> a). Relative size does not matter: an atom is no more an object than a skyscraper.
>
> b). Simplicity does not matter: an electron is no more an object than a piano.
>
> c). Durability does not matter: a soul is no more an object than cotton candy.
>
> d). Naturalness does not matter: helium is no more an object than plutonium.
>
> e). Reality does not matter: mountains are no more objects than hallucinated mountains.

Apart from the foregoing description of objects, including what objects are, Harman is also credited with the categorization of objects. Caution has to be exercised in this case. The categorisation might generally be totally inadequate, for instance if we follow the views of the Principle of Withdrawalism. I proceed here on Harman's assertion that an object is what it is and is not usable. Based on this view, Harman has categorised objects into real objects and sensual objects. The distinction between these constructs of objects plays a central role for instance in the teaching and learning of Life Sciences. I should however start by giving a description of each one of the categories. In his work on the Quadruple object in 2011, Harman mentions that real objects represent the object as always withdrawn. This confirms what I have mentioned earlier in this chapter that real objects are not totally knowable. Perhaps an understanding of the real objects would be achievable after comparing them with another category of objects: the sensual objects. As explained by Harman, the sensual objects are a product of the caricaturisation of real objects. In other words, these are real objects as perceived or sensed. This is the basis of the Principle of Vicarious Causation (Morton, 2013). The principle states that in between any interacting real objects there exists a sensual buffer zone whose role is to define the relationship (Harman, 2016). Due to the existence of this buffer zone, the effect that the objects cause on each other is

called vicarious causation (Morton, 2013). One point that I have to make clear here, regards the sensual category of objects. From the onset, the aspects of sensibility and perceptibility that are tied to sensual objects are not restricted to living objects. The sensuality of the said sensual objects is based on their mere presence as objects. In that case, non-living objects might also be regarded as being sensual. This is justified by the principle of vicarious causation as mentioned by Morton (2013). The sensuality of sensual objects from the principle is based on the effect that they have on each other. For instance, objects have effects on each other irrespective of the presence of humans. This is explained in the following statement by Harman (2011):

> If objects exceed any of their perceptual or causal relations with other objects, if they inhabit some still undefined vacuous space of reality, the question immediately arises as to how they interact at all. More concisely: we have the problem of non-relating objects that somehow relate. Since no causation between them can be direct, it clearly can only be vicarious, taking place by means of some unspecified intermediary. Whatever this third term may be, it already seems clear that it has something to do with the shower of loose qualities that captured the interest of the carnal phenomenologists. (p.91)

Apart from his categorisation of objects as being real and sensual, Harman has also explored the qualities of objects. His argument is that objects irrespective of being real or sensual also have qualities related to each category. Harman (2010) thus came up with two corresponding categories of object qualities viz: real object qualities and sensual object qualities. He describes real qualities as those qualities that withdraw as the real object withdraws, and sensual qualities as those qualities that characterise the sensuality of objects and do not withdraw from the objects. The sensual qualities therefore lie within the experiential front of object encounter. In essence, real qualities are prone to withdrawing while sensual qualities foreground the view of the object.

4.4 THE ARRIVAL OF THE SPECULATIVE REALISTS: LEVI BRYANT AND IAN BOGOST TOWARDS OOO

In the foregoing section, I have outlined Graham Harman's contribution to OOO, at least those aspects that are suitable for my study. In the following section I am going

to discuss the contributions of Levi Bryant and Ian Bogost to OOO as well. Like in the case of Harman, my focus shall only be on those aspects that are relevant to my study without either overmining or undermining their contributions. The two scholars have been described by Heft (2016) as a new generation of speculative realists.

Bryant's main contribution towards OOO concerns what he termed flat ontology. In this section, I am going to discuss the principles of OOO according to Bryant. Bryant (2011) describes flat ontology as a very complex concept in philosophy wherein a multiplicity of ontologically connected themes is put into a single category. Bryant (2011) states the first tenet of flat ontology as follows:

> …. due to the split characteristic of all objects, flat ontology rejects any ontology of transcendence or presence that privileges one sort of entity as the origin of all others and as fully present to itself. (p.245)

The implication of this tenet is that no object possesses nor should be accorded a presence that seems to suggest that it has universal authority to control other objects. In essence, all objects have an equal presence, and none of them should be granted an apriorism status wherein they would seem to be the source of other objects. Thus, there is neither a source nor a sink regarding the relationships existing among entities. The entities are at the same level of presence, with presence being the sole determinant of their relationship to each other. Bryant's argument could partly be bolstered by what he has regarded as the *split characteristic* of objects. The split characteristic view resonates with the view that objects withdraw some of their characteristics during interaction with other objects. In his explanation of the split characteristic of objects Bryant has it that objects are split in the sense that in one way they have actualised qualities while they also have virtual qualities (Bryant, 2011).

Bryant's second tenet of flat ontology states that neither the world nor the universe do not exist (Bryant, 2011, p.246). This might appear to be a very controversial tenet from a general OOO perspective. It is unimaginable to view the world as non-existent. One would certainly wonder. Bryant argues that the non-existence of the world is based on the premise that there does not exist a super being that yields the power to assemble all the other entities of the world into a specific order, as we may see the world. My first assumption upon reading this statement is that Bryant is perhaps politely decentring the self-proclaimed agency of the human over all other things. He

goes further to state that this principle is the one that lays the foundation for flat ontology. Bryant (2011) describes flat ontology as follows:

> ….flat ontology refuses to privilege the subject-object, human-world relation as either a) a form of metaphysical relation different in kind from other relations between objects, and that b) refuses to treat the subject-object relation as implicitly included in every form of object-object relation. (p.246)

In formulating his third tenet, Bryant borrows a lot from the work of Graham Harman especially regarding the relationship between the subject and the object. As he mentions in his prime work in Democracy of the Objects, Bryant (2011) further mentions that:

> In shifting from a dual ontology based on the nature/culture split to collectives, onticology and object-oriented philosophy place all entities on equal ontological footing. Rather than two distinct ontological domains, the domain of the subject and the domain of the object, we instead get a single plane of being populated by a variety of different types of objects including humans and societies. (p.246)

Bryant's view of flat ontology is therefore an attempt to do away with dual ontology and the presence of boundaries between the object and the subject. In his further explanation of flat ontology, Bryant (2011) mentions that the philosophy does not doubt in any way that humans have a lot of agency within them. The argument he poses is that:

(i) The possession of this agency does not limit agency to the humans alone;

(ii) The possession of the agency does not give the humans an extra mileage of authority to interfere in the agency, and the possession of agency by other objects.

This is well stated in Bryant (2011)'s statement below:

> … nothing … establishes that humans must be included in every inter-object relation or that how humans relate to objects differs in kind from how other entities relate to objects. (p.246)

The direction of Bryant's stake in the establishment of OOO is that there exists relations between and among all objects. Further to that, these relations exist independent of human presence. In that way, humans are just another category of objects that form relations with other objects. Moreover, the relations that humans in their objectified status form with other objects are not and should not be privileged in any manner. Bryant in that way manages to justify his democracy of objects, an aspect that places a very central role in this study. The existence of the democracy should be regarded as both an input and an output of a flat ontology. As an input the existence of some democratic relations gets rid of any pre-condition to association, and also to any form of prejudice that objects may make of each other. Consequently, relations are formed without pre-conditions leading to the formation of an egalitarian society that is also an output.

Flat ontology then ushers in another critical principle in OOO, which is also critical in this study. This is the Principle of Univocality. In his description of the Principle of Univocality Bryant mentions that Being has just one voice (Heft, 2016). This view which also comes from the declaration of a flat ontology, puts Being as the ultimate nature of all entities. Since the equivalence of being is accessible only at an ontological level, where Beinghood is tied to difference-producing, at the same level, being a being of one says the same thing as being a being of another thing. As such, if all the beings are just the same, they are therefore univocal in the extent to which they present and represent their beinghood. The Univocality of Being fits perfectly into the OOO philosophy wherein, Beinghood would be equivalent to Objecthood. In that way, all objects speak the same voice with differences in degree but not in kind. As explained by Heft (2016), the Principle of Univocality also adds to the views of irreducibility, since by being equivocal, the objects are what they are and may not be reduced to anything else. In other words, the underlying factor is that OOO presents objects as being similar in their beingness and different in their uniqueness.

The other author whose contribution to OOO is indispensable to leave out in my study is Ian Bogost. Bogost contributed to OOO through his concept of Alien Phenomenology which he expresses through his theory of ontography. In his explanation of the theory of Ontography, Bogost (2012) mentions that his theory is based on the relationship that exists between entities. This theory is underwritten by flat ontology (Heft, 2016) and emphasises for instance, that though the theory looks at

objects, and their relationship within a given situation, it also emphasises that objects nonetheless maintain their unitariness. Bogost' Ontography looks at entities as group members where their relationship is determined by flat ontology. Nonetheless, apart from their membership which is a determination of their belonging to the same group and or set, they however maintain an existence of their own. This aspect agrees very much with Harman's emphasis that tools are not usable but are just what they are. The difference is that Harman focuses on how individual objects interact with each other, while Bogost focuses on the relationship and existence of grouped objects. Both of the philosophers concur when it comes to the role that flat ontology philosophy plays in the ways that it oversees the removal of boundaries between entities. Bogost's Ontography philosophy therefore looks at how objects relate to each other within the various groups where they belong. The importance of his theory is that it augments and bolsters the OOO as a theory through its emphasis of the existence of non-discriminatory relations among entities within a collective.

The other key theme that comes from the Alien Phenomenology philosophy of Bogost is the use of Metaphor and Analogy. He argues that the use of metaphors and analogies allows us to imagine how it could be any other object other than ourselves. This is very important in the way in which OOO would be conceptualised and extended. Using metaphors would open the avenues for a common Beinghood. In other words, this has the potential to decentre the human through allowing the human to extend sentiency to ontological levels where it is equivalently shared by all entities. This would essentially lay a firm foundation for OOO. From Bogost's point of view, aliens are non-human objects. By referring to alien phenomenology, he tries to express how humans may come to understand the dynamics of being non-human. Like Harman, Bogost emphasises that alien phenomenology opens up avenues for humans to have a feeling of the non-human, he also takes note of the view that the non-human like any other object would always have some of their features and characteristics withdrawn. Bogost's emphasis of alien phenomenology is often referred to as anthropomorphism (Davies, 2010; Duffy, 2003). The anthropomorphic perspective however could be attributed to humanism due to its spreading of human parameters to the non-human entities, which may be misconstrued as a manifestation of humanity's desire to conquer all elsewhere.

4.4.1 Timothy Morton and the promise of OOO

Timothy Morton has approached OOO mostly from the philosophy of speculative realism. In this section I am going discuss how he attempts to advance OOO through speculative realism. In his introduction of OOO Morton (2011) stated thus:

> OOO belongs to recent attempts to rethink realism in the wake of the distinctly anti-realist philosophies that have held sway for some decades. In so doing it shares obvious affinities with ecocriticism and ecophilosophy. (p.164)

Based on the above statement Morton presents OOO as a more authentic form of realism having observed that realism has been under persistent attack from idealists and their idealism. He argues that his view of OOO is that it locates itself into a space where it does not belong either to nature or non-nature. It therefore positions itself in the middle of the natural and the non-natural, not as a matter of compromise but as a matter of necessity. OOO Morton (2011) argues further, is a median between essentialism and nihilism. Morton (2011) goes further to define OOO as:

> …a form of realism that asserts that real things exist—these things are objects, not just amorphous "Matter," objects of all shapes and sizes. (p.165)

Based on the foregoing statement on the relationship between OOO and realism, the latter can be defined as the belief that real things exist, with or without human input in their existence. Morton's view of realism further agrees with Harman's assertion of the manner in which real objects withdraw during interaction with other objects. Morton appears to also have borrowed this from the philosophies of Husserl and Heidegger, who both concur that real things generally withdraw some of their features during interactions. Morton also agrees with the views of Latour regarding the relationality of objects. He however differs from Latour in the manner in which he presents object-singularity. Morton argues that though objects interact with each other, the objects individually maintain closed operational boundaries. Perhaps this aspect of closed operational boundaries might be compared in essence to the aspect of withdrawal which objects perform. This is because by maintaining a closed operational boundary, the Being of the object may never be fully understood as it only operates within a closed space. This is confirmed by Morton (2011) in the following statement:

> An object is profoundly withdrawn—we can never see the whole of it, and nothing else can either. (p.165)

One of Morton's major contributions to OOO is how he links the concept to the ecology. This contribution is essential in this study; ecology remains a central concept with regard to how issues of the Anthropocene may be addressed. Ecology looks at how objects interact with other objects within the bounds of their environment, which is also an object in its own right. Morton (2011) introduces the concept of Hyperobjects to OOO. His argument for the introduction of the concept of Hyperobject was based on his belief in realism. He summarized his views as follows:

> OOO is a form of realism that asserts that real things exist—these things are objects, not just amorphous "Matter," objects of all shapes and sizes, from football teams to Fermi-Dirac condensates or, if you prefer something more ecological, from nuclear waste to birds' nests. (p.165)

After having described OOO as a realist movement, Morton extends the views Harman, Heidegger and Husserl, and described how objects withdraw from each other, while operating within a sphere that is characterised by a generally flat ontology. Morton did all this to bring in and locate his theme of Hyperobjects. He described a hyper object as an object that has massive distribution within time and space to the extent that it forces mankind to reconsider the definition of what would be the essence of an object. He goes further to mention that the Hyperobject imaginative forces us to reformulate the way we conceptualise objects on one hand, while also relooking at how subjects view objects. In another way, the Hyperobject phenomenon makes us analyse how objects view other objects and by doing that we place ourselves at the same ontological position as any other objects whether animate or inanimate. This then opens the horizons for the exploration of how objects may collectively collaborate towards the inadvertent effects that come with the Hyperobjects such as the Anthropocene. This view is summarised by Morton (2011) in the statement below:

> The BP oil spill of 2010 provides yet more evidence that ecological reality contains Hyperobjects: objects massively distributed in time and space that make us redefine what an object is (ET, 130– 35)… Contemplate global warming, a Hyperobject that you can't directly see or touch—it's withdrawn. It affects all weather on Earth yet it's not reducible to particular manifestations such as sunshine or rain. Instruments such as computers

> processing terabytes per second can see global warming—not human eyes. What is truly disturbing is that the wet stuff falling on my head is now a mere accident of some unseen substance. Nature has disappeared; no—we are realizing we never had it in the first place. The world is real—but not because you can kick it. Giving up a fantasy is far harder than giving up a reality. (p.168)

The implication of Morton's views is that OOO should open our views of Hyperobjects to the extent that we would be able to interrogate them. The concept of Hyperobject is therefore very crucial in this study since it has the potential to explore the networked complexities of objects, notwithstanding how their potential to withdraw would possess some unlimited power to conceal from our view the very aspects that might have the agency to accelerate the effects of the Anthropocene.

4.5 CONCLUSION

I have so far looked at OOO as given by its principal authors. Irrespective of the differences in the approaches to OOO as presented by the various authors discussed in this chapter, it should be noted that the destination of each one of them is the development of a flat ontology, where all entities are equal at least ontologically. Moreover, it is also important to note that the equality being mentioned here does not mean physical equality which would certainly not be possible given the diversity of the entities discussed. It is the ontological equality which is basically the equality of being. The first aspect that I discussed regards the necessity for the eradication of the theory of correlationism. As discussed above correlationism as theory advances the need for human thought to supersede anything else. Correlationism states that objects only make sense if they are cognitively synthesized first. This then places humanity at the centre of everything since the cognitive synthesis is a human mind feature. As such all non-human objects would be denied access to objects that are external to their cognitive synthesis levels. Due to these shortfalls, correlationism was then replaced or at least had its views contested by speculative realism. It is reported in the literature that the definition of speculative realism would always remain as one of the most disagreed definitions (Austin, Ennis, Gironi, Gokey & Jackson, 2013; Phetteplace, 2010). As mentioned by Harman (2010), speculative realism refers to the mosaic of theories that oppose correlationism. It is based on the view that objects should be

studied from a realistic perspective, that is as they are. OOO is regarded as a dimension of realism (Gratton, 2014).

I have singled out what I regard as important themes presented by the referred authors, which I find to be essential to my study viz:

a. Principle of reductionism /irreductionism
b. Principle of flat ontology
c. Withdrawing of objects
d. Univocality
e. Alien phenomenology

Having selected these themes as essential for use in Chapter 6 in developing a Critical Posthumanist and Democratic Pedagogical Theory. Each theme will add value to the overall argument of the thesis, and their individual contributions must be discussed here. To achieve this, I analyse how each theme contributes towards either the critical posthumanist aspect or towards the democratic aspect of the theory. For instance, The Principle of irreductionism adds value to the issue of both critical posthumanism and democracy. Towards critical posthumanism, the principle irreductionism rejects the attempt to humanize all entities within the collective. In that case, it emphasises that the different entities are good as they are to the extent that none of them deserves to be reduced to another. Such a view rejects humanism, an important desire of how Life Sciences pedagogy should be re-conceptualised. On the other hand, by rejecting reductionism the principle simultaneously advocates for posthumanist democracy. This is because it would suggest that both the human and the nonhuman should not be placed in binarized relations as a determinant of their respective roles and contributions within the collective. In that case, the principle advocates for the ontological equivalence of both the human and the nonhuman. That in essence would be democratic.

The contribution of the principle of irreductionism discussed above is related in a way to the contribution of the principle of flat ontology theme towards the overall aim of the study. The principle of flat ontology contributes towards critical posthumanism by its emphasis on the recognition of the need to treat the human and the nonhuman as

being ontologically on par. In that case, the human and the nonhuman are regarded as being together with each other within the collective. To that extent, they would be democratically sharing the resources within the collective without either of them playing the master and the other playing the servant.

On the other hand, the withdrawing of objects theme contributes towards critical posthumanism by its emphasis of how the relationship among the human and the nonhuman should be understood beyond the general level. In that case, there is a view that insists that what looks apparently clear might be driven some latent factors behind the scenes. This is important for instance on the analysis of how the relationship between the human and nonhuman contributes towards the Anthropocene. For instance, this theme allows for the broadening of understanding of how the nonhumans also possess some latent sentience that cause them to respond to the activities of the humans. A typical example would be how the atmosphere responds to the emission of chlorofluorocarbons by causing the global warming. This example shows that the atmosphere has certain withdrawn characteristics that would only appear under certain circumstances as a response for instance to human actions.

The univocality theme contributes towards the overall aim of the study as well. For instance, it emphasises that every entity within the collective should be allowed to have a voice. This aspect is very important in the study especially the issue of dichotomisation between the human and the nonhuman is discussed. In that case, the theme allows for the recognition of how the dominant humans subjugate and conquer the subalterns, a process that causes the Anthropocene. Univocality therefore demands for all voices within the collective to be accorded equal prominence. Such an eventuality would consequently lead to the recognition of both a critical posthumanist (since the nonhumans are listened to) and democratic (since the nonhumans are treated as companions) dispensation within the collective.

The selection of these themes would also be based on their suitability with regard to answering the following questions:

(a) How does each theme add value to critical posthumanism?

(b) To what extent does each theme promote the manifestation of democracy within the above-mentioned hybrid and heterogeneous world?

The first question focuses on the analysis of how each theme would promote the recognition of all entities within the collective be they human or nonhuman. In that way, the question focuses on how the theme would reject the recognition of human agency ahead of the agency of the nonhuman entities, thereby establishing a flat ontology between the human and the nonhuman. By doing that, there would be critical posthumanism within the collective. On the other hand, the second question would be used to direct the analysis of how the prevalence of critical posthumanism would promote the development of democracy within the collective. This brings in themes such as univocality which emphasise the need for all entities within a collective to have a voice, and thus be in a place to be heard. When this happens, then there would be democracy within the collective.

My next task would be now to explore how each of the themes that have been put forward by the discussed authors would be useful in the creation of a hybrid common world. By hybrid common world, I mean a world where the division between the natural and the cultural is removed. This would be an egalitarian society characterised by democracy, and beloved of critical posthumanism. I reserve this aspect for discussion in Chapter 7. The next aspect now regards how the chosen and discussed themes of OOO could essentially lead to the development of a hybrid common world that is characterised by democracy and critical posthumanism within which all the objects are ontologically equal. Such a common world would indeed be able to address the challenges of the Anthropocene.

CHAPTER 5: CRITICAL DIFFRACTIVE PEDAGOGY

5.1 INTRODUCTION

This study seeks to develop a critical posthumanist and democratic pedagogical approach in the teaching and learning of Life Sciences. The developed approach is expected to enable the teaching to be able to address the issue of the Anthropocene. Chapter 2 of the thesis is an overview of the Anthropocene phenomenon including its background and challenges. In Chapter 3, I looked at Actor Network Theory (ANT), and I ended the chapter by extracting some themes which I will use in Chapter 6 wherein I develop the critical posthumanist and democratic pedagogical approach I have alluded to above. Chapter 4 focuses on Object Oriented Ontology (OOO). I also ended the chapter by singling out some themes that I will use in Chapter 6 as well. In this chapter, I am going to develop a new theory of Critical Diffractive Pedagogy Theory (CDPT). To develop this theory, I diffract principles of Critical Pedagogy Theory (CPT) and Diffractive Theory (DT) and come up with a new view of their intra-action. As explained by Barad (2012) intra-action as a concept poses the argument that agency is not possessed by individual entities themselves, but rather it develops and emerges through the development of relationships. I summarise this chapter by extracting some themes and also explain how each theme will contribute towards the overall aim of the study.

My structuring of the chapter is as follows. First, I look at the history of critical pedagogy, followed by the classification of its various approaches. Thereafter, I explore the importance of critical pedagogy in teaching and learning, followed by an analysis of the place of critical pedagogy in learning. The last section is an overview of the diffractive methodology approach before I conclude the chapter. My use of critical pedagogy in this study acknowledges the fact that the theory itself is informed by the same humanism philosophy whose influence I want to expunge from the teaching and learning of Life Sciences. Critical pedagogy's emphasis on critical analysis of knowledge (Shor, 1993) as the basis of freedom makes it useful within the posthumanist tradition. Through the critical analysis of knowledge, it becomes possible for a pedagogical perspective to map out the relationships between the human and the nonhuman. Critical pedagogy therefore leaves an open space for understanding

the possibilities of interaction between the human and the nonhuman which is of essence in addressing the Anthropocene.

5.2 THE HISTORY OF CRITICAL PEDAGOGY

The history of critical pedagogy as a philosophy can be traced to the Frankfurt School at the University of Frankfurt back in 1923 (Frankfurt School, 2008). The Frankfurt school was established to study socialism. An understanding of critical pedagogy has to be traced back to critical theory. According to McLean (2006) the name critical pedagogy itself was first used in 1937, and from it critical pedagogy developed. In his analysis of the historical development of critical pedagogy, Giroux (2003) mentions that critical literacy essentially provides the insight and foundational background that is needed for the development of critical pedagogy.

The linking of critical pedagogy with the 1930s was alluded to by Wolin (2006). According to Wolin the introduction of critical pedagogy came in as a result of the apparent shortcomings that started to emerge between the disciplines of philosophy and the social sciences. He elaborated further that on one hand philosophy was pre-occupied by ideals and ultimate ends in the process ignoring the issues associated with reality and existence. On the other hand, social sciences were ultimately focused on factual representation of things. Critical pedagogy was therefore brought in to bridge the gap that was simmering between the two fields.

Within the Frankfurt School the pioneering work on critical theory was done by scholars such as Herbert Marcuse and Walter Benjamin with their focus on analysing how critical thinking could be used as a foundation for self-emancipation (Giroux, 2003; McLean, 2006). Their focus was on how to bring about liberatory social change. The prominent and outstanding feature of critical theory according to the literature (Bohman, 2001; McKernan, 2013) is its emphasis on the achievement of practical human emancipation. It therefore deviates from the theoretical overview of relations and aspires to see some utilitarian engagement. This view is alluded to by Popkewitz and Fendler (1999) in their analysis of the role of critical thinking in critical pedagogy. They argue that critical pedagogy gives the learners the urge to be sceptical of the commonly accepted truisms in society.

Critical theory has diverged into a multiflora of other sub theories including race theory (McKernan, 2013) which makes the theory inter-disciplinary (Torres,1999). Paul Freire is regarded as one of the key fathers of critical pedagogy. According to Wink (2000), Freire used critical theory to come up with a critical pedagogy that seeks to impress upon the learners the need to analyse the oppressive systems within their lives as a way of bringing about learning. He referred to this as reading the world as the basis of learning. In that regard, Freire has a wide understanding of pedagogy. He possibly narrows the gap between pedagogy and literacy and in a way contextualises the operations of both of them. Freire's approach has been described by McLaren (1997) as the development of culture circles as units of learning. The approach could be described as an attempt to promote the development of co-agency and co-constructivism. It thus has some social constructivism undertones. According to Shor (1993) the central idea of Freire's views is that education should bring about empowerment as a tool for social change. The social change being implied is underwritten by democracy and equality. Blackburn (2000) however has another dimension of Freire's advocacy. He believes that Freire's pedagogical aspirations go beyond the liberalisation of the society and goes further to suggest ways through which the oppressed may be accorded their due humanity. The humanisation process according to Giroux (2010) has to be based on collective personal experiences that are shared through individual narratives in a manner that relates them to the learning process and content.

Due to the diversity of the views regarding critical pedagogy, the approach has been known by various names, for instance 'border pedagogy' (Giroux, 1988; Janmohamed, 1993), 'liberatory teaching' (Shor, 1993), 'pedagogy of possibility' (Simon, 1992) and 'emancipatory pedagogy' (Gordon, 1985; Swartz, 1996) among many others. The gradual encroachment of critical pedagogy upon education has been reported in the literature (Apple, 2006; Doyle & Singh, 2006; Giroux, 1997; McLaren 2006). The authors concur that critical pedagogy started with both a theoretical and a political parameter to it. Due to its nature, its adaption within education fora has been to work with the need for teachers to be able to pursue social justice as both a means and an end to education (Huerta-Charles, 2001; 2007).

In a thorough study of the terminology of critical pedagogy Jeyaraj (2014) has come up with a table that categorises it. The outcome of the study is illustrated in Table 5.1 below:

Table 5.1: Definition of common names related to critical pedagogy (Jeyaraj, 2014, p.43)

Term	Definition
Border pedagogy	Border pedagogy is a multicultural educational approach which is attentive to developing a democratic public philosophy that respects the notion of difference. Border pedagogy aims to remove cultural and political barriers to attain a greater conceptualisation of the human experience; and links the notions of schooling and education to a more substantive struggle for a radical democratic society (Giroux, 1991; Kazanjian, 2011).
Pedagogy of possibility	Pedagogy of possibility is a moral practice that interrogates social forms and their possible transformations in correspondence with three basic principles: 1) securing human diversity, 2) securing compassionate justice, and 3) securing the renewal of life (Simon, 1992).
Public pedagogy	Public pedagogy is a concept focussed on learning outside formal schooling environments and educational scholars who frequently use this term often situated within feminist, critical, cultural, activist dimensions (Burdick, Sandlin, & O'Malley, 2014).
Emancipatory pedagogy	Emancipatory pedagogy takes a fundamental interest in equity and social justice and is a process of teaching and learning that involves multiple ways of knowing, being and behaving in the world. It challenges dominant patterns of knowledge formation and presents alternate perspectives that are antithetical to the status quo (Swartz, 1996).
Postmodern pedagogy	Postmodern pedagogy recognises that education is a situated, collective learning process with difference at its core. This

	pedagogy enables the naming of institutional, cultural, and socioeconomic trajectories that individuals bring into the classroom (Kilgore, 2004).
Empowering education	Empowering education is a student-centred, critical-democratic pedagogy aimed at self and social change. The goals of this pedagogy are for multicultural democracy in school and society; as well as the development of academic knowledge, habits of inquiry, and critical curiosity towards society, power, inequity and transformation (Shor, 1993).

5.3 THE IMPORTANCE OF CRITICAL PEDAGOGY IN TEACHING AND LEARNING

Critical pedagogy seeks to introduce a more dialectical and highly mediated approach to schooling. As explained by Giroux (1983), critical pedagogy theory calls for a multidimensional understanding of the relationship between agency and structure and the extent to which the lived and experienced situations in schools relate to the social power relations that exist within the school.

According to Fielding and Moss (2012) the role of critical education is to undertake a reconstruction process. They refer to it as the reconstruction of the ruination of the public education system. Fielding and Moss have gone further to explain that critical pedagogy should necessarily be practiced in all educational settings as a way of espousing democracy in education as a fundamental value that leads to the successful fulfilment of justice for all within a community. Their views are alluded to by Lichtenstein (1985) who mentions that critical pedagogy seeks to overturn social order. His further argument is that social order is based on privilege of which is not fairly distributed across all the members within a collective. One such privilege is democracy.

In a study on how critical pedagogy should be understood and applied in education, Aliakbari and Faraji (2011) have come up with a statement of what they regarded as the principles that undergird critical pedagogy. Their study was based on an analysis of key literature on critical pedagogy. Their analysis is based on the relationship

between critical pedagogy and other key societal attributes that have an influence on education. Their analysis is based on the work of Paul Freire, and the views of the Frankfurt school. They came up with the following key principle positions and described critical pedagogy in terms of:

1. Educational Process
2. Politics
3. Curriculum and Authentic Materials
4. The roles of the teacher and learner
5. Marginalisation
6. Critical Consciousness

These principles are discussed below in conjunction with what other authors say about critical pedagogy as well.

(a) Educational process

According to Aliakbari and Faraji (2011) critical pedagogy should bring within education, the ability to emphasise emancipation of all people irrespective of personal and group attributes such as gender and race etc. The main assumption before this principle is the assertion that education is an embodiment of societal issues. Without critical education, education could be used as a perpetual catalyst meant to legitimise societal inequalities, prejudices and oppressiveness through credentialism. This view agrees with Kanpol's (1998) view that critical education should allow every citizen to be able to relate, analyse and critique the relationship between society and education to the extent that they realise and value their own autonomy as a subject within society. This view has earlier on been raised by Freire in 1970, when he talked about the effects of the tendency of banking knowledge within learners (Freire,1970). Freire advocated for problem posing education systems that do not just accept things religiously, but have to critically question their being and motives. Aligning himself with the Frankfurt school, Freire realised that the very tool that was supposed to set mankind free has been hijacked by the powerful in society. Education became a tool of conquering, subjugation and rank-and-filing, more than a tool of emancipation. This was caused by the unquestioned oppressive acceptance of education and pedagogy, wherein reality has been fixed, and oppression is to be learnt in school and be

pedagogically fed to the learners (Joldersma, 1999). As they leave the school system, the learners would have learnt to submit to authority, to subjugation and consequently to oppression.

After realising the inadequacy of education regarding emancipation, Freire advocated for the promotion of a radical, critical and problem-posing education. As explained by Joldersma (1999) such an education seeks to ensure that learners develop the capacity to get knowledge on their own. This view suspects the teachers of being agents of the oppressive system that latently feed learners with compromised knowledge that further pushes them into submission. Such knowledge does not develop the learners' thinking capacities, but only makes them functional to the extent that they are expected to be submissive. Problem-posing education in accordance with critical pedagogy is meant to cause and stir resistance in education; learners should demand their voice, and also be allowed to listen and critique all voices including their own within the education collective. It advocates that learners should develop attributes that would allow them to question things, subjects and objects. They should be allowed to explore the tensions that lie undetected within the teaching and learning processes and how this consequently affects their lives outside the school. In the same way, they should be able to look into their own contributions to find the invisible tensions that characterise the system. As proposed by Freire, problem-posing education should make reality an uncoverable entity and not an unquestionable, infallible and all-truth entity that has to be worshipped. Reality in critical pedagogy should be regarded as subjective to the situation and the individual, and in addition that it is alterable, and re-formulable. In that regard, both the current reality and the situation are malleable and transformable into new forms without carrying forward their a priori statuses. This has the potential to open the learners' understanding of relations between entities within a collective, while these relations keep changing and transforming within both space and time. This would essentially make the learners "come to see the world not as a static reality, but as reality in process, in transformation" (Freire, 1970, p.71).

Critical pedagogy as such seeks to develop learners' consciousness through liberated thinking. As explained by Foley (2007) it achieves this though raising questions that would allow learners to see controversies, struggle and engage with them, and be part of them. It brings empowerment to the learners and allows them to challenge

oppressive conditions that they face in their daily lives. Similar views have been mentioned by Ares (2006) in his analysis of the processes purpose of education. He talks about the real aim of education only being achievable through processes of critical pedagogy. According to Ares critical education processes expose the social order to be critically analysed, with the intention of bringing out social justice for all. Critical pedagogy from that perspective seeks for inclusion of all, it disregards and disagrees with the status quo which is categorically sustained by social order. That is part of the reason why it advocates for the engagement of learners' backgrounds during the teaching and learning process so that there would be a possibility of critical analysis on the disparities existing between home and school, and education and society. The whole idea is to ensure that pedagogy and through it education, should be able to relate to the learners' experiences. As mentioned earlier, these experiences are often characterised by subjugation and oppression. Critical pedagogy enhances the development of agency within the learners, which would allow them to be critical of their experiences within and without school. It should further allow such agency to be shareable and not be limited to the particular individual. This view has been alluded to by Giroux (1998) when he mentions that the development of critical thinking capabilities within the learners as a result of critical pedagogy would in essence make the learners fit well within the demands and dictates of a democratic society to which all are aspiring.

(b) Politics

This relationship between critical pedagogy and politics is informed by the belief that all systems of education are an embodiment of the political outlook of society (Freire, 1970; Freire & Macedo, 1987; Shannon, 1992). To that extent, critical pedagogy has to come in as a panacea to the issues such as subjugation and hierarchisation that comes with politics. Since politics is inevitable in society as it deals with the relationship between different entities, critical pedagogy has to come in to deal with how the parameters governing these relationships would not be systematically introduced into education in a normative manner. This view agrees with what McLaren (1989) says when he mentions that power and politics always have a stake in the education system to the extent of the pedagogy level. In some cases, politics has been seen to impose

the social order on education, to the extent that education would mirror society (Ezer, Millet & Patkin, 2006; Zapata Barrero, 2011). On the other hand, critical pedagogy would be of essence in trying to identify the imposed social order disentanglement and prune the maleficent influence of politics from education. This has been mentioned by Leistyna, Lavandez and Nelson (2004) below:

> Critical pedagogy hopes to forge policies and institutional practices that move beyond mere accommodations and compromises to existing power structures. Social transformation of this sort happens on many levels and on many fronts. (p.11)

As mentioned by Leistyna, Lavandez and Nelson, critical pedagogy goes deep to reject attempts at any compromises on the purity of education from the influences of society.

It would become the role of critical pedagogy to present a front through which the influence of politics in education is only accepted to the level that is necessary. This view is further alluded to by Leistyna, Lavandez and Nelson (2004) below:

> As a direct consequence of this political climate, public schools are being inundated with pre-packaged and teacher-proof curricula, standardized tests, and accountability schemes. But these educational practices are nothing new and in fact many of them have proven in the past to be unsuccessful. (p.4)

For Freire (1985), the political element of education is partly due to the need for learners to use education to emancipate and liberate themselves. Freire's argument is that human capabilities are best found in the cases where the human is emancipated. As a result of that he advocates for an emancipated and liberated society and humanity. Other scholars such as Kessing-Styles (2003) and Joldersma (1999) have expanded the need for emancipation and liberation to the extended need for social justice. The two authors agree that liberation and emancipation may not survive in the absence of the long-term presence of social justice. It is their argument that liberation and emancipation are only outcomes of the process of social justice. As such, through critical pedagogy, the role of education must be both to promote and sustain social justice. As mentioned by Kessing-Styles critical education should even set the tone for transformation of lives through education to the extent that it should

seek the eradication of institutionalised oppression, and the transformation of institutions associated with such. As a precondition for the success of such transformation, Freire (1985) notes that there must be a conscious discourse change together with the development of a language that would promote tolerance, inclusion and change of mindsets towards individual and group liberty. His argument is that education should bring about the necessary discourse and language to promote the liberation of individuals and societies.

Freire's argument has been summarised by Aliakbari and Faraji (2011) to imply that the process of education is only realisable as that process that happens between domination and critique. The implication is that education is therefore various forms of struggles for emancipation and liberation. This view is alluded to by Giroux (1997) when he mentions that critical education should essentially problematise every experience that the learners encounter only a daily basis. He mentions that it should be regarded as a form of empowerment that seeks to oversee the learners' development of their individual liberation formations. Such developments would in the long run be applied to the wider society, and in that manner critical pedagogy would have achieved its intended goal of promoting emancipation and liberation. The role of the curriculum as the formalised tool for the social and political promotion and sustenance of life would be achieved as suggested by Kessing-Styles (2003).

In another way, critical pedagogy unlocks channels through which action may be justified as an attempt to find meaning within the prevailing circumstances. The actions that are implied here would come in, in a way, to address the social ills that politics would bring to education. This is alluded to by Pollock (1998) when he describes critical pedagogy as:

> A Socio-political act, a sensuous, material production that erupts in the moment of performativity across the intersecting planes of identity, community, culture and politics. (p.43)

Pollock's statement implies that critical pedagogy is a collective process and product that comes about during the enaction of praxis. He reiterates that critical pedagogy is a hybrid attribute of which understanding forms a very central pillar of being and community-hood. It has both cultural and political parameters that are intricately interwoven together to form a network of interdependent entities. Its analysis is

important in learning as it exposes the primary struggles that entities face within the collective as they strive for dominance and ascendancy. This has been described by Conquergood (1998: 32) as the extent to which critical pedagogy exposes meanings that lie sedimented and traditions that are generally regarded as normative. In that manner, critical pedagogy comes to be regarded as an emancipatory approach characterised by the decolonisation of relations (Denzin, 2009). When relations are decolonised, the emancipation of all entities is achieved and there would be egalitarianism within the collective.

The critical political importance of critical pedagogy in addition to its link to praxis, also lies in its relationship to democracy. As explained by Fischman and McLaren (2005) in their work on critical pedagogy, the approach is an expression of everyday life and realities that are:

> …constructed in and through people's linguistic, cultural, social and behavioural interactions which both shape and are shaped by social, political, economic and cultural forces. (p.1)

The views of Fischman and McLaren imply that critical pedagogy is a pluralistic concept that seeks to interrogate the extent to which learning may be informed by the contextual experiences of both the teachers and the learners. The influence of the contextual experiences may not be separated from the latent influences of politics that would form the background of those experiences in a latent manner. It is such circumstances that might justify the need for the radicalness of critical pedagogy. The radicalness of the envisaged approach is also in agreement with the views of Denzin (2009) when he indicates that critical pedagogy must be considered in the planning and enaction of any teaching because of its potential to disrupt the hegemony that often lie intricate, implicit and cemented within the pedagogical practices. Such pedagogical practices as explained by Giroux and Giroux (2006) often harbour a reproductive effect typical of neoliberal conservatism attributes. The views of Giroux and Giroux (2006) are clear in the following statement from their 2006 study:

> Critical pedagogy subjects structures of power, knowledge, and practice to critical scrutiny, demanding that they be evaluated in terms of how they might open up or close down democratic experiences. (p.1)

What Denzin, and Giroux and Giroux are in agreement about here is that because of the hegemony that politics causes in education, critical pedagogy should therefore come in to neutralise that hegemony through the exposure of its pillars. The need for the radicalness of critical pedagogy has been further elaborated upon by Giroux and Giroux in their analysis of how this would help to shape educational practices and experiences. They argue that the recognition and adoption of radicalness in critical pedagogy, would work as a foundation for the development of critical literacy. Critical literacy on its own has a profound importance in the way that it opens the views and perceptions of individuals to watch out against the development and prevalence of control and subjugation, whether physical or psychological.

Based on its radical apparatus, critical pedagogy would be a pedagogy of resistance, conscientisation and emancipation. The conscientisation would be against the latent influences of politics while the emancipation would be against the ingrained suppressive practices brought about by political organisations with the society. This view has been corroborated by Denzin (2009) in his description of critical pedagogy when he mentions that the concept should avail the tools for which fundamental concepts such as identity, agency and citizenship which are generally regarded as neo-liberalist may have to be understood through an analysis of their very construction as political, educational and cultural practices. Similar sentiments have been given by Ulmer(1985) when he argues that critical pedagogy should be understood as a discursive process of presenting reality through text, with reality being based on the lived experiences of the learners and that of the teachers to some extent. This then links with critical pedagogy as an attempt to unravel the compromised realities and identities that are generally hegemonised through education as a result of the influence of politics.

(c) Curriculum, and Authentic Materials

The relationship between curriculum, authentic materials and critical pedagogy is a quite complex one. For instance, as stated in the literature, critical pedagogy emphasises that the curriculum may not be a static compiled document. It must in fact be based on the learners' needs, experiences (Giroux, 1997; Shor, 1993), encounters and needs. If that is not met, then the curriculum might be regarded as being a set of

imposed experiences. The learners would not be able to relate to its content and consequently it would face resistance. As a result, there is a need for a delicate balance to be found linking the three. As explained by Degener (2001) the balance may only come if the curriculum relates to the learners' experiences and does not alienate the learners from their contexts since the context is the de facto source and origin of the experiences. This view is alluded to in the literature (Lankshear & McLaren, 1993; Quigley, 1997) with authors agreeing that critical pedagogy would be most useful if it links with the learners' cultures, promotes their participation and advocates for social empowerment. Failure of such a development would eventuate into non-critical and non-transformative learning and pedagogies that are characterised by ignoring the social circumstances of the learners as the marginalised lot (Macedo, 1994).

The authentic material would therefore be materials that may be used by both the teachers and the learners to promote transformative learning. As indicated by Kessing-Styles (2003), these materials would be the embodiment of a curriculum as a summary of how individual learner's experiences may be solved socially by these learners themselves. Learners should be in a position to examine the extent to which the experiences captured in the materials align with their own daily experiences. In the case that there is no direct link, the learners should nonetheless be in a position to critically examine the context under which the experiences happened or might be expected to happen. This would allow learners the opportunity to problematise the unfamiliar experiences and offer resistance (Kincheloe, 2005; Ohara, Saft, & Crookes, 2000; Okazaki, 2005). Ares (2006) explains how this leads to the build-up of momentum with which learners rebel against oppressive systems.

(d) The role of the teacher and learner

The role of the teacher is regarded as critical in the promotion of critical pedagogy. As explained by Kincheloe and McLaren (1994), the teachers without drilling the learners should rather empower them through an awareness emphasis for the development of consciousness to observe and resist social stratification. If the teacher fails to achieve this function, they become a forwarding agent of subjugation working hand in glove with the powerful in society to promote a subservient education to learners. In that

regard, the intellectual status of the teachers should supersede their professional obligations of supplying knowledge to the learners for examination purposes. As explained by Sadeghi (2008) the teacher's role should include the ability to encourage the learners to present their voices and use them as part of their learning processes. She however brings another paramount dimension to the teaching and learning process: dialogue. Sadeghi isolates dialogue as a critical aspect that teachers need in order to focus their teaching. She mentions further that the role of dialogue is for the teachers to get an understanding of the learners' views as a starting point for the planning of the pedagogical process. Sadeghi mentions further that teachers would need to be transformative intellectuals capable of mixing their own experiences and those of the learners, as given by the learners to promote a dialogical process capable of allowing the learners to be grounded in their own understanding. This according to Freire (1973) would allow learners to become progressive and active agents in their own learning process. The banking tendency would therefore become bankrupt. The role of the teacher would be to foreground the development of agency within the learners; the same agency that they would use to critically explore the issues that they face, especially how those issues relate, agree and disagree with their education. Similar sentiments have been aired by Horton and Freire (1990) in their analysis of how the teacher's use of critical pedagogy would be important in promoting the development of critical agency within the learners. The two scholars concurred that one of the basic pillars of critical pedagogy would be the level of interaction between the teacher and the learners. Like Freire has mentioned earlier, this would work in a co-constructivist approach to avoid the banking of knowledge within the learners.

From another direction, Degener (2001) has tried to contextualise the use and development of critical pedagogy in teaching and learning. He explains that critical pedagogy should lead learners and teachers to reflect on their own common-sense knowledge in a manner that would transform their lives. Such a development would lead to the development of critical consciousness as a way of averting the problematic disempowering circumstances from bewildering their common-sense knowledge. An assumption can therefore be made that common-sense knowledge itself if left to flourish might promote further disenfranchisement of the norm from the expectation. That means the common sense of an oppressed person accepts oppression as a norm. Critical pedagogy should provide the tools to overcome the prevailing

circumstances and create new ways of creating what Guthrie (2003) refers to as the development of co-agency between the teacher and the learners, and also between the learners and the learning context and content. The teacher's role is not to spread activism, but to let learners develop agency through his own agency that would allow them to overcome their issues.

The other critical aspect in the relationship between the teacher and the learner concerns dialogism. Dialogism has been described by Skutnabb-Kangas and Phillipson (1995) as the respect for linguistic human rights. The implication is that critical pedagogy is facilitated by language and dialogue. This view is alluded to by Giroux (2018) when he mentions that for learning to be successful, teachers have to oversee the development of a critical theoretical language that connects their teaching to the learners' learning. This leads to the manifestation of a discourse of learning characterised by critical engagement. The issue of critical language has also been fronted by Degener (2001). Degener looks at the influence of the teacher in terms of the enacting and fomenting of the discourse. He argues that the teacher's role is very critical in the sense that the teacher determines the allocation of privilege in terms of the interactions and dialogism during teaching and learning. In that manner, the teacher has the power to decide which voices to promote and which voices to subdue and pacify (Lankshear & McLaren, 1993). Critical pedagogy addresses such power imbalances by exploring them and their sources, and then exposing them. It would associate the power of the teacher with the society to which the teacher would be an agent. Critical Pedagogy would demand that the role of language should be associated with the embodiment of the curriculum itself, and particularly how the curricular outcomes may be interpreted in terms of the learners' daily experiences. If it is divorced from the learners' daily experiences, it would then be imposed on the learners and would be regarded as totalitarian. This view has been alluded to by Norton and Toohey (2004), when they mention that language is created through the historical interactions of various discourses that would be shaped into a particular set of meaning dimensions and parameters determined by a group's contextual experiences.

The critical application of language is therefore a paramount move towards all pedagogy. It is a tool of emancipation for the oppressed. From another angle, Giroux (1983) has explained critical pedagogy as an approach that deals with issues of

reproduction and resistance. He implied that the reproduction takes place when what happens in society for instance, is replicated in schools in one way or another, often with the teachers acting as the agency responsible for the enforcement. On the other hand, however, the learners might present a front of resistance, when they confront the education system. The resistance and confrontation would indeed be outcomes of the establishment of a critical pedagogical approach within education. Giroux explains further that critical education serves to deal with issues of reproduction of societal issues that education unrepentantly brings during teaching and learning, and through the hidden curriculum. It deals with it through the fomenting of the spirit of resistance among the learners. In his analysis of how to establish and manifest critical pedagogy in education, Giroux (2010) has vouched for the need to review the role of teachers to ensure that they foster the development of engagement during teaching and learning. Such conditions have the potential to turn the learners and teachers together into intellectuals. The engagement process would also allow the learners to get into a position whereby they are able to relate their learning to their day-to-day contexts, and thus the learning would become both contextualised and relevant. This would be the basis of the engagement that he wishes teachers would become:

> …engaged intellectuals, willing to construct the classroom conditions that provide the knowledge, skills and culture of questioning necessary for students to participate in critical dialogue with the past, question authority, struggle with ongoing relations of power and prepare themselves for what it means to be active and engaged citizens in the interrelated local, national and global public spheres (Giroux, 2010, p.711).

In an analysis of the relationship between critical pedagogy, and the teachers and learners, Kincheloe (2008) has followed the dimension where critical pedagogy should be regarded as a source of justice and equality through education. He emphasises that this would be achievable when critical pedagogy works towards the alleviation of unfairness within society. He mentions that this would nonetheless only be achievable if the role of education would allow and the cultivation of a critical mind as a determinant guiding the relationship between the teacher and the learner. He mentions that this can only be achieved if the nature of education is typically understood and regarded as the political entity that it is. The implication of Kincheloe's views is that learning should be able to address the issues that the learners would be facing and

be able to bring critical consciousness to their context and being. In that case, learning ceases to be the banking and regurgitation of ideas without relating to the learners' individual situations. Learning should be a process of both acquiring knowledge and at the same time interrogating the relevance, suitability and applicability of that knowledge.

(e) Marginalisation

Generally, the main intention of critical pedagogy is to avoid and do away with marginalisation. This view has been emphasised by Freire (1970) when he mentions that the ultimate goal of critical pedagogy is to ensure that the lost voices and identities of the subjugated are returned to the owners who will start using them without restraint. Freire's argument is that teaching them without paving the way for such a recovery would tantamount to banking pedagogy. Learners would be able to learn only after they understand who they are and what issues they encounter in their lives. As such, the resurrection of voice and identity would become a precursor to their learning. As emphasised further by Freire, such a development would lead to the coupled development of learners into agents of social change. The learners would not only demand change, but rather, they would become part of the change process due to the active agency that they will possess. The learners would analyse their positions in society and make possible linkages between them and others in their circumstances in a reflective manner. By doing that they are able to trace the trajectory that their lives and circumstances would have followed eventuating into their current situation. The tracing of the trajectory paths would also lay bare the various nodes of entanglements that have gone through to become what they currently are. According to Degener (2001), when learners are able to identify themselves and relate their situations to their contexts, they would then be in a position to prevent the development of such situations in the future.

Analysing it from how it may address issues of marginalisation, critical pedagogy has also been analysed from a caring perspective. For instance, by Gabel (2002) mentions that:

> Pedagogy with a caring ethic requires teachers to be human, to accept the constructive process of doing something like meaning making, to recognise

> the definitional challenges and ambiguities of being and doing, and to be mindful of the need to establish and maintain caring relation. (p.178)

In the above text Gabel has introduced the critical concept of being and how it should be mindfully exposed through a critical pedagogy. The author has also talked about the need to maintain a caring relationship through a critical pedagogy. The caring attitude would work to ensure that there would not be any marginalisation reflected through education. Gabel's views seem to imply that critical pedagogy should have a reflective parameter that would allow the self to maintain relations with the other, which relationship should be both fair and equitable to all. In that manner, critical pedagogy would be regarded as foundation for the establishment and maintenance of equitable relations through learning. This has been alluded to earlier by Noddings (1984) when he emphasises the need for the maintenance of conditions and relations that necessitate and promote the flourishing of all within a community, a view that also resonates with the views expressed by Hooks (1996) when she talks about critical pedagogy as engaged pedagogy. The importance of the said engagement would be to ensure that no entities would be disregarded and there would be an inclusive collaboration among all the members of a group. Hooks elaborates further that through critical pedagogy as an engaged pedagogy, there requires a pedagogy that focuses on the well-being of students and teachers that is nonetheless characterised by disagreement, foments conflict, and inspires resistance. Hooks' views could be assumed to imply that critical pedagogy deals with marginalisation and emancipation through resistance. It is a radical approach that seeks to penetrate the most negligible of the relationship of entities in an educative setting with the intention of harmonising their differences. It might be regarded as attempting to overturn the vulnerability among entities into stability and peace. These views resonate with Gabel's (2002) categorisation of critical pedagogy as a breathing and living pedagogy that is informed by culture-specific ways of knowledge organisation and presentation. Gabel has gone further to explain that critical pedagogy is a transformed, relational and social-oriented discourse that seeks to promote diversified understanding and caring of oneself and the other as a way of sharing each other and space within a community. Gabel's views resonate with the views of McLaren (1998) in his description of critical pedagogy as a planned manner in which teachers engage in a political sphere characterised by bodily and affective investment. The political sphere as explained by Gabel is grounded in

lived experiences. She reiterated that critical pedagogy allows us to accommodate and to be accommodated; it allows us to interact with entities that experience a diverse way of life to the one that we encounter. It is a pedagogical approach that as mentioned earlier is characterised by an inclusive discourse that emphasises the removal of boundaries between and among entities be they subject or object. It is an accommodative and liberatory approach and paradigm within which diversity is not regarded as difference, but rather as part of a mosaic whose functionality all entities contribute towards. In a further elaboration, Gabel has indicated that one of the key fundamental yardsticks of critical pedagogy is its ability to liberate the voices of the underrepresented and disregarded. Ellsworth (1992) has raised similar sentiments when he mentions that there is a need to ensure that the embracing of diversity does not lead to the suppression of some voices by others. She goes further to mention advocating for liberatory pedagogy should not lead to the silencing of some by others in the name of diversity.

(f) Critical Consciousness

According to Freire (1973), the highest level of achievement of critical pedagogy is the development of critical consciousness. His categorisation of levels of consciousness is illustrated in Table 5.2 below.

Table 5.2: An illustration of levels of consciousness (Freire,1973)

Level of critical consciousness	Characteristics
1. Intransitive	Individuals do not question anything in their life and accept life as experienced. They attribute change to other factors unknown to them such as magic and miracles. Individuals are not worried about any form of injustices that they might be facing.
2. Semi-transitive	Individuals in this category are quite aware of the issues and problems that

	they might be facing. They however lack the complexity to address the issues and problems timeously, and thus solve them one at a time. The individuals attribute issues and problems to being accidental and tend to accept them as being partly normal to their lives. Consequently, the individuals often bring about short-sighted and narrow solutions to their problems.
3. Critical consciousness	The individuals that are found in this category have true and full consciousness; they regard their problems and issues as being structurally-enhanced and caused. These individuals relate their issues and problems to the social encounters that they experience in their day-to-day lives and are aware of the nature of the determinants of reality. These individuals are aware of the shortfalls of passivity and thus tend to reject it and advocate for collective struggle as a way of bringing emancipation to their issues.

As illustrated in Table 5.2 above, the main desire of critical pedagogy should the achievement of critical consciousness.

Through its emphasis of critical consciousness, critical pedagogy is hailed in the literature as a vehicle that may be used to bring about praxis. As defined by Freire (1970) praxis is an expression of how action and reflection may be brought together. Reflection allows the learners to try and interpret their learning as they go along. On the other hand, action is there when they manage to implement the outcomes of the

reflection process. The issue of praxis has been reiterated by Kessing-Styles (2003) when he mentions that through praxis learners would get into a position where their understanding of reality is not fixed but diverse. This is because praxis allows reality to be regarded as a dynamic entity which keeps re-defining itself in time. Reality would thus be regarded as a continuum of experiences that keep unfolding in a diffractive manner. Such an understanding of reality allows them to transform their intellectual capacities and by doing that intellectualism moves from a theoretical entity to an experiential asset that has to be used to solve daily issues and problems. In that way, praxis brings with it dialogism to learning of which would lead to the development of co-agency and co-construction of both knowledge and understanding (Sadeghi, 2008).

Adding another dimension to the issue of critical consciousness as an inevitable parameter of education, Cho (2012) mentions that within education, critical pedagogy brings in a wave of egalitarian power relations that seek to manifest and strengthen the unheard sound of the voices of all the entities within the education system including mostly the learners. The overall intention of critical pedagogy according to Cho, is to stimulate, inspire and foster the development of critical consciousness as a value for promoting the fundamental issue of social change as an aspect of humanity and society. Cho implies perhaps that critical pedagogy should unlock and open all the downtrodden and muted voices, so that every other voice should contribute to the nature of what they would be learning. This would happen if only critical pedagogy goes down into the trenches and demands the manifestation of a critical imagination of which would allow both the teacher and the learners to envision the often taken for granted issues that might be responsible for making learning an unquestionable process. Critical imagination as the basis for the development of a critical pedagogy would potentially provide a broader perspective with which to both engage and question every aspect of the teaching and learning scenario from the teachers, the learners, the curriculum and the society at large.

From another angle, Denzin (2009) has discussed critical pedagogy as a pedagogy of hope due to its orientation towards critical consciousness. He mentions that critical pedagogy is the only form of pedagogy through which democracy may be realised in society. The implication of hope that Denzin mentions is that critical pedagogy might be coming to address some aspects that may be oppressive in society. His views

concur with the views of Carey (1997) when he mentions that critical pedagogy brings in a civic discourse through which people can freely assemble and share ideas without fear. Carey argues that the essence of a critical pedagogy is the development of a critical consciousness. The importance of critical consciousness is the possibility to look beyond the self, and subsequently undertake a speculative analysis of relationalism between the self and the other. The other may be physically invisible but exists through an imagined presence that is informed by ecologism. In that case, ecologism means the collaborative and associative togetherness that characterise entities that are within the same collective. Critical pedagogy would potentially unlock and open all the downtrodden and muted voices other than the self, so that every other voice should contribute to the nature of what they would be learning. The manifestation of a critical consciousness would also in a way allow both the teacher and the learners to envision the often taken for granted views of learning that might be responsible for making learning an unquestionable process. Critical consciousness as the basis for the development of a critical pedagogy would potentially provide a broader perspective with which to engage and question every aspect of the teaching and learning scenario from the teachers, the learners, the curriculum and the society at large. This view is alluded to by Denzin (2009):

> Within this radical pedagogical space, the performative and the political intersect on the terrain of a praxis-based ethic. (p.380)

The view of the praxis as an aspect of critical consciousness within critical pedagogy is further corroborated by Madison (2003) when he mentions that within the critical pedagogical space develops a politics of possibility in terms of relations. This learning possibility space would be both productive in the sense of it fostering critical consciousness and embodied by hope and care of one as concerns the other. The importance of space can be found in its emphasis of what Conquergood (1998) refers to as the multiple ways through which existence may be performed as a result of critical consciousness. Critical pedagogy may therefore be understood as an avenue through which multiple possibilities might become performative in learning. The approach opens diverse forms of viewing and understanding phenomena that are informed by the context.

In their tracing of the development of critical pedagogy, Kincheloe and McLaren (2000) have resorted to analysing how education as a cultural transmission in general leads to the development of hegemony. They explain that critical pedagogy then comes in as a panacea to disrupt and deconstruct the developed cultural hegemony edifices regarded as education. They elaborate further that critical pedagogy envisions a more justice-oriented, democracy-organised and egalitarianist society (Kincheloe & McLaren, 2000; Lather, 1998) that is devoid of oppression (Kincheloe, 2005). Kincheloe and McLaren (2000) have also expanded the concept of critical pedagogy to beyond the general understanding. They argue that critical pedagogy is more of a cultural pedagogy. Their view of critical pedagogy assumes that humans are cultural agents that profoundly generate ways of knowing, and knowledge itself and values in ways that are informed by their context.

5.4 DIFFRACTIVE METHODOLOGY: AN OVERVIEW

In the last section I looked at critical pedagogy as a pedagogical approach. As I indicated earlier, in this chapter my intention is to build a critical diffractive pedagogy theory that I will use together with OOO, and ANT to build a critical posthumanist and democratic theory (CPDT) in Chapter 6. In this section, my focus is on the exploration of a diffractive pedagogy theory. I first want to explore how the concept is viewed in the literature, and thereafter investigate its pedagogical affordances in the teaching and learning of Life Sciences. At the end of this section, a critical diffractive theory will be conceptualised from some themes of critical pedagogy theory and from diffractive methodology. Following that I will then extract some themes to be expanded on in the next chapter. The main author whose work will be referred to on diffractive methodology is Karen Barad, especially her work entitled Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning.

The concept of diffraction as a both a pedagogical apparatus and an analytical tool was first introduced into discourse by Donna Haraway in 1992 (Mitchell, 2016). It would therefore be important to give a brief overview of what Haraway regards as diffractive pedagogy. Cited in her work on the Modest Witness in 1997, Haraway mentions that diffraction as a theory was developed as a result of the disagreement with the application of the theory reflexivity in social sciences. She totally disagrees

with the critical theory that uses the notion of reflection. This background is essential in understanding how the theory of diffraction reached its current status. The development of the theory of diffraction from the theory is clear from the following statement by Haraway (1997).

> Reflexivity has been recommended as a critical practice, but my suspicion is that reflexivity, like reflection, only displaces the same elsewhere, setting up worries about copy and original and the search for the authentic and really real. Diffraction is an optical metaphor for the effort to make a difference in the world. Diffraction patterns record the history of interaction, interference, reinforcement, difference. Diffraction is about heterogeneous history, not about originals. Unlike reflections, diffractions do not displace the same elsewhere, in more or less distorted form. Rather, diffraction can be a metaphor for another kind of critical consciousness at the end of this rather painful Christian millennium, one committed to making a difference and not to repeating the Sacred Image of Same. Diffraction is a narrative, graphic, psychological, spiritual, and political technology for making consequential meanings. (p.71-72)

In her explanation of diffraction, Haraway mentions that despite the difference between diffraction and reflection from a physics perspective, there is also more to diffraction that lacks in reflection. She mentions that diffraction is oriented towards the recognition and observance of patterns of difference as they manifest across phenomena. This aspect will be referred to when I discuss diffraction as advanced by Karen Barad later. In a very specific way, the orientation of diffraction to the issue of differences is philosophically quite imposing. It comes with the implication that diffraction opens the avenues for the recognition of how the differences that entities may possess have the potential to be become aggregated in a manner that would bring about even more differences. The cumulative effect of these differences would bring about multidimensional diversity and grounded enmeshment of entities which would lead to the recognition of relations that are characterised by both affect and effect.

Haraway (1992) has gone further to explore the concept of difference to a prime level as a parameter of diffraction. She explains that difference should be conceptualised as a critical aspect that is found within the fabric of all entities which at the same time has a transitive character that allows it to be metamorphosised while at the same time

keeping its main classical characteristic of bringing diversity among the entities. She argues that difference should not be taxonomic which could lead to it becoming a separatist force (Haraway, 1992:299). Difference in her view should be regarded as a relational force that allows for the reading of one entity through another. She replaces critique with diffraction since it aims to make a difference. In that case, difference should be regarded as a building block of diversification that comes with corresponding effects of difference that are also differences in themselves. Haraway (1992) emphasises that:

> Crucially, diffraction attends to the relational nature of difference; it does not figure difference as either a matter of essence or as inconsequential: a diffraction pattern does not map where differences appear, but rather maps where the effects of differences appear. (p.300)

In the above statement Haraway comes up with another crucial characteristic of diffraction; that it attends to a relational nature of difference. She points out that difference is neither an isolating nor an isolated concept. Rather it should be regarded as a relational concept that provides for entities to operate through each other.

Picking upon the work of Haraway, Barad (2007) reiterates that she intends to focus on diffraction as a tool of analysis that focuses on the effects of difference. She seeks to look at diffraction as being characterised by difference, and at the same time as a source of difference. She elaborates as follows:

> In fact, I will argue that there is a deep sense in which we can understand diffraction patterns - as patterns of difference that make a difference - to be the fundamental constituents that make up the world. (p.72)

The argument being posed by Barad in this case is that the nature of the world is an outcome of the manifestation of how relationships pre-exist entities. The implication then becomes that the world is just a series of overlapping differences that tend to culminate into more difference through processes of entanglements and relationships. Corroborating that view, Barad goes further to mention that diffraction apart from being regarded as being the tool to measure the effects that come with difference, is the very effect that allows for the illumination of the extent of entanglement of the very ontology that defines the world. In a way, she implies that through looking at the world through the difference apparatus, the dichotomisation that characterises the world is set aside,

and the world gets to be seen as a wave that keeps moves through entanglement as it goes further. She confirms that diffraction does not only illuminate the extent of entanglement of the world and everything that is part of it, but rather it opens up the extent to which the world itself is fully entangled.

Barad further argues that for the successful application of diffraction, a diffractive apparatus needs to be recognised. She explains that if diffraction has to be successful, the apparatus has to be tuned to meet the diffraction requirements and details of the phenomenon that has to be investigated. From this explanation, it would appear as if a diffractive apparatus is an approach through which the diffraction process is undertaken. The implication is that the process of diffraction should be tailor-made to respond to the current needs of the situation at hand. In that way, diffraction would then be able to precisely attend to the diffraction needs of the situation. She confirms it thus:

> The analysis at hand then will require thinking through the details of diffraction as a physical phenomenon, including quantum understandings of diffraction and the important differences they make, in order to tune the diffraction apparatus, in order to explore the phenomenon at hand, which in this case is diffraction, in order to produce a new way of thinking about the nature of difference, and of space, time, matter, causality, and agency, among other important variables. (2007: 73)

Barad introduces the concept of diffraction through an analysis of its classical meaning of the phenomenon. She describes diffraction as the manner in which waves combine; any kind of waves for that matter. She goes further to describe how the diffractive pattern emerges whereupon different waves bump into each other and in the process form new waves and wave patterns too. Barad (2007) elaborates thus:

> Waves can overlap at the same point in space. When this happens, their amplitudes combine to form a composite waveform. For example, when two water waves overlap, the resultant wave can be larger or smaller than either component wave. For example, when the crest of one wave overlaps with the crest of another, the resultant waveform is larger than individual component waves. On the other hand, if the crest of one wave overlaps with the trough of another, the disturbances partly or in some cases completely cancel one another out, resulting in an area of relative calm. Hence the

> resultant wave is a sum of the effects of each individual component wave; that is, it is a combination of the disturbances created by each wave individually. This way of combining effects is called superposition. (p.76)

In the above quotation, Barad gives an explanatory description of how the process of diffraction takes place. An understanding of this process from the classical sense that it is given bears critical importance in the understanding of how it would be used form a pedagogical perspective. Due to the scope of my thesis, I am not going to investigate how waves are formed. The focus of my work shall be on how diffraction leads to the process of superposition which in my view is related to how the process of diffraction takes place. In that case, I would regard diffraction as the progressive superposition of different effects upon each other leading to new effects. In that case, diffraction is simply an interference that is caused by the superposition of different effects.

5.4.1 Diffraction as a methodology

In her further elaboration of the concept of diffraction, Barad goes ahead and gives what she regards as the characteristics of diffraction as a methodology (Barad, 2007, p.89). I have proceeded to classify the characteristics of diffraction into four main categories as shown in Table 5.3 below:

Table 5.3: Characteristics of diffraction

Category	**Characteristics**
Differences and relationalities	• Differences are marked from within and as part of an entangled state. • Objectivity is about taking account of marks on bodies, while all differences are materialised, and all differences matter. • Differences emerge within phenomena's agential separability and real material differences, but without absolute separation.

	• Making a difference in the world is about taking responsibility for the fact that our practices matter. • The world is materialized differently through different practices (contingent ontology). • Phenomena are objective referents to marks on bodies concerning accountability and responsibility noting differences that matter.
Diffractive methodology	• Performativity suggests that subject and object do not pre-exist as such, but emerge through intra-actions. Intra-acting takes place within and as part of each entity. • All diffraction is about reading through each other (the diffraction grating).
Entangled ontology	• All phenomena are material-discursive. • Subject, object contingent, not fixed. • Respectful engagement that attends to detailed patterns of thinking of each; fine-grained details matter. diffraction/difference pattern intra-acting entangled states of nature cultures. • The focus is on how practices matter.
Ethico-onto-epistemology	• Knowing is a material practice of engagement as part of the world in its differential becoming.

	• Ethico-onto-epistemology ethics, ontology, epistemology are not separable. • Transdisciplinary engagement attend to the fact that boundary production between disciplines is itself a material-discursive practice.

The characteristics stated in Table 5.3 above give a bird's eye view of what diffraction really comprises. In her further description of diffraction, Barad mentions that diffraction should be regarded as a critical practice that is characterised by an inclusive engagement. She elaborates that the theory as such is based on agential realism which promotes and advances a performative analysis and understanding of entities that are often regarded as binary-placed. Categorically, it demands the inclusion of all kinds of knowledge-making practices irrespective of them belonging to seemingly binary positions. Barad explains further that due to its agential realist characteristic, agential realism is underwritten by the belief that all material and immaterial practices are connected by intra-action that happens within the world and within which it should be regarded as part of that very world. This is captured by Barad (2007) in the following statement:

> We do not uncover pre-existing facts about independently existing things as they exist frozen in time like little statues positioned in the world. Rather, we learn about phenomena - about specific material configurations of the world's becoming. The point is not simply to put the observer or knower back in the world (as if the world were a container and we needed merely to acknowledge our situatedness in it) but to understand and take account of the fact that we too are part of the world's differential becoming. (p.90-91)

The above statement by Barad regarding diffraction brings into focus on a key theme about diffraction. This is the theme of differential becoming which gives the impression that entities are characterised by a differential becoming that is fluid in form and determined by the context. This theme expands the concept of diffraction to include how both human and nonhuman entities come into being through relationships.

It is this same relationship that makes their agential status non-static and dependent upon their intra-actions with other entities, and with each other, and in the process causes the causality of phenomena. The interaction would follow the interferential pattern that would be diffractive in nature. The implication would be that all contacts are generally diffractive due to the intra-activity that characterises them, and in addition to that, they would be outcomes of configurations and reconfigurations of entities.

In her description of diffraction, Barad has made another crucial point. She clarifies the relationship between the material and the immaterial entities and how they are connected through the process of diffraction. She says that all material practices including knowledge, have material consequences. She gave an example of how knowledge has an immaterial and non-physical entity while it possesses material engagements through the manner in which it links with practices of knowing. The materiality of the processes and practices of knowing are emphasised more regarding how they would tend to reconfigure the world. This is clear from the following statement by Barad (2007).

> Making knowledge is not simply about making facts but about making worlds, or rather, it is about making specific worldly configurations-not in the sense of making them up ex nihilo, or out of language, beliefs, or ideas, but in the sense of materially engaging as part of the world in giving it specific material form. And yet the fact that we make knowledge not from outside but as part of the world does not mean that knowledge is necessarily subjective (a notion that already presumes the pre-existing distinction between object and subject that feeds representationalist thinking). (p.91)

In the above statement, Barad points out that diffraction is a process of making worlds through material engagement where the subject and object only come into being through their entangled relationships . She argues that during the process of bringing the becoming of worlds different entities come into being and would be still connected through an agential cut. Barad goes further to explain how the process of diffraction is not objective in a general sense either. She links the concept of objectivity to the taking of responsibility for our intra-actions with the world of which we are a part. This brings back the earlier discussed concept that diffraction is like a wave-effect that is characterised by fluidity in nature accompanied by entities as they temporarily come into being through their relationships.

5.4.2 Towards understanding diffraction from a pedagogical perspective

It would be essential to explore how Barad conceptualised diffraction from a pedagogical perspective. The main aspect that has a pedagogical appeal regarding her theory of diffraction is the issue of dynamic relationality. This aspect has it that the wave form that diffractions take is characterised by iterative boundaries that remain both material-discursive and fluidly re-configurative. Barad (2007) confirms this below:

> My method of diffraction is to engage aspects of each in dynamic relationality to the other, being attentive to the iterative production of boundaries, the material-discursive nature of boundary-drawing practices, the constitutive exclusions that are enacted, and questions of accountability and responsibility for the reconfigurings of which we are a part. That is, the diffractive methodology that I use in thinking insights from different disciplines (and interdisciplinary approaches) through one another is attentive to the relational ontology that is at the core of agential realism. (p.93)

The issue of iterative boundaries mentioned above is very important to how the theory of diffraction could be applied during teaching and learning. It is the iterative nature of boundaries that would allow for the diffractive analysis of how to teach a particular subject. This thus presents relational ontology as another theme that I am extracting for future use in chapter 6. Barad argues that the strength of diffractive methodology lies on its refusal to take for granted the boundaries that exist between any entities. In that case, diffraction allows for the adoption of a interdisciplinarity approach that has promotes the development of affinity among boundaries. In Barad's words, diffractive methodology is very attentive to the fine aspects and details that characterise different disciplines. In that way, it makes it possible to work across disciplines or as I quoted her mentioning earlier, it allows for the possibility of viewing a discipline through another discipline. This makes its applicability in disciplines such as pedagogy very fruitful. In fact, Barad further argues that the prominence of diffractive pedagogy also lies on its emphasis of the material-discursive nature of boundary-making among entities as being non-negotiable as a critical parameter that confirms associated relationality of materiality and immateriality. This is clear from the following statement by Barad (2007):

> What is needed are respectful engagements with different disciplinary practices, not coarse-grained portrayals that make caricatures of another discipline from some position outside it. My aim in developing a diffractive methodology is to attempt to remain rigorously attentive to important details of specialized arguments within a given field without uncritically endorsing or unconditionally prioritizing one (inter)disciplinary approach over another. (p.93)

In the above statement Barad goes further to emphasise the need for respectful engagements when dealing with entities. She implies that entities have agential cuts where they are together/apart at the same time.The implication is that diffraction as an outcome of waves that tend to overlap and extend into each other is characterised by a level of consciousness and thought that pay attention to difference. She further argues that the proposition of respectful engagements would also initiate the development of critical thinking on how the relationality operates among entities. She goes further to mention that the recognition of relationality among entities paves way for the understanding of how the relationality preceded the entities. In that case, the issues of interiorities and exteriorities that often characterise entities is done away with. This is summarised by Barad (2007) as follows:

> This diffractive methodology enables me to examine in detail important philosophical issues such as the conditions for the possibility of objectivity, the nature of measurement, the nature of nature and meaning making, the conditions for intelligibility, the nature of causality and identity, and the relationship between discursive practices and the material world. (p.94)

Through my studious search of literature on diffractive methodology, I have come up with the following themes. These themes are the ones that I will combine with the themes from critical pedagogy theory to develop a Critical Diffractive Pedagogical Theory (CDPT). The themes are as follows:

- Egalitarianism of power relations
- Promotion of change
- Minoritarian attitude
- Engagement

I am going to discuss these themes in the next section.

5.5 TOWARDS A CRITICAL DIFFRACTIVE PEDAGOGY THEORY (CDPT)

I have explained at the beginning of this chapter that my intention in this chapter is to develop a Critical Diffractive Pedagogy Theory (CDPT). I also mentioned that I will do this by interweaving some key themes from both the Critical Pedagogy Theory and the Diffractive Methodology Theory. To do this I use the definition of Diffractive Methodology as given by Murris and Bozalek (2019) who regard the approach as:

> ……a way of activating experimentation with the affirmative method of diffractively reading texts, oeuvres and philosophies through one another (p.1).

In the first section of this chapter I looked at Critical Pedagogy Theory. Subsequent to that, I looked at Diffractive Methodology Theory. In this section, I intend to focus on a Critical Diffractive Pedagogy Theory. In the next section I am going to give an overview of my Critical Diffractive Pedagogy Theory (CPDT). I will end the section by giving a statement of the themes that I regard as the fundamental pillars of the theory. It is the same themes that I will use in chapter 6.

5.5.1 Engagement

As I indicated above, CDPT is formulated from the integration of some themes from both Critical Pedagogy Theory (CPT) and Diffractive Methodology Theory (DMT). This theory is developed based on some of the above selected themes. The CDPT focuses on how teaching and learning should be both critical and diffractive where, being critical and being diffractive in this case are not exactly the same but rather, they would be used to explain each other. For instance, by being critical, the approach would focus on how all the barriers such as race and language included in the diffractive approach would be questioned. The major question in this case would imply some level of engagement with each situation that would be open for a multiplicity of points of analysis. The engagement would essentially enact a level of resistance to the status quo. In that case, CPDT would emphasise the need for the enaction and advancement of critical dialogue. In that case, critical dialogue rejects the proposal to confront those with opposite views. Rather, it seeks to engage them in a more open and dynamic manner that would be characterised by entanglement. The relationship between any entities would thus, as proclaimed by Barad (2007), be in the form of agential cuts

which are characterised by the unsettled separateness (Murris, 2017). Critical dialogue thus diffracts the centrality of all entities, exposes them to each other and in the process recombines all the different aspects into new mosaics of being. In that case, CPDT would be characterised by aspects of permissive and persuasive resistance. Resistance in this case would be regarded as a process of openness to negotiation of differences as the various entities on one hand would not allow the subjugation and ruining of each other's status, while on the other hand it will bring to the fore a platform where the entities in their difference would become partners. Overall, this would be tantamount to the sustenance of diversity which is not rubber-stamped but rather is emphasised through the complementarity of differences. As a pedagogical theory CPDT would preface the possible resistance and confrontational aspects that lie between for instance the curriculum on one hand, and the reality with its dynamic nature on the other. It would therefore present the need for the development of engagement through critical dialogue in order to soften the respective boundaries that lie separating the polarised entities.

5.5.2 Egalitarianism of power relations

CPDT would essentially reject the dichotomisation of positions but would attempt to find the egalitarianisation of power relations. The theory would have to recognise and address the existence and promotion of power relations by the status quo. Having such a realisation would be an achievement in the sense that it would create a space for how to flatten the upper and lower bounds of power relations in existence. In that way power within the collective would be made a democratically accessible entity that seeks for the decolonisation of statuses and status positions including their associated privileges. The process of the egalitarianisation of power relations would be associated with the underlying principles of entanglement and differential becoming. The main underlying principle of differential becoming in this case, would be that the relations between any two entities for instance would be characterised by open and differential subjectivity. Open subjectivity would in that case allow for the development of a freely connecting agency that would in a non-essentialist manner pool the individual differences of the entities and allow them to multiply in a manner that would promote diversity within the collective. The open subjectivity in addition to promoting the

differential becoming would also in a way promote the open development of entanglement among entities. In that case, the boundaries associated with the dichotomisation of different entities would be removed as the different entities become with each other.

5.5.3 Promotion of change

As a theory CPDT would also be underwritten by the promotion of change. The promotion of change would emphasise the need for diversity to be upheld and the putting forward of a need for all entities to be relational in nature . The issue of the recognition of change as a key parameter of the relationship that characterises the existence of all entities is also associated with how such recognition would also emphasise the critical role that social justice plays in a pedagogical approach that is associated with both criticality and diffraction. I argue that if a system is open to change, the implication would be that it rejects the a priori categorisation of any entities. Such a system would essentially also be based on the need to protect equality and democracy within the collective. A typical example would be how in the teaching and learning of Life Sciences learners would reject the a priori categorisation that characterise the human and the nonhuman, and the living and non-living within the subject. The development of such an attribute would come with the potential to extend democracy beyond the nonhuman. This would potentially allow for the recognition of change from an inclusive manner that does not allow for some entities to discriminate against others.

5.5.4 Minoritarian attitude

The CPDT theory would also promote the development of a minoritarian attitude as the entities relate to each other within the collective. The importance of the minoritarian attitude is that it allows for the development of mutual changes between identities that are normatively regarded to be distinct in terms of the power that they possess within the collective (Deleuze, 1991). In that way, it rejects the hierarchical distribution of power within the collective. Given that within the collective power distribution is often problematic and hierarchical, with some entities being more powerful than others, the

minoritarian would not be a quantitative concept based on the numbers of entities, for instance with the majority always regarded and confirmed to have numerical supremacy over the minority. Rather, with the minoritarian attitude, the minority are those that are subjugated irrespective of their numbers. They might be more in terms of numbers but however, they would possess less power, and therefore a minority. They are the underdogs. The minoritarian attitude would only happen when the majority gets disturbed in their status quo, and by doing that they would be forced to abandon what they regard as their representative standard that they would have defined in a majoritarian way themselves. In that way, they change from being majoritarian to being minoritarian. They would ignite and liberate the minoritarian attitude within themselves (Zehavi, 2010) In that case, CPDT extends the boundaries of democracy to mean that it is associated to a greater extent with social justice and diffractive association with each other, more than it being associated with how the majority stamp their wishes in the name of representation. By becoming minoritarian CPDT allows for the progression of being through the re-consideration of the standards that guide relationship within the collective. From a pedagogical view this would imply the consideration of multiple perspectives during teaching without having to dichotomise them. All entities including the often subdued such as women, the people of colour, the poor, the non-living and the nonhuman would all be given a fair share of dignity from a minoritarian perspective.

Having given a bird's eye view of the description of my theory, I end the section by giving a statement of the themes that form the pillars of the theory. I also give an overview of how each of the themes contributes towards the overall aim of the study. In that regard, the theory is guided by the following themes:

- Egalitarianism of power relations
- Promotion of change and social justice
- Minoritarian attitude
- Engagement

Having established the above themes as the foundation of the theory that I propose here, my next task would be to discuss how each one of them contribute towards the

achievement of the overall goal of the study. In other words, how would each one of them contribute towards the development of a critical posthumanist and democratic pedagogical approach in the teaching and learning of Life Sciences. For instance, the egalitarianism of power relations would be very important in the realisation of a critical posthumanist and democratic pedagogical approach. The egalitarianism of power would ensure that both the human and the nonhuman entities have equal influence within the collective. Such a level of influence would displace the humanist perceptions that make the humans put themselves in control of all the other entities within the collective. As such, when power is shared in an egalitarianist manner, there would be a manifestation of critical posthumanism. On the other hand, the egalitarian sharing of power would imply that all the entities within the collective are equivocal. The implication of equivocality is that the voices of all the entities are heard. This would be a manifestation of democracy within the collective.

The promotion of change theme works towards the promotion of diversity within the collective. The importance of diversity is that it takes care of the views and contributions of all entities. In that case, the promotion of change also emphasises equality as the a priori status of entities would not be accepted. The theme would as such in accordance with its emphasis of diversity, accept both the human and nonhuman entities. To that effect, change would be regarded as an element of strength within the collective. Through the parameters of change it would become feasible for different entities to be involved in processes of differential becoming. It is the manifestation of such processes that would allow for understanding the human and the nonhuman as connected entities sharing a single community.

The importance of the minoritarian attitude theme in the planning of a critical posthumanist and democratic pedagogical approach is due to the theme's emphasis on the need for the rejection of all forms of hierarchisation within the collective. Such an attitude would lead to the dominant to have an understanding of the implications of being the inferior who would be technically in the minority from a dominance perspective. In that case, the attitude would allow the dominant to question both their attitude and their status quo. When that happens, aspects such as human dominance within the collective would be questioned by the humans themselves, to the extent that they would be able to notice the consequences of their actions on the generality of the environment for instance. It is such developments that have the potential to illuminate

the dominant ways through which they have to address the consequences of their actions.

The engagement theme contributes tremendously towards the development of a critical posthumanist and democratic pedagogical approach. For instance, the parameters of engagement allow the promotion of resistance within the collective. The development of resistance is based on the engagement's emphasis of a critical dialogue among the entities. The critical dialogue would indeed expose the extent to which the human and the nonhuman depend on each other within the collective. Engagement should therefore be regarded as a critical process that is characterised by situations where the co-existence of all entities within the collective are analysed. During that analysis the interdependencies would be exposed. It is such expositions that would lead to the acknowledgement of the link between the human and the nonhuman. In another way, the links would also allow for the recognition of the importance of all as they co-exist together with each other in the collective. This is the recognition that has the potential to come with the inevitable democracy within the collective.

5.6 CONCLUSION

In this chapter I sought to develop a Critical Diffractive Pedagogy Theory (CPDT). To achieve this, I first took an overview of Critical Pedagogy Theory (CPT), followed by a similar overview of Diffractive Methodology. Following the exploration of these two theories I then developed a theory. I ended the section by stating the themes that form the pillars of the theory. I am going to use these themes subsequently in Chapter 6 like I mentioned earlier, to develop the overall theory of Critical Posthumanist and Democratic Pedagogical Theory that I will use in chapter 7 to explore how the issues of the Anthropocene may be addressed in the teaching and learning of Life Sciences.

CHAPTER 6: TOWARDS A CRITICAL POSTHUMANIST AND DEMOCRATIC PEDAGOGY THEORY (CPDPT)

6.1 INTRODUCTION

In this chapter, I intend to synthesise and develop a Critical Posthumanist and Democratic Pedagogy Theory (CPDPT). In my working on this theory, I seek to use the themes that I extracted from the following chapters: Chapter 3 (Object Oriented Ontology), Chapter 4 (Actor-network Theory) and Chapter 5 (Critical Diffractive Theory). During that process, due to the possible overlaps that could happen on the extracted themes, some of the related themes from different theories would be combined into a single broader theme. For instance, a theme such as hybridisation from OOO might be combined with a theme such as entanglement from ANT to form hybridised entanglement as a broader critical posthumanist and democratic theme. The pedagogical efficacy of this theory I am going to explore in Chapter 7, where I discuss its applicability based on the demands of the Life Sciences curriculum. In other words, in Chapter 7 I am going to explore how the themes that make the foundations of this theory could be used pedagogically in Life Sciences in a critical posthumanist and democratic approach. As such, in the next chapter, I will explore how the application of the theory would enable learners to become critical, posthumanist and democratic in their learning of Life Sciences. As I indicated in Chapter 1, though some previous studies have come up with approaches to the teaching and learning of Life Sciences, none of them has suggested the development and application of a critical posthumanist and democratic approach with the intention of addressing the Anthropocene especially from a South African perspective. It is this gap that I would like to fill in this study. The theory that I seek to develop is meant to address the shortfalls by humanism caused in the teaching and learning of Life Sciences.

In the following section I develop and synthesise a Critical Posthumanist and Democratic Pedagogy Theory in a thematic manner. The first theme that I am going to discuss is critical posthumanist and democratic pedagogy as kinship. Under this theme, I discuss how the recognition of relations of kinship between the human and the nonhuman would go a long way in transforming the collective into a posthumanist forum. After having emphasised the importance of the kinship recognition within the

collective, I then discuss how this kinship would be sustained by the socio-material relational justice that would prevail between the human and the nonhuman. The socio-material relations would be discussed next in terms of how they would lead to the hybridisation of the entities within the collective, in this case, due to the association with each other, the entities would be discussed with particular respect to how they tend to share materialities irrespective of their a priori situations.

The next aspect that I will discuss is how critical posthumanism could be viewed from an emancipation perspective. According to this perspective, it will be discussed in terms of how it emancipates the subalterns from the dominant humans. The subalterns in question include both the subjugated humans and the nonhumans as well. Such an eventuality would be possible if the ontological plane were to be recognised as being flat, and thus without any hierarchisations. This is what I will discuss after the emancipation theme. I will then go further and discuss how critical posthumanism could be regarded as an aspect of subjectivity. The centrality aspect here describes how both human and nonhuman entities would be subjective to each other's roles and presence within the collective, and the extent to which this influences their relationship towards a posthumanist transformation. I will continue to discuss the implications of powers within the collective, and how it relates to both subjectivity and the process of becoming which will be the themes to be discussed next. I will conclude the discussion of the themes through an exploration of how critical posthumanism is influenced by the heterogeneity of the collective.

6.2 CRITICAL POSTHUMANIST AND DEMOCRATIC PEDAGOGY THEORY: A SYNTHESIS

In this section, I am going to explore critical posthumanism. In that regard, I am going to look at critical posthumanism as the adoption of a disidentification attitude by humanity by the adoption of an ethical recognition of kinship between the human and:

(i) other humans
(ii) non-human animals, and
(iii) earthly others.

As indicated in the literature, the disidentification attitude is a radical democratic attitude characterised by the rejection of hegemonic identities and interpellations (Asenbaum, 2020; Deseriis, 2015; Muñoz, 1999; Rancière, 1999). This disidentification attitude whereby different entities would be capable of being in kinship and thus be entangled with other different entities would be informed by democracy. Democracy in this case would then be regarded as an ethical process of living together among the various entities, human and nonhuman.

Based on the three underpinning characteristics of critical posthumanism stated above, in this section I am going to synthesise a Critical Posthumanist and Democratic Pedagogy Theory (CPDPT) thematically based on the themes that I discovered in Object Oriented Ontology (OOO), Actor-network Theory (ANT) and Critical Diffractive Pedagogy Theory (CDPT). At the end of the chapter, I will discuss the pedagogical implications of the themes with particular respect to the teaching and learning of Life Sciences. I will explore the pedagogical implications of critical posthumanist and democratic theory, a process that will lead to the development of critical posthumanist and democratic pedagogical theory (CPDPT). The Critical Posthumanist and Democratic Theory is based on the following themes:

(a) kinship

(b) emancipation

(c) subjectivity

(d) power

(e) becoming

The essence of these themes is to lay a foundation through which Life Sciences may be taught and learnt through a critical posthumanist and democratic approach. The themes therefore demonstrate how the teaching and learning may allow the learners to becoming posthumanist as they learn. In other words, the themes work in such a way as to explain how the relationship between the human and the nonhuman could be flattened to the extent that humans could regard all the other entities as belonging to a flat ontological plane with them within which they would be entangled networks that are formed by heterogeneous entities that continually become subjective to each

other's presence. In that way, during the teaching and learning of Life Sciences, learners would be able to understand how their humanity relate to the nonhuman, and how such a relation potentially affects their understanding of experiences that the nonhumans face during their interactions with the humans. When this happens, learners would have transcended into a posthuman form within which they would be able to imagine, envisage and share the experiences of the nonhuman in-situ.

6.2.1 Kinship

In this study, I have realised that kinship is one of the primary themes that define and determine critical posthumanism. Kinship as a theme in this study draws from themes of how entities relate to each other and this kinship is developed through relations that they share with each other. The central idea that defines this theme is that entities within a collective irrespective of their different identities are akin to each other. In that case, kinship becomes a global theme that combines aspects related to socio-material relationality, hybridised entanglement and heterogeneous material discursivity. My discussion of kinship in this section shall therefore be based on the parameters of these three themes as derived in the previous chapters. All of the three sub-themes relate to each other in terms of kinship. They each discuss the implications of the kinship between the human and the nonhuman. I am going to start the discussion of this theme by exploring what kinship implies, after which I shall discuss the sub-themes.

In her analysis of how critical posthumanism relates to the kinship of the human and the nonhuman, Colebrook (2012) has described it as a fragile relationship between humans and the non-human others. This description is linked to the one given by Haraway (2015) where she defines critical posthumanism as an attempt to make kin within the universe. This kinship is essential in the manner that the entire universe is just one ecological system, characterised by reciprocated relationships among the entities that are symmetrically aligned to each other within the collective. The identity of the entity does not really matter regarding its potential to engage and be in kinship with any other entity. Haraway's further argument is that all the species and their environments are akin to each other to the extent that being human has no particular special place within the collective. She summarises her argument thus:

> No species, not even our own arrogant one pretending to be good individuals in so-called modern Western scripts, acts alone; assemblages of organic species and of abiotic actors make history, the evolutionary kind and the other kinds too. (p.159)

The summation of Haraway's argument is that all entities find themselves within assemblages where they are on par with each and are in relations with each other irrespective of them being human or nonhuman. The kinship would therefore be responsible for the development of the assemblages. Nonetheless, this would only make sense if the kinship transcends individual identities such as human and nonhuman. Haraway's argument could be regarded as being fairly speculative, and thus opens up the imagination to the possibility that all entities can potentially connect with each other and form diverse yet open networks that in themselves would be open to connection with any other similar or dissimilar networks to form broad heterogenous assemblages. There appears to be some agreement between the views of Haraway and those of Herbrechter (2012).

However, Herbrechter (2012) has brought in another aspect that perhaps influences the extent to which the human and the nonhuman become akin to each other. He talks about how critical posthumanism should be regarded as an emerging paradigm wherein the meaning of being human is subjected to radical changes that are brought about by aspects such as technological developments and climatic changes which tend to expand kinship across the human and nonhuman divides. The implication of Herbechter's definition is that critical posthumanism is an expansion of human capacity beyond the general human horizon. His views agree remarkably with those of Haraway (2015) mentioned above. Caution however has to be taken regarding the implication of the statement that human capacity is enhanced. It should not be meant to imply that the enhancement of human capacity concerns how humans would be better than nonhuman entities or even the objectification of the human persona. Rather, the enhancement would imply that humanity would assume a new level of being together with the nonhumans, a new forum of kinship that would not be possible in a humanist approach. That ideally is an enhancement of both the capacity and the perception of such capacity, since prior to that, humans have regarded themselves as supreme to all the nonhuman entities. The enhancement therefore takes place at an ontological level where it opens humanity to otherness, and in the process leaving all

the entities akin to each other. This view is echoed by Bolter (2016) when he describes critical posthumanism as an attempt that seeks to break the boundaries between the human, the animal and the technology. In the process it seeks to establish a being-together attitude among all the entities within the collective irrespective of their individual and a priori identities. In that way, the a priori status of the entities is set aside, and new relations are formed as they interact and intra-act. As this happens, critical posthumanism becomes a process that is characterised by deconstructive kinship among all the entities within the collective.

6.2.1.1 Socio-material relational justice

Critical posthumanism could be looked at from a perspective of desiring to avoid and if necessary, eradicate any traces of the dichotomisation of materiality along the nature and social categorisations within the collective. In other words, the eradication of the dichotomisation would be the opening of kinship This would be the basis of social justice as emphasised by Postma (2016) below. He mentions that the importance of posthumanism lies in its ability:

> ..to go beyond the normal/deviance binary by emphasising the productivity of difference and multiplicity. A posthumanist approach to social justice not only attends to marginalised groups (class, 'race' gender, disabilities) that are excluded from full participation, but also provides ways in which the dominant could become part of an ethic of inclusivity. (p.312)

A very important aspect from Postma cited above is the issue of how critical posthumanism influences both the dominant and the marginalised by opening each one of them for association with another. He indicates how critical posthumanism could lead to ethical inclusivity. Ethical inclusivity is achieved when all the entities within the collective do not undermine the role and importance of each other. This means there would be egalitarianism and social justice within the collective. In such a case, entities would tend to be cognisant of how they affect and are affected by other entities within the collective.

The quest for a more inclusive understanding of the relationship among entities led to what Abram (1996) regards as the increasing need for an understanding of the more-

than-human world. This quest led to the circumspection of the role of mankind within the communities comprising both human and non-human entities. Responding to such an analysis, Hayles (2008) comments that the critical posthuman should be regarded as a collective of human and nonhuman that has the potential and ability to self-organise itself into a larger system. Hayles' description of the critical posthuman has some fundamental indications. For instance, there is mention of potential and ability which implies that the critical posthuman has many possibilities of kinship. In other words, the posthuman lacks premeditated limits; it is capable of combining with other entities to come up with new possibilities that have unlimited potential. This implication is confirmed by mentioning that the critical posthuman is capable of self-organisation into an extensive system. If it is able to self-organise, this means that the critical posthuman is capable of self-reorganisation. The ability to self-organise and re-organise is based on the commonality that comes along due to the materiality of all the entities, which is the basis of the kinship. This alludes to the view that the posthuman is essentially materialist, vital and intelligent in every other way and able to enter into self-configuration and reconfiguration. In essence, this ability to be attentive to difference as a mode of consciousness is what Barad (2014) refers to as diffraction that I have discussed earlier in Chapter 5. Due to its material kinship between human and nonhuman, the critical posthuman is able to move and re-move the human from their egoistic enclosure where they regard themselves as the centre of the universe, to a position whereby they have to meet the universe halfway (Barad, 2007). When the critical posthuman meets the universe halfway, it opens itself to changing others, and to be changed in their interaction with the other subjects in the universe. It achieves this through the extension of its materiality, which becomes a source of kinship. Becoming posthuman therefore means the entanglement of all entities within which they are free to associate and be akin to each other without any prejudice nor a priori identities. This will see the consequent development of the flow of materiality among all of them. This is what Halberstam and Livingston (1995) mean when they mention that the critical posthuman keeps changing its boundaries and dimensions in order to remain open to multiplicities of viabilities. In other words, it actually gets rid of its boundaries totally, and leave itself open to association with any other entities, a trend that is only possible due to the materiality that connect the human and the nonhuman, the very materiality that makes human and nonhuman akin to each other irrespective of their diversity.

For this to happen the human should be cognisant of the materiality that they share with the nonhuman. Such a recognition of materiality would create some homogeneity of relations among all the entities with the collective. A posthuman statehood would be created, and they would belong to a state where they recognise that they are materially related to other entities regardless of any profiling. They have to be enlightened to the extent of upholding the entanglement that they share with the entire universe living or non-living, human or nonhuman. They would become amenable to sharing space and all other resources in a materially democratic and fair manner that is devoid of subjugation and prejudice. This view agrees with the views of Braidotti (2013) when she mentions that the role of critical posthumanism should be to achieve an unlimited openness and intensification of socio-material relations between themselves and the other than human others.

6.2.1.2 Hybridised entanglement

Kinship in critical posthumanism may also be analysed from a hybridisation perspective. This perspective builds on how critical posthumanism works on the removal of boundaries which has been discussed earlier. However, the additional emphasis in this case relates to how the removal of the boundaries would allow the entities to hybridise with each other, and form new entities that have the characteristics transcending both of the divides. A typical example of hybridisation is found in the work of MacKenzie (2002) critical posthumanism was studied as the removal of boundaries between the human and technology (technicity). This line of analysis looks at how for instance, the removal of the boundaries between humans and technology see humans and technology working alongside each other such as how technological limbs replace human organs as described by Snaza et al. (2014):

> Posthumanists argue that we have never been separate from machines and that notions of “humanness” could not be produced without machines. We have always been technological. If you are a wounded war veteran from America’s latest wars then you have become part of a war machine that disassembled the subject, reshaped you, and sent you out to do battle in an efficient, disciplined, unrelenting, uncaring manner. (p.44)

In that way, both the human and the nonhuman become hybrids rather than the common and original humans. They become both enhanced and substituted. In another way, they begin to behave ethicality towards each other, since they would be part of each other.

The hybridised form of kinship has also been discussed from a feminist perspective, for instance Haraway (2015) looked at the removal of boundaries between the male and female as a way of addressing male hegemony. She argues that due to this form of hybridisation, being human is then viewed as being independent of its gender. This is alluded to by Braidotti (2013) when she refers to critical posthumanism as a neo-foundationalist approach that emphasises the need to assemble and ground the scattered practices and concepts that are results of the contradictory and fractured nature of the world. The assembling implied by Braidotti here implies the entanglement of the scattered entities resulting in a worthwhile hybridised posthuman.

The entry of critical posthumanism thus seeks to restore fairness-oriented democracy to the relationship between human and non-human entities within communities. Posthumanism is about “lending our voices to those whose voice had been stilled” (Yancey,1994, p.247). For the hybridisation process among the human and nonhuman to be successful, there is a need for the recognition that every entity has the potential of equal agency within the entanglement, be they human or non-human, and living or non-living. It is this agency that brings about the potential kinship among entities. The commonality of the agency would therefore work towards the removal of the Cartesian dualism that is often used to characterise the relationship between the human, other humans and the non-human (Schwartz & Wiggins, 1985). As alluded to by Bolter (2016), leaving all the entities in kinship within the collective, critical posthumanism then comes in to foster a link between the human, and the non-human. This link would see them being transformed into being hybrids of each other and thus being akin to each other. The hybridisation between human and nonhuman is expanded by the work of Hayles (2010) who in her analysis of posthumanism, indicates that the theory should be regarded as a project that looks at the co-constitution of human and tools, a process of hybridisation in essence. The tools that are being implied here, could be all the other entities that Spivak referred to as the subaltern. Hayles further claims that posthumanism is important in the sense that it recognises the co-evolution of humans

and tools in a hybridised manner that is characterised by each affecting and being affected by the other. This co-evolution would essentially be regarded as the foundation of the hybridisation process that Haraway (1991) describes as being responsible for the manner in which the universe becomes characterised by cyborgs. Similar sentiments have been echoed by Latour (2007) when he describes the same as a parliament of things, a term that gives reciprocity and symmetricity to all the things that are found within the collective. It is this symmetricity and reciprocity that allows the entities to hybridise with each other, and thus experience kinship. Latour further hints that the parliament of things is an envisioned discourse community comprising of diverse stakeholders, including both humans and non-human agents that work together, co-habit and share the affordances of a common world available to all. In the process of these sharing dynamics, the entities entangle and hybridise with each other. In that process, the self-confirmed sacred position of the human within the collective is erased as the human becomes a posthuman by being a hybrid that has the characteristics of both the human and the nonhuman. In another way, the prominence of the parliament of things also lies on its emphasis of how entities that tend to be of different origins and nature would hybridise with each other, and be able to share a common world through being entangled materially. This is part of Latour's (1993) argument that as humans we have never been pure, and that our imaginary purity is rather a construction of our minds as we try and justify how modernised we have become. He argues therefore that humans have always been hybrids, since being human is a process that has both human and nonhuman parameters.

Hayles posits an important description of critical posthumanism theory. She mentions that the theory analyses the extent of the networks within which tools and humans work with each other in a circulated effort characterised by feedback and feedforward loops. The implication of this statement is that as they interact within the collective, humans and tools advance each other in terms of how they associate. The views have also been raised by Latour and alluded to by Haraway in her work on The Cyborg Manifesto. Haraway argues that the relationship between human and nonhuman is inseparable and is characterised by entanglement. She argues further that the way forward would be through the recognition of coalition co-existence effectively occasioned through affinity and kinship towards each other. Haraway's argument (though she refuses to be called a posthumanist) is two pronged. First, she maintains

that some entities within the collective are companion species (Haraway, 2003). She elaborates on her second point that due to the common companionship of all the entities within the collective, many commonalities are shared irrespective of origin. She therefore regards all subjects within the collective as cyborgs (Haraway, 1994) characterised by each having a modified nature due to the sharing of materiality with another. A close analysis of Haraway's thesis indicates that within the collective, interactions have become so interlocked and inseparable to the extent that all the entities have become related to the extent of being hybrids of each other. The sharing and dependences characterising entities within the collective has been aptly summarised by Åsberg and Neimanis (2013) thus:

> The microbiome maps the combined genome of all the organisms of that body you thought was yours alone. Bacteria, bacteria-eating viruses, fungi and other semi-living microbiotic forms cohabit around and within human cells, on our skin, in our mouths, in our guts and of course in our genome. We live in symbiosis with thousands of species of anaerobic bacteria: about six hundred species in our mouths that neutralize toxins that the plants we eat produce in their defence, and about four hundred species in our guts. And we depend on them….There's always a politics to location, and not realizing the importance of scales, relations and relationality may prove fatal among our queer posthuman bodies in the microscopic register. Those old bodily themes of individuality, autonomy and self-possession are neatly deconstructed with these microbiomes. (p.7-8)

What Haraway, and Åsberg and Neimanis are saying is that within the collective the human is a hybrid entity with and without themselves. Every subject within the collective is just a hybrid (Braidotti, 2006; Braidotti, 2017; Latour, 1993) to the extent that the purity claimed by humanism is nothing more than a fallacy that is perhaps motivated by desires of self-preservation. The claims about purity want to conceal the truth that both human and nonhuman entities are never, and have never been pure within the collective. In essence, they have always been hybrids. These claims of purity are the source of the problem and with them come issues such as hierarchisation and binarisation. Haraway calls for equivalent relations within the collective since all entities share kinship. The recognition of that kinship and equivalent relations would be sine qua non to the development of ethical co-existence within the collective that would be characterised by heterogeneously entangled networks. The a

priori identities are lost during the hybridisation process. Democracy, collective empathy, ethical relationality and respect would become common goods available to all within the collective since they would all be related through the sharing of materiality during hybridisation.

6.2.1.3 Heterogenous material discursive engineering

The human and nonhuman kinship within Critical Posthumanism may also be understood as heterogenous material discursive engineering. As described by Barad (2003:22)

> Material-discursive practices are specific iterative enactments—agential intra-actions—through which matter is differentially engaged and articulated (in the emergence of boundaries and meanings), reconfiguring the material-discursive field of possibilities in the iterative dynamics of intra-activity that is agency. Intra-actions are causally constraining nondeterministic enactments through which matter-in-the process- of-becoming is sedimented out and enfolded in further materializations.

This theme is based on the way in which entities that are from different backgrounds could possibly associate and connect within the collective in a form that leads to profound material discursivity engineering. The essence of material discursivity is based on the view that within a critical posthumanist collective discourse and materiality may be used to work alongside each other. In that case for instance, materials and discourse practices may be related directly to the extent that the heterogeneity of the collective would include both material entities and discourses, in a terrain where both of them would be regarded as subjects on par with each other. Heterogenous material discursive engineering comes with the emergence of connections, reconnections and association of the entities that would be characterised by the rejection of any claims of their a priori status. As such, there is some importance that is attached to their adjacency which allows them to share agency commutatively among them. However, for the sharing of agency to be constructive, there has to be democracy in the manner in which it happens. The democracy would then come in to

counter some instances where the sharing of agency may not be productive. Nonetheless, the sharing of the agency would not be based on any a priori conditions nor status but would be simply based on them being adjacent to each other and sharing the benefit of their heterogeneity. In other words, the adjacency would be independent of the heterogeneity of the individual entities. In that way, there would be an intensification of intra-actions among the entities to the extent that new assemblages would be formed. The assemblage would in essence be made up of actors that relate to each other while at the same time maintaining their heterogeneity within the premises of their collective. The key attribute of the adjacent commutativity would be that as long as entities are close to each other, and because they share materiality in addition to their adjacency, they would have an unlimited potential to interact, associate and connect irrespective of their individual differences. These heterogeneous interactions are not pre-meditated. This attribute works to get rid of the dichotomisation of entities within the collective, by providing a platform and medium through which entities could link and connect and thus co-operate with each other in the achievement of some common good for the collective. As they inter-act and intra-act the entities would go beyond their individual potential due to the multiplicity of their heterogenous engineering which brings tremendous diversity. The heterogeneous engineering is partly attributable to the diffractive patterns that characterise the ways through which entities associate within the collective. Due to the nature of the diffractive patterns, the heterogeneity would manifest as an aspect that keeps changing and would be fluid by nature. It keeps the collective open to further diversity as more entities would be prone to joining and disjoining it.

The heterogenous material discursive engineering characteristic of the critical posthumanist theory is informed by another important aspect: the materiality of both the collective and the entities. It is this same materiality that they share and allow them to associate and dissociate with each other and thus keep the diversity of their networks. The need to observe materiality as the transversal link of all entities within the collective must be emphasised. In that way, the dualisation of categorisation would be done away with. When that happens, irrespective of their individual differences the entities would capably co-operate and associate with each other. The implication of the discursivity and common materiality is that all the entities would treat each other ethically by complementing their differences and using such differences as sources of

diversity and plurality. The importance of plurality is that it confirms inclusion and tolerance of each other among the entities. Inclusion and tolerance themselves are informed by ethicality. By being in ethical relations with each other, the entities would then establish equivalent and symmetrical relations within the collective, and by establishing that, they would reject any form of hierarchisation that might emerge within the collective. The entities would thus be within an ontological equivalence among all of them. This would essentially allow the development of material relations that transcend the differences of individual entities within the collective. In other words, differences would not be regarded as sources of hierarchisation, but would rather be used as a foundation for unlimited discursivity.

6.2.2 Emancipation

Under the emancipation theme, critical posthumanism is described in terms of how it promotes the emancipation from humans of both the subalternate other humans, and nonhuman animals. One of the deep-seated drives of critical posthumanism is the analysis of the relationship between human beings and other human beings. This comes from the often-mentioned principle of humanism that regards humans as white Christian, rational and propertied (Moore & Moran, 2016). In that regard, all the other forms of humanity including white women, the poor, and people of colour are regarded as inferior beings – the subalterns, who do not possess sufficient substance to be regarded as humans. That being the case, critical posthumanism thus comes in as an emancipation factor that would seek to bring ways through which the so-called inferior humans could be saved from the vices of the dominant humans. This would be a case of humans being emancipated from other humans. A typical example of how the non-white population in South Africa had to be emancipated from the Apartheid policy that the white South African imposed on them. In another manner, posthumanism would allow for the recognition of ethics among humans by seeking for the restoration of humanity without due consideration of any distinguishing parameters such as race and wealth. This could be achieved through the recognition of ethics as a measure connecting all humanity to each other. There is a possibility that the recognition of ethics as an integral aspect of humanity would translate into the recognition of ethics among all subjects within the universe.

Critical posthumanism thus seeks to promote the emancipation of all the subalterns within the collective. As explained above, the poor, women, children, people of colour and the disabled are regarded as the subalterns (Mendoza, 2018; Spivak, 1988). In other words, the subalterns are regarded as those entities that are viewed as nonhuman. The emancipative action of critical posthumanism would be achieved through the emphasis that all entities within the collective are related to each other due to their sharing of materiality. The realisation that emancipation would be critical within the collective is affirmed below by Åsberg and Neimanis (2013). They argue that due to the close relationship between the human and the nonhuman, it would be very important for the humans to emancipate the nonhumans.

> The human genome can only be found in about ten per cent of the cells that occupy the commonplace space we call "my body." The other 90 per cent are filled with the genomes of bacteria, fungi, protists and other such microbiota that keep us alive. (p.7-8)

If the thesis of Åsberg and Neimanis stated above is valid, then humanity as such does not separate us from non-human animals. The entire universe would benefit from acknowledging and respecting the mutual links between human animals and nonhuman animals, and other nonhumans at large. Similar sentiments are shared by Diamond (2001) when she comments on the relationship that govern human-kind and animal-kind. She says we share in equal measure vulnerabilities with non-human animals to the extent that we need to recognise their presence as some kind of our kith-and-kin in the fold of mother nature.

Through its emphasis on emancipation, critical posthumanism therefore brings in the duo aspects of morality and ethics (LippertRasmussen, Lippert-Rasmussen, Thomsen & Wamberg, 2012; Miah, 2008; Mulcahy, 2021). For emancipation to take place, there would be a need for the ethical recognition of the importance of the other. Such a recognition would indeed be informed by morality that would inform each entity (human or nonhuman) of the critical need to maintain peaceful co-existence with the other entities (Anderson Ravindran, 2019). In that way, each entity would be prone to recognise the shared agency that commonly transcend their presence and interactions with other entities. As explained further by Diamond, the basic point of mutuality is that we share a common grievable presence with animals. The implication here is that we

each need the presence of the other, and if the presence is lost, we each are forced into a grieving situation. The aspect of the grievable presence is the one that should be addressed in the manner in which the two entities associate and interact. When an entity is grievable to another, the implication would be that the entities would be indispensable to each other. As explained in the literature (Butler, 2016; Redmalm, 2015), grievability implies that the entities could not afford to lose each other. A failure of the entities to take cognisance of how they each need another would lead to the approaching of the Anthropocene. A typical example would be how the failure of humankind to recognise how much they need the nonhuman such as forests might lead to critical phenomena such as desertification. In that regard, the Anthropocene is a grievable consequence of the recklessness of humanity towards the environment. Human animals and non-human animals should therefore be regarded not as mere neighbours, but as the kith and kin that they are.

6.2.3 Subjectivity

The theme of subjectivity would be very important in this study. This is because the theme emphasises the potential for different entities to affect and to be affected by the other entities. It therefore comes in with a parameter of how for instance the human and the nonhuman may potentially work alongside each other. It is indicated in the literature (Braidotti, 2019; Postma, 2016; van der Zaag, 2016) that the place and meaning of the word *subjectivity* in critical posthumanism, has been carefully used ahead of the other term (subject), as an indication of a shift from the usual centre proclaimed by humanist and liberal views. The use of the term thus emphasises the need to be outward looking rather than inward self-proclamation by entities (Braidotti, 2018). As described by Postma (2016), subjectivity is a mosaic and conglomeration of entities whose individual and various forces cause and promote the subjectification process. In that case, subjectivity is not a singular process, but a convergence of multiple interacting forces that affect and are affected by each other, in the process allowing the unregulated interactions of all the entities within the collective, irrespective of their identities. The ways in which subjectivity has opened avenues for the human and the nonhuman to interact with each other materially has also been alluded to by Sharon (2014):

> The human being is conceptualized here not as an independent and autonomous entity with clear cut boundaries but as a heterogeneous subject whose self-definition is continuously shifting, and that exists in a complex network of human and non-human agents and the technologies that mediate between them. (p.1)

This kind of subjectivity as portrayed by Sharon not only opens the human entities for interaction with other entities within the collective, but it also opens up all the entities, human and nonhuman to non-predetermined relational interactions with each other within the collective. The nature of the interactions of the entities would be open and self-deterministic as it happens in-situ and in real time. This process whereby the prior conditions and states of the entities are disregarded is the subjectification process, and the extent to which it is fulfilled is called subjectivity. In that way, subjectivity looks at all entities as simply relationally materialistic, self-organising and intelligent, and thus prone to combine and recombine within and among themselves and with any other entities to form hybrid and heterogeneous collectives.

Subjectivity as such, becomes a critical aspect of critical posthumanism in the sense that it is concentric, diverging and converging boundaries is characterised by the transgression of boundaries which ultimately leads to both hybridity and heterogeneity of entities. In the words of Deleuze (1995) subjectivity operates like a magnetic field where a multiple of individuations tend to surrender their identities irrespective of intensity to form and become part of one common identity encompassing all. Subjectivity could otherwise be regarded as a process whereby space is left for each other to accommodate change and to influence change as well. It could be likened to a zone of exchange characterised by processes of give and take, and the smudging of boundaries to create a zone of commonality. Using Latour's (2007) description of actors, networks and actancy, I argue that subjectivity could be compared to actancy in actor-network-theory, wherein the actancy is an indication of the potential of the actors to act along with other actors within a network. Subjectivity would thus be the potential to act, and also to be acted upon without offering any kind of resistance to the other entities while at the same time without being reduced to the other entity. It would allow the formation of heterogeneous assemblages that tend to get form and get formed as individual entities experience each other's presence within the collective. In my view, due to subjectivity each individual entity forms a concentric

locus of subjectivity that is characterised by affinity to associate with any other entity within its vicinity. These concentric networks tend to converge into formations of universal materiality and thus connect the individual entities together. In that manner, even entities that tend to be identifiably different would thus get connected into a mosaic of heterogenous networks. This is depicted in Figure 4 below:

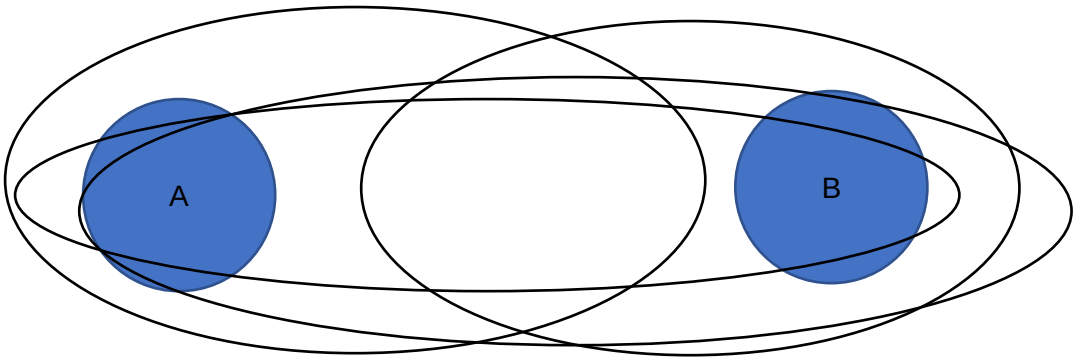

Figure 4: an illustration of the development of subjective affinity networks between two entities

As illustrated in Figure 4 above, any two entities tend to exude a network or some networks of subjectivity that surrounds itself which networks in the process of entangling the entities become entangled into each other and form new networks themselves. These networks are characterised by affinity and form an outward bound open buffer zone within which the interaction between the entities would be permissible irrespective of their identifiable differences and their a priori conditions. Nonetheless, these lines of affinity only illustrate the readiness of the entities to connect with any other network, and thus should not be confused with boundaries of any kind. They are imaginary lines of subjectivity and affinity. The affinity itself should be understood to be multidimensional due to the potential that the individual entities possess to change at any time. The imaginary lines might be regarded as being similar to what Latour (2007) regards as actancy described above. The actancy would be projected as more of a possession of the potential to affect and be affected. The implication from this comparison is that subjectivity itself is a potential to affect and be affected. It could be regarded as a neutral potential that is characterised by tendencies of universal recipiency of the desire of other entities to connect and associate. As mentioned above, there lies a zone of give and take of subjectivity. What is being given

and taken within the subjectivity zone is agency. The zone is therefore characterised by the sharing of agency.

The notion of subjectivity has another critically important aspect when it is linked to neo-materialism for instance as mentioned by Coole and Frost (2010). This dimension places the human within and among a myriad of non-human others to form heterogeneous assemblages. Such heterogenous assemblages as explained by Balibar (1997), circumvents individualism through the development of trans-individuality patterns that form the basis of open interaction and association. This view indeed agrees with Figure 1 illustrated above. The development and manifestation of trans-individuality creates a porous zone where mutual exchanges take place without prejudice and premeditation.

The occurrence of trans-individuality as an element of subjectivity described above is related to a key aspect that has been raised by Postma (2016). Postma mentions that subjectivity is characterised by the location of agential elements such as volition and desire within it. These elements he explains, are not locked within individuals, and are rather found floating within events and from hence they originate. They help to bolster the process of subjectivity by existing prior to any entities human or non-human. According to Deleuze (1991) this existence matrix brings in an equivocal relationship among the elements and the entities. In the process, sufficient grounds are created for subjectivity to be equally experienced. This is alluded to by Postma (2016) when he mentions that:

> Subjectivity is not to be associated with the autonomous, rational and volitional humanist subject, but one produced within an assemblage of forces. (p.313)

The implication here is that for humans to fit within the posthumanist collective, they have to surrender their claim to objectivity, rationality, autonomity and volitionality. By surrendering those aspects humans get recognised as equals within the collective, and all the previous boundaries are done away with. Going forward, they become receptors and donors of affinity that come from the commonage of the assemblage.

Postma (2016) has also brought in a key characteristic of subjectivity. He talks about how subjectivity manifests within the assemblage as *self-becoming.* He adds further that in its being, the extent of the self-becoming is manifested in expression and

speech. Caution has to be taken on the implications of *expression and speech* being discussed here. They should not be understood from a humanist perspective. Earlier on, I alluded to the issue of potential as a key aspect that all entities within the collective possess. This potential is broad and includes how entities could express and associate with each other. I argue that the various entities manage to relate with each other. Subjectivity allows them to share and be shared, to affect and be affected. As such, there is sufficient grounds to relate and entangle as an assemblage. Subjectivity then becomes regarded as something non-static, but as something that is nomadic and rhizomic (Grisci, 2008; Murris, 2017). Its non-static and rhizomic nature is also discernible in Figure 1. As it spreads itself, it conquers and gets conquered by other entities and other networks and in the process gathers more meaning from various entities that tend to multiply in linkages that work alongside each other within the assemblage. As this happens, the boundaries that often encapsulate the individual entities are scrapped and eliminated forever through enfolding into each other and disappearing diffractively. This is alluded to by Deleuze and Guattari (1987) when they refer to subjectivity as a point that is transformed and continues to transform as it moves within the assemblage. This characteristic transformability is as a result of the subjectivity being characterised by relationality, multiplicity and heterogeneity which make it fit within the flux of non-polarising power that keeps unfolding within the assemblage (de Castro, 2004; Postma, 2016).

6.2.4 Powers

As detailed in the literature (Deleuze & Guattari, 1987), the concept of powers is categorised into *Potestas (pouvoir)* or Potentia (conatus, puissances). Deleuze and Guattari go further to explain that the former is explained to be associated with tendencies of domination and control, while the latter is associated with being affirmative and driven by elements of passionate involvement and desire. Deleuze and Guattari (1987) have explained further that the Potentia power category emphasises life-affirmation as its yardstick. It manifests through the various forms of both interaction and intra-action among the entities. As explained by Nietzsche, Potentia strives towards the complete fulfilment and actualisation of life. He notes nonetheless

that its progress is hampered by Potestas which tends to be irregularly reactive and controlling.

From a critical posthumanist perspective, the issue of power is explained with respect to how the power assumes productive and life-affirming roles (Deleuze & Guattari, 1987). Describing these views as generally borrowed from the works of Spinoza and Nietzsche, Postma, talks of the contrasting features of the concepts of powers and Power. Powers denote the multiplicity of capacities while Power denotes a singular and unilateral dominating system (Postma, 2016). The essence of Powers is the unrelenting influence in the process of subjectification, says Postma. Almost similar to the subjectivity described in the foregoing section, Powers form networks of relations, wherein the individuated subjects find themselves. The role of the Powers within the networks is to assume the role of the driving force behind the paramount process of becoming. Postma argues further that regardless of the Powers being neutral, they nonetheless are shared in constructive and affective patterns among the entities manifesting in various patterns. In that way, the difference between Powers and Power becomes clear. Powers as such would be regarded as decentralised and evenly accessible resource available to all the entities within the collective. On the other hand, Power is centralised and possessed by a few who use it as a tool of control and subjugation. The concept of Powers differs from the humanist and rationalist conception of Power where Power is categorically separated from freedom and knowledge (Berlin, 1969). In his explanation of the concept of Powers, Postma (2016) has reiterated that in contrast to the humanist view of Power described by Berlin above, in a posthumanist sense, the entire assemblage including the earth itself always form continually and engage each other in power flow processes.

Critical posthumanism emphasises the manifestation of Potentia power which would allow all entities within the assemblage to be treated with equal regard. In that way, critical posthumanism seeks to advance Potentia power within the assemblage within which, the Potentia power would be generative and continue to grow and be shared among almost all the entities without prejudice. It is Potentia power that would see even nonhumans accorded equal recognition and regard just like all the other entities. Potentia power has the ability to remove the boundaries laid by the Potestas power in the same manner that the lines of affinity of subjectivity does it, as illustrated in Figure 1 above. We can see here that subjectivity is informed and motivated by Potentia

power and is not after domination, deprivation and control. This could be regarded as power through which all the entities come to be what they are in the assemblage. It could be regarded as a potential for growth and expansion of the network. It is limitless and is shared across the entire assemblage spreading in the manner of a Rhizome as suggested by (Deleuze & Guattari, 1987). As Postma (2016) says, the manifestation of Potentia power allows for the subjectification of all. In essence it promotes the development of becoming without limiting the potential to achieve it. It has the potential to positively influence the process of becoming posthuman. In Chapter 7, I will explore how the issues of power would be essential in the process through which learners may become posthuman and address the challenges of the Anthropocene in the teaching and learning of Life Sciences. An attempt will be made to achieve this by first exploring the general outlook of power as manifesting in both the teaching and the curriculum statement itself.

6.2.5 Becoming

The other critically important theme in critical posthumanism is the theme of becoming. As explained by Braidotti (2006) becoming refers to the positive life force that she calls *zoe*. Becoming from this perspective appears to spread the concept of life to include all matter, be it human or non-human. It is more or less a neutral form of being that would allow any entity to associate with another entity. This should be regarded as the medium through which all material vitality is shareable within the collective. The views of Braidotti have been alluded to by Postma (2016) who has indicated that becoming is a monistic ontology in the sense that it regards all entities human and nonhuman as potentially in possession of vitality, and that such vitality is crucial in the understanding of how they are in a position to link with each other. In other words, it implies that becoming allows each entity to become itself.

I find this view of becoming appealing, for instance, in the way it tends to subjectify the meaning of life. There is a possibility that if life is subjectified, then all the entities within the assemblage might be regarded as participating in a fair share of life irrespective of them being human or nonhuman. As I shall analyse later, this is important in the exploration of how this contributes to democracy within the collective. But this assertion may not be enough on its own, for it to hold validity, the definition of life within

the assemblage has to be extended. That means life could be a currency of becoming that is potentially held by all entities. This currency should be discernible through its presence which in itself should be a measure of vitality. In essence all entities within the collective have vitality by virtue of them being material. This decentres the generic classification of entities into living and non-living rendering all the entities to have equivalent potential of becoming due to the vitality of matter that constitutes them. This view is corroborated by Braidotti (2006) where she discusses how matter should be regarded as intelligent and self-organising. Similar sentiments have been shared by Postma (2016) who argues that all existence including intelligence are effects of becoming. Becoming as such then could be regarded as that drive that invites all matter to be diversifiable through unlimited potential to interact with all else. With sufficient subjectivity and Potentia, all matter transforms into wide rhizomic networks spreading goodwill in the process. Postma writes about matter transforming into diversified multiplicities.

A very pertinent dimension of becoming is what Deleuze and Guattari (1987) refer to as becoming minoritarian. Becoming minoritarian is about how the minority tends to resist the yokes and bondages of power that is placed on their very necks by the majority. These placements demand subservience and obedience from the minority. It achieves this by increasing the height of the walls of the boundaries that separate the minority from the majority. It is an apparent challenge to power, authority and domination through the rejection of a priori forms of existence. The approach advocates for unlimited deterritorialization and the removal of boundaries that blackbox the pre-determined and fixed modes of being. Hence it is focused on de-blackboxing. It disagrees with the tendency of seeing the majority and the minority in purely quantitative terms. It seeks to transform Power to Powers, so that all entities within the collective would be able to exercise and generate it. Becoming minoritarian is preferable in this case because the majority exercises Potestas power. In that way, the majority is both aggressive and dominating, and it denies opportunities for diversification and outgrowth. In that way, the majority suppresses the self from creativity and subjectification. The preference for the becoming minoritarian is based on the minoritarian's openness for becoming the self (or becoming other) (Postma, 2016). It does not limit the potential to realise oneself and to have interactions with others.

Becoming minoritarian establishes multiple modes of difference and how they may be combined to support diversity. It therefore applies mostly to how the majority becomes open to others through opening channels through which they may connect and reconnect. It rejects outrightly the desire of monopolising power in order to maintain the suppression of the subjugated. In contrast, the majority focuses on the declaration of unilateral singular standards of being. As mentioned by Deleuze and Guattari (1987) the majoritarian standard is the one emphasised by the humanistic view of mankind. Postma elucidates that becoming is always a collective activity taking place through assemblages, a process that Barad (2007) calls entanglement. Barad explains further that the intra-actions are such that there is no assumption of the pre-existence of entities. This implies therefore that the process of becoming recognises subjectivity and is open for the spreading of relations and Powers in the assemblage. In that way, diversity is enhanced and promoted. As described by Postma (2016) the process of becoming is such that it emerges from the inter-actions and intra-actions of the particular forces that are involved within the assemblage. It cannot therefore be pre-assumed as it is an outcome. The process of becoming is life assuring due to its allowance for the formation of multiple connections. Deleuze and Guattari have emphasised that this formation of multiple connections dissolves boundaries and allows the formation of new subjectivities.

As explained by Postma (2016) one of the primary life forces is the desire to become. If the desire to become occupies such a central place within the collective, it implies that it is the one that provides the momentum for the inter-actions that Barad talks about. Important to realise, however, is that the concept of desire as used in this case refers to the potential of becoming. It is not associated with sentiency and thus is also attributable to non-living entities. In other words, non-living entities are prone to the desire to becoming just like the living entities but however, in their own respective ways since each becoming is different. The desire and affect would essentially also take cognisance of the implication that come with the aspiration to wish to spread in a certain direction. In that manner, it forms the basis of the formation of the assemblage (Deleuze & Guattari, 1983). The level of desire and affect essentially is determined by the relations withinwhich they are involved in the process of becoming. That readiness is an indication of the possibilities of association and entanglement that characterise the collective and its entities.

The affect part is the acknowledgement that within the collective the various inter-actions produce effects leading one to affect and be affected. Postma (1996) calls this the mutuality of effect. This is alluded by Spinoza when he mentions that there exists a reciprocal effect between affecting and being affected (Spinoza,1994). The reciprocal relationship manifests in such a manner that all entities within the collective spread change and receive change within the assemblage. The implication is that for affect to be present, it has to be preceded by relationships which themselves precede the entities.

6.3 CRITICAL POSTHUMANISM AND THE MANIFESTATION OF DEMOCRACY WITHIN THE COLLECTIVE

I have so far discussed the general outlook of a critical posthumanist theory. I however have to find the location where I have to discuss democracy within a critical posthumanist theory. In order to achieve this, I shall rely on Latour's (2004) concept of due process. In his work on The Politics of Nature, Latour explains due process as a process through which new ideas can be introduced as propositions into a common world where other ideas have already been introduced. He thus argues that this should take place through the observance of four general rules viz:

(i) perplexity

(ii) consultation

(iii) hierarchisation and

(iv) institution (Latour, 2004, p.109).

In explaining the four general rules above, Latour argues that when deciding upon the number of aspects that may be discussed regarding an issue, there shall not be a simplification of the number of propositions that can be taken into account. He calls this normative view perplexity. He goes further to explain that under no circumstances shall the number of voices that participate in a discussion be limited in an arbitrary manner. This he calls for consultation, implying that there is a need for a wide consultation that should take place so that all voices are given an opportunity to be heard. In the third rule, Latour argues that there needs to be hierarchisation of

propositions to the effect that the compatibility new propositions that are brought with those that are already there should be ensured. This he says would ensure that the new propositions have a legitimate place within the already established aspects of the common world. It is after this that Latour suggests that the fourth rule of institutions shall come, where there shall be no longer any questioning of the legitimacy of all the propositions as they collectively represent the collective life.

I am arguing essentially that the agency of critical posthumanism subjectivity within any collective should lead to the achievement of democracy among all the entities within the collective. This would then complete the intention of the chapter, which is the synthesis and development of a critical posthumanist and democratic pedagogy theory. In the following chapter I explore how democracy may be achieved as a result of the application of a critical posthumanist pedagogy. To achieve this, I am going to explore how democracy might manifest within the application of the above discussed themes in this chapter. I regard democracy to refer to the identification of normative processes of intra-action/engagement/association within the collective.

The issue of subjectivity is such that it allows for any kind of entities to associate with each other, and to work beside each other, and with each other. In such a manner, subjectivity categorically brings about a flat ontology, and thus removes the boundaries that enclose the individual entities. It opens the avenues for all the entities to refer and relate to each other in-situ. To achieve this, subjectivity considers the historical status of the entities together. The importance of the historical consideration is because it is an indication of how subjectivities became and how they have cumulated energy and power as part of their ongoing configuration. History exactly tells and thus reveals how entities hybridised and interlinked. In this manner the tendencies to isolate and disregard each other could be done away with. When all the entities get to associate with each other without the placement of barriers and boundaries, this would be ideal for democracy within the collective. Nonetheless, it should be noted that democracy is a continual struggle for inclusion and exclusion. It is about the opening up of contested spaces where the voice of the other could be heard. The issue of the shared and open subjectivity of the entity within the collective could also be related to the aspect of how Potentia flows within the collective. In Chapter 7, I will elaborate on how such occurrences in subjectivity would promote the

achievement of becoming posthuman which would also address the challenges of the Anthropocene.

In the foregoing paragraph I have looked at how subjectivity could participate in democratic processes within the collective. In this section I am exploring how the same may be achieved through the process of rhizomitisation. The process of rhizomitisation itself is an outcome of the subjectivity. I wish therefore to explore how rhizomitisation would promote democracy within the collective. By rhizomitisation I refer to the uncontrolled and open spreading of agency among entities within a collective. By being uncontrolled and open, the spreading in that way is non-segregatory, random and consequently fair and democratic in the manner in which it supports the development of interlinkages. As the agency is spread, so is the potential and desire to belong together. This links well with the assertion that nature is self-organising and intelligent. The essence of the self-organisation would be that the nature and presence of matter is independent of human intervention. In that case, nature would be regarded as intelligent to the extent that being intelligent is not associated with cognitive ability.

The self-organisation ability of matter and its potential to perform rhizomitisation allows for the recognition of how the collective would be characterised by a becoming minoritarian attitude. This attitude would essentially reject the general view of democracy which declares that the wish of the majority should prevail. Becoming minoritarian implies that the wishes of all should be treated with fairness irrespective of the individual identities and affiliations. The critical question however remains as how this could be achieved. Since it is inevitable that the majority will never voluntarily become minoritarian, the call for democracy cannot be a moral appeal to treat the other alike but rather it is a much more agonistic process triggered by the demands of the excluded, such as the anthropogenic demand of the world to be treated differently. Democratic education of the Life Sciences would then entail listening to the silent voices of the excluded others in the reconfiguration of the collective. In that way, both the minority and the majority would be regarded as categories of entities that have to work with each other. Democracy must be defined more familiarly towards a fairness parameter where all entities would be treated with absolute consideration of what they would basically need in order for them to work fully for the achievement of common good for all entities within the collective. This then confirms the need for the acknowledgement, intensification and expansion of heterogeneous assemblages

within the collective. The heterogeneity of the assemblages essentially gives the indication that the entire collective consists of entities that irrespective of their differences have an open intersubjectivity and prone to unfiltered associations into assemblages. By being able to form wide heterogenous assemblages, the entities share tremendous complementarity in their association.

In this section I have tried to explore how democracy may be articulatable within this theory that is based on critical posthumanism. In this manner it justifies why the theory deserves to be regarded as critical posthumanist and democratic theory. In Chapter 7 I am going to discuss and explain in greater detail using relevant examples of particular scenarios of the teaching and learning of Life Sciences how the application of critical posthumanism would lead to the manifestation of democracy and thus addressing of the challenges of the Anthropocene.

6.4 THE PEDAGOGICAL IMPLICATIONS OF THE CRITICAL POSTHUMANIST APPROACH

In this chapter, I have distilled and synthesised themes that form the background of a critical posthumanist and democratic theory in the teaching and learning of Life Sciences. The main aim behind the themes is to ensure that they may be used to both inform and reform the pedagogical approaches being currently used in Life Sciences. In that case, the parameters of each theme would be integrated in the teaching and learning of the subject. A typical example would be how a theme such as kinship could be used in the planning of the pedagogy of Life Sciences to ensure that the teaching going forward would take cognisance of the proposition that all entities within the environment for instance, should be taught and learnt in a manner that emphasises that they would be akin to each other. Such a view would be very radical in a subject which has been founded on the primary pedagogy that regards the human and the nonhumans as non-related. It is the adoption of such radical approaches to the pedagogy of the subject that would potentially bring to light aspects related to how the human and the nonhuman should be understood as companions so as to both avoid, and also address critical aspects such as the Anthropocene. The pedagogical contributions of each of the themes that make up the critical posthumanist and

democratic approach shall be discussed in Chapter 7. However, what is of critical importance is that each of the themes contributes something towards the realisation of a critical posthumanist and democratic approach, with the central aspect being their synergy on the removal of the boundaries between the human and the nonhuman, from a pedagogical perspective.

6.5 CONCLUSION

In this chapter, the focus was on the development and synthesis of a critical posthumanist and democratic theory. This theory would be used as a theoretical framework to undergird the teaching and learning of Life Sciences in order to address the Anthropocene which will be discussed in Chapter 7. In this chapter, I have explored and synthesised a critical posthumanist and democratic theory in a thematic manner. These themes are the principles of critical posthumanist and democratic pedagogy theory whose application in the teaching and learning of Life Sciences would allow the learners to becoming posthumanist and be in a position to address the challenges of the Anthropocene.

CHAPTER 7: TOWARDS A CRITICAL POSTHUMANIST AND DEMOCRATIC EDUCATION IN LIFE SCIENCES

7.1 INTRODUCTION

In the previous chapter (Chapter 6), I focused on the synthesis and development of a Critical Posthumanist and Democratic Pedagogical Theory (CPDPT). I synthesised this theory from Object Oriented Theory (OOO), Actor-Network Theory (ANT) and Critical Diffractive Pedagogical Theory (CDPT). The theory that I developed has characteristics of both a border pedagogy theory (Romo & Chavez, 2006), a theory that seeks to foster the development of making contextual crossings and connections during learning, with the intention of understanding the other, and also a cyborg pedagogy (Angus, Cook & Evans, 2001; Garoian & Gaudelius, 2001; Gough, 2004; Gough & Gough, 2017) which focuses on how a posthuman body comes to be. The intention of building this theory is to find a pedagogical theoretical tool that may be used in the teaching and learning of Life Sciences so that learners may experience becoming critical posthumanist and democratic in their learning. Once they reach that level, they would then be able to understand with the challenges of the Anthropocene that have both been fuelled and overlooked by the pedagogical approaches in Life Sciences at high school level. Having developed the CPDPT in Chapter 6, in this chapter, I then seek to discuss how it may be adopted, adapted and applied in the teaching and learning of Life Sciences in order to address the challenges that I mentioned above. I do that through using what I have singled out as the key themes of the theory.

Following the Critical Posthumanist and Democratic Pedagogical Theory, the teaching and learning of Life Sciences from a critical pedagogical and democratic approach is going to be analysed from two perspectives viz:

(a) The curriculum perspective

(b) The pedagogical perspective

The curriculum perspective shall focus on how the current curriculum could be re-organised without changing the content so as to achieve a critical pedagogical and

democratic outcome. On the other hand, the pedagogical part focuses on how the re-organised curriculum could be rolled out.

I start the chapter by giving an overview of how the humanist-oriented organisation of Life Sciences curriculum is contributing to the Anthropocene phenomenon currently. Thereafter, I then look at how the adoption of a critical posthumanist and democratic pedagogical approach could address the humanist orientations of the curriculum and the pedagogical approaches. My discussion of the curriculum content is focused on climate change which is related to the climatic change planetary boundary. I cite examples from the South African curriculum.

7.2 A CRITICAL ANALYSIS OF HOW THE CURRENT TEACHING AND LEARNING OF LIFE SCIENCES TEACHING PROMOTES THE ANTHROPOCENE

In this section, I give an overview of how Life Sciences as a school subject is currently organised, taught and learnt in South Africa. I then describe how such an outlook is informed by humanism and as a result tends to promote the acceleration of the Anthropocene. Subsequently, I discuss how the application of the Critical Posthumanist and Democratic Pedagogical Theory through its themes, would bring to light a new way of teaching that would lead to the addressing of the Anthropocene.

As I have just indicated above, my argument is that the Anthropocene as a problem is exacerbated by the manner through which school subjects such as Life Sciences are taught and learnt in schools. This includes the way through which the curriculum is organised, and the ways through which the subject is assessed. It has been reported in the literature that Life Sciences is taught and learnt in a pro-humanist manner (Guosheng,2001; Lynning, 2007; Varela, 2009), which consequently leads to the perpetration of the Anthropocene. Pro-humanist approaches tend to promote the Anthropocene due to their centralisation of human agency ahead of all else within the collective. Before I engage on the path to suggest ways through which it may be transformed from being humanist to being critical posthumanist and democratic, I shall explore how the subject is currently taught, and also what informs such pedagogical decisions. In my exploration of how the subject is taught and learnt I shall use the South African example, I shall engage with The Curriculum and Assessment Policy

Statement (CAPS): Grades 10-12 life sciences (Department of Basic Education, 2011), which is the current curriculum for the subject. I shall also refer to other international science teaching practices such as the inquiry-based approach and the Nature of Science (NOS) since they too contribute towards how the current pedagogical decisions are arrived at locally. From the curriculum document, I extract the information that is illustrated in Table 7.1 below. This information is the one within which aspects of the climatic change planetary boundary are found.

Table 7.1: Curriculum statement on climate change (Department of Basic Education, 2011, p.51)

TOPIC	**CONTENT**
Human Impact on the Environment: Current Crises for Human Survival: Problems to be Solved Within the Next Generation	Causes and consequences of the following (relate to conditions and circumstances in South Africa): • **The atmosphere and climate change** - carbon dioxide emissions; - concept of 'carbon footprint' and the need to reduce the carbon footprint; - deforestation; - greenhouse effect and global warming: desertification, drought and floods; - methane emissions; - ozone depletion.

A general overview of Table 1 above shows that the focus of the curriculum is on the human actions more than anything else. For instance, the topic focuses on the Anthropocene with a particular focus on how humans are geared for survival through their generations. On the right side of the table is the content that has to be covered. A close look at this content also indicates that it is humanistic-oriented. For instance, all the aspects are presented as either effects or consequences of human activities in the process regarding all the nonhuman entities involved as inert and passive. A typical example would be aspects of carbon dioxide and methane emissions which are effects of human activities. The same applies to ozone depletion, deforestation and

global warming. The problem with this presentation and outline of the content in this way, is that by not expressing the events as unfortunate and undesirable effects of human activities, they are actually presented as if they are indispensable and necessary trophies for mankind. In a way, humans are also regarded as if they are victims of these process, yet they are the very perpetrators. In the process, nonhumans are presented as inert objects which are acted upon by the humans. The aspect of them possibly having agency and being able to respond actively to interactions is disregarded. This in essence is a humanist orientation that has to be addressed.

The curriculum further directs the following:

> Knowledge production in science is an ongoing endeavour that usually happens gradually but, occasionally, knowledge and insights take a leap forward as new knowledge, or a new theory, replaces what was previously accepted. As with all knowledge, scientific knowledge changes over time as scientists improve their knowledge and understanding and as people change their views of the world around them. Scientific investigations are mostly about things that are poorly understood or not understood at all. Scientists are frequently involved in debates and disagreements. As more people take on such investigations, they tend to reach consensus about the ways in which the world works. The science theory that is taught in schools has been tested and is generally accepted. A good teacher will inform learners of debates and arguments among the scientists who were the first to investigate a phenomenon (Department of Basic Education, 2010, p.8)

An analysis of the above section from the curriculum indicates that the curriculum is founded on humanist principles. For instance, its emphasis on the scientists being frequently involved in debate confirms the level of centrality that is accorded to the humans in the subject. The debates that are being referred to would most perhaps only involve humans as they discuss the fate of the nonhumans. The same applies to the statement regarding how learners are fed with tested and confirmed knowledge by the teachers implying that the knowledge is static, inert and canonised. The recognition of knowledge as a relational process of becoming (Mcphie & Clarke, 2015) that has materiality and agency is disregarded too. This leaves no space for the

contribution of the other-than-humans in the body of science and in the process opens tremendous opportunities for binary bias.

Similar assertions are discernible from the following expectations that must be achieved following the studying of Life Sciences. By studying and learning about Life Sciences, learners will develop:

- greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind;
- an understanding of the ways in which humans have impacted negatively on the environment and organisms living in it;
- an awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make.

The above statements all indicate that the subject is founded on humanist principles and the role of the non-human-others is obliterated completely. For instance, the analysis of how humans benefit from biotechnology implies that the humans are a central figure in the environment. This has been reported elsewhere in the literature (see Myshak, 2016; Post, 2013; Sharon, 2013).

In terms of pedagogy, the CAPS curriculum emphasises the need for the recognition and adoption of the Nature of Science (NOS) philosophy as a foundation of understanding Life Sciences (Department of Basic Education, 2010) with regard to how “science involves contested knowledge, and non-dogmatic inferences based on evidence and peer review”. (p.22)

The NOS is based on the following tenets:

- Scientific investigations use a variety of methods;
- Scientific knowledge is based on empirical evidence;
- Scientific knowledge is open to revision in light of new evidence;
- Science models, laws, mechanisms, and theories explain natural phenomena;
- Science is a way of knowing;
- Scientific knowledge assumes an order and consistency in natural systems;
- Science is a human endeavour; and

- Science addresses questions about the natural and material world (https://www.nsta.org/nstas-official-positions/nature-science).

A close analysis of these tenets indicate the extent to which they are aligned with humanism. For instance, some of them refer to the centrality of the humans, from producing explanations, to knowing, to science being a human endeavour and, science being based on empiricism. Across all of them, the role of the other-than human is muted completely. The nonhumans are accorded a latent role where they are restricted to objecthood, subalterns solely there for being used by humans.

Regarding the pedagogical approaches used in Life Sciences, one of the key approaches that is highly regarded in the teaching and learning of sciences in South Africa is the inquiry-based approach (Botha, 2016; Department of Basic Education, 2011; Mamombe, Mathabathe & Gaigher, 2019). According to the National Research Council (NRC) (2000, p.25) the following are the major characteristics of the inquiry-based approach:

- Learners are engaged by scientifically oriented questions.
- Learners give priority to evidence.
- Learners formulate explanations from evidence.
- Learners evaluate explanations in the light of alternative explanations.
- Learners communicate and justify proposed explanations.

The inquiry-based approach as represented by its characteristics above appears to humanistic. For instance, its demands for evidence and the engagement with scientifically oriented questions all point towards the central role that is accorded to humans during its application in science. The same applies to its demand for explanations and justifications of such.

7.3 AN APPLICATION OF THE CRITICAL POSTHUMANIST AND DEMOCRATIC PEDAGOGICAL THEORY IN THE TEACHING AND LEARNING OF CLIMATE CHANGE IN LIFE SCIENCES

In the foregoing section I have looked at how the Climate Change section of the Life Sciences curriculum supports humanism, and how this could be re-organised to cater for the equal recognition, and re-connection (Mcphie & Clarke, 2015) of the human and the nonhuman. Having suggested the reorganisation of the topic of climate change, my next mission is now to explore how the topic may be taught in accordance with a critical posthumanist and democratic approach. To achieve this, I have to look at the themes from Chapter 6. The themes are as follows:

(i) Flat ontology
(ii) Entanglement
(iii) Becoming
(iv) Subjectivity
(v) Heterogeneity
(vi) Materialism
(vii) Companionship

The key question to answer in this section pertains to how each of the above themes would be applicable and achievable to the teaching and learning of Climate Change. In doing so, I will give some examples.

7.3.1 Teaching climate change informed by a flat ontology

In the teaching and learning of climate change the application of flat ontology would allow for the human and nonhuman to be regarded as being on par and connected during the various interactions that take place. Along a flat ontological perspective in the teaching and learning of the ozone depletion subsection of climate change for instance, the learners would be in a position to recognise at a microscale as a starting point, the relationship that would be at play between themselves, the teacher, the teaching approach and the concept of ozone depletion itself. This would happen because realising such an ontological position gives the learners the insight that they

would be learning together with many other entities together. As explained by Mcphie and Clarke (2015), the learners would be in a position to realise the embodiment that exists among all the entities human and nonhuman. In that way, they would then potentially arrive at a position to understand that they belong to the same status as the nonhumans such as the teaching approach and the concept of ozone depletion itself. Such realisation is very important in the sense that it removes the learners from the humanist claim of centrality in the environment and places them in a position where they would be able to share materiality with the nonhumans. The humanist boundaries would then start to collapse as the learners become aware of how entangled they are with the nonhuman others. In other words, the learners would be in a position to realise that they would not be learning about ozone depletion but would rather be learning with ozone depletion since all of them would be of the world.

During the teaching and learning of ozone depletion, the teacher could show the learners a video of an industrial zone which is characterised by a hive of activities including air pollution from the factories, among many other activities contributing towards ozone depletion. The teacher could then ask the learners to work in groups and discuss the following question:

> *How does ozone depletion live with the humans and the nonhumans?*

Such a question brings into the focus of the learners that the phenomenon of ozone depletion should not necessarily be looked at from the perspective of the human contribution towards it, in a linear cause and effect manner. It would become clear that the ozone depletion, the human and the nonhuman are all relationally entangled processes that are made of the same material by virtue of all of them being of the earth, and thus of the environment. It would become clear that both the human and the nonhumans might in essence be just humanist creations focused on finding ways through which the humans could gain control of the nonhumans. After each group presentation, a class discussion would ensue. The teacher would ask a question such as:

> *During your discussions what measures did you put in place to ensure that there was no bias in your favour as a human?*

Such a question goes further to force the learners to recognise the potential of bias that could emanate from them during their discussions. The question also has the

capacity to uproot the potential of humanism that might be latent in the discussion. By using such a question, a realisation of the flat ontology of the human and the nonhuman would become unavoidable. The emphasis on a flat ontology would thus also come with a democratic appendage to the pedagogical approach as the human and the nonhuman would be regarded as co-embodied and relational.

In addition to the question that would guide the learning process of the learners, the teacher might have to follow an open inquiry-based approach during which learners would be working with the ozone layer depletion process to explore the various entanglements that would potentially exist. In this study, I am going to add a dimension to the open inquiry-based approach as described by Banchi and Bell (2008). Their description of open inquiry talks of a structured process. It is this structuring that I believe makes it humanistic. This view is alluded to by Edwords (1984) who points at structuring as one of the key characteristics of humanism. I am therefore going to remove the structuring by allowing both the human and the nonhuman to work along with each other following an open inquiry-based approach. Though I am going to leave the cycle intact, the participants within each cycle would be both human and nonhuman. In that case, I leave the responsibility on the human to listen to the contribution of the nonhuman as the inquiry progresses. This agrees with Latour's (2004) description of how humans are forced to listen to the voices of the many others. The inquiry in that way becomes a posthumanist inquiry-based approach in a manner in which as Latour mentions, the excluded would persistently knock on the door of humanity clamouring for recognition which they will get.

In this case, the students would be working with the nonhumans, for instance the atmosphere, through all the stages of the inquiry. As they go through the stages for instance, as the learners ask questions for instance they are forced to listen to the questions being asked by the atmosphere. When they get to communication stage, they should also listen to the communication that would come from the atmosphere. A typical example of communication from the atmosphere include aspect such as drastic weather changes. The same applies when they get to data gathering stage, they should be prepared that the nonhumans might regard them as data too, and thus collect data from them. For instance, as they observe some phenomena during data collection, they should imagine how the nonhumans would be regarding them during the same process. Such an approach has been described by Mcphie (2018) as an it-

narrative. It is based on the recognition of the shared distribution of agency between the human and the nonhuman.

Due to the critical posthumanist emphasis, humans, in this case learners, would not have ready-made tools to use, but would be working together with all the other entities. They would be working together with questions themselves at the question asking phase, with the questions also contributing their views. The open inquiry would therefore be characterised by the diffractive intra-action of all the entities that are involved. The entire inquiry would be characterised by multiple voices that freely contribute. In a turn of events, the curriculum, which is a dominant voice, would be forced to listen to the voices of those entities that it talks about. For instance, the curriculum would be forced to listen to the voices of atmospheric pollution. Beyond the curriculum just stating that learners should describe atmospheric pollution, something which is not normally the case, the voices of the pollutants, and those of the processes involved would all stand tall against the curriculum and demand to be heard beyond being just stated as aspects to be learnt for examination processes. This would be a critical posthumanist and democratic pedagogical approach.

The learning would be an open process characterised by the teacher going beyond the curriculum in order to include the knowledges of the many others. With due cognisance of the fact that there would always be some latent possibilities of exclusion among them, the teacher, the learners, the concepts, the context and everything else would be open to operating together with each other in a situation that is informed by inorganic material agency withinwhich no hierarchisation is permissible. The simplified illustration of these unfiltered interaction and intra-actions is shown in Figure 5 below. The posthumanist inquiry-based approach on ozone depletion would be guided by the following inquiry cycle.

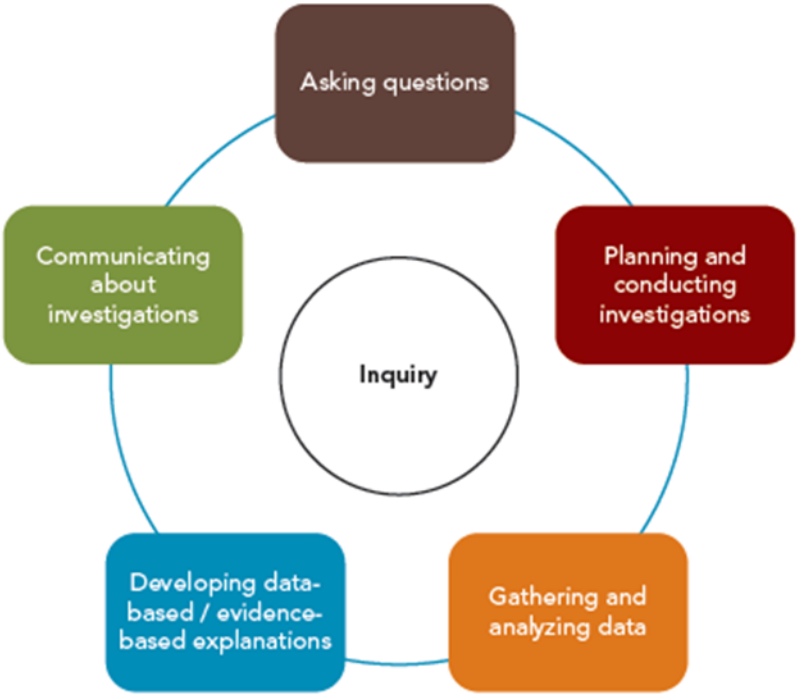

Figure 5: the open inquiry approach on ozone depletion (Contant, Bass, Tweed & Carin, 2018, p.35)

The successful application of the above cycle would be best on the view that instead of asking their own questions, and investigating their own questions a process within which human bias would be difficult to minimise, at each stage, the learners would also engage the nonhumans to get their own contributions regarding that stage. This would potentially show a clear recognition of the flat ontology existing between the human and the nonhuman.

To ensure that the open inquiry is therefore devoid of humanism as I indicated above, and in the best interests of a critical posthumanist and democratic approach, the learners would also listen to the voices of the nonhumans so that they may get their own contributions. For this to be successful, they would have to engage with what Bayley (2018) regards as the performance of the memories of otherness during which process they would extend their materiality and thus invoke a possibility of what Barad (2017) refers to as a response-able science. When this happens, the collective would be characterised by a flat ontology, within which the dermatological and cognitive boundaries (McPhie, 2018) that generally encapsulate being a learner, the very essences of being human learners would begin to leak and spread towards the nonhuman others. The question for this activity shall not be prescribed by the teacher,

that would be left for the learners and their nonhuman companions alluding to Haraway's (2016) view of staying with the trouble during learning. The staying with the trouble is observed as the learners get involved with a new pedagogical approach that tend to be disruptive to their conventional ways of learning. The pedagogy would however come with the recognition of a posthuman partiality that is characterised by a democracy of objects as explained by Mcphie (2018). The role of the teacher meanwhile would be to act as the devil's advocate and occasionally ask questions with the desire for the learners to observe that even during the investigation, there would be an interaction of the human and the nonhumans, and that such interactions would be based on their being ontologically on par with each other. The interaction would be fostered by the shared materiality between the human and the nonhuman.

Having gone through the lesson in an open inquiry in order to experience the flat ontological relationship among the entities, the next task would now be for the teacher to organise an assessment task that would further cement the learners' experience and understanding of flat ontology. A typical task that could be given to learners would be based on discovery learning where they would be tasked to investigate individually how ozone depletion is perpetrated in their own surroundings. The task would emphasise how both the human and the nonhumans participate in ozone depletion. To achieve such a task, learners will be required to work in groups of five members each. Among the five of them, each one would assume one of the following roles: (i) a human body (ii) a factory (iii) temperature (iv) an ozone layer depletion phenomenon (v) capital. I would then ask each one of them to discuss how they feel about the ozone layer depletion phenomenon.

I would then emphasise to the learners that they would have to think and operate beyond being human. In that way, they would have to imagine for instance how it feels to be temperature, or a human body, or even a factory. Such an approach allows the learners to imagine being various nonhuman entities. By assuming such feelings that are unprecedented to them, the learners would have indulged in a cyborg pedagogy within which they cease to operate as pure humans, and they become cybernetic entities (Angus, Cook & Evans, 2001). A question such as:

> *How do we understand ozone depletion if community includes CO_2 and sea life affected by rising ocean temperature?*

potentially pushes the learners into the zone frequented by boundary-less entities. Within such a zone, the human and the nonhuman are connected to each other with connections that are capable of blurring any kind of boundaries in the process transforming learners into material-semiotic cybernetic entities as mentioned by Angus, Cook and Evans (2000):

> It is hard to locate the boundary between the inside and the outside, between self and other, or between the opposites in any of those binaries that often structure the way he thinks. And, so the argument goes, once he starts to look for and to make such connections and blur such boundaries in the process, this should bring new responsibilities: towards the people, animals, environment, machines, etc. who are intimately woven into his life, his body, his self: as he is woven into theirs. (p.197)

The situation whereby the human would assume nonhuman characteristics would go a long way in emphasising the issue that the human/nonhuman dichotomisation is a humanist creation meant to justify human dominance over the nonhumans.

7.3.2 Teaching climate change informed by entanglement

The other key theme that would be of essence in the teaching and learning of climate change would be entanglement. This theme builds on the previous theme that talks about teaching climate change through a flat ontology. Under this theme, in addition to there being a flat ontological assumption, there would also be an entanglement of the entities. The theme in that way has an experiential parameter as a determinant of the relationship among the different entities. The experiential parameter happens when the learners for instance explore the relationship between them and other entities, human and nonhuman. Take for instance the teaching of the concept of global warming, which is an aspect of climate change in the Life Sciences curriculum. The application of entanglement as a theme would bring to light how all the entities within the environment would be entangled with each other as they associate and interact. With respect to the teaching and learning of global warming, which is an aspect of climate change, a key question with which the teacher may start the lesson could be:

How is the global warming phenomenon experienced by a dam?

Such a question is crucial in the exploration of how the human and the nonhuman are entangled in their day-to-day experiences. For instance, the question opens for discussion how human activities such as the release of chlorofluorocarbons lead to the increase of temperature on the earth's surface that would in a perpetual manner lead to increase of temperature of the water in the dam. The increase of the water temperature would in turn affect the productivity of the phytoplankton, and thus affect the entire food chain. In another way, increase in the atmospheric temperature would also lead to increase in the rate of evaporation of the water in the dam, which in a way would reduce the amount of water in the dam in the long run. A clear analysis of all the occurrences that are described above indicate that indeed there would be an entanglement between the human and nonhuman activities to the extent that neither of them would isolate itself. When learners explore such a question, they would in the process imagine all the possible intra-actions that take place within the dam. In that case, they would in a way afford the dam a level of what Marder (2013) regards as non-conscious intentionality. The non-conscious intentionality (Mcphie & Clarke, 2015) would be possible in the sense that there would be an implication of the dam and everything about it responding to the global warming phenomenon. The only way that a nonhuman entity such as dam and all the nonhumans within it could be envisaged as responding to the global warming would imply that they would be capable of possessing some level of consciousness. The accordance of whatever level of non-conscious intentionality to the nonhuman would be a definite move in the direction of critical posthumanism. Learners would develop an understanding that they share some consciousness with nonhumans such as dams, and temperature and water, and all the fish within the dam. In that way, they would experience the manifestation of entanglement with the nonhumans. As elaborated by Marder (2013) this would trigger thinking patterns that are free from essentialism and that would be characterised by fluidity, non-representativity, immanent and outright material-practical.

Such a question as stated above, also highlights the issue that both the human and the nonhuman are entangled not in the environment, but rather with the environment. Entanglement in the environment has the potential to imply a cause and effect relationship between the humans and their environment, while the entanglement with the environment indicate a level of critical togetherness where the human and the

nonhuman (in the form of the environment and the dam) are together with each other within the collective. During the development of these relations global warming is observed. In that manner, learners would be in a position to realise that global warming is an outcome of an entanglement between humans, human activities (of which are nonhuman), materials such as mines, processes such as mining itself, electricity and conveyor belts, and more. Such a view would elaborately open their understanding of global warming as a phenomenon, as they begin to place the human among the various other entities that take place during global warming.

The teacher could use a role modelling pedagogical approach, during which learners assume various roles with some of them acting as the global warming phenomenon, others as humans, while others might act as various other entities. During such a role play entity, each role actor would be tasked with expressing how they feel as such an activity, for instance how they operate. Take for an instance a learner who will be acting as an entity like mining, they would explain how they happen and what comes out of them. On the other hand, a learner acting as carbon dioxide would demonstrate verbally and nonverbally how they emerge during the interactions and how they contribute towards the global warming phenomenon. In order to ensure that all the voices within the collective are given a fair opportunity be heard, some of the learners may be asked to act as the peasant farmers who are located downstream from the mines. These learners would then air their own grievances regarding the problems that they would be facing from the mining activities. During the airing of these complaints, some of the learners would represent the mine owners, who come in to try and suppress the views of all the other entities including the voices of the air that is polluted, the voice of the water that is polluted too, the voices of the peasant farmers and the voices of rain that would become acid rain after combining with the sulphur dioxide that has been released into the atmosphere in the process forming sulphuric acid that flows into rivers and damage the aquatic entities. The important aspect about this pedagogical approach in the teaching and learning of global warming would be its great potential which comes with the humans acting as nonhumans. In this way, it becomes clear that global warming is indeed an entangled phenomenon involving both the humans and the nonhumans to the extent that efforts to address it would need to address both parameters: humans and nonhumans. In another way, learners would

also come to understand the human/nonhuman embodiment of the greenhouse phenomenon.

In order to assess learners' understanding and experiencing of the entanglements associated with global warming, the teacher could give the learners a task to design a poster where they illustrate how different kinds of human and nonhuman entities experience and respond to the global warming phenomenon in an urban ecosystem**.** Such a task might employ some mapwork as that of Mcphie and Clarke (2015) in their fictional walk study. Each learner would be handed a topographic map where they would make a random choice of a part of the map that has both human and nonhuman entities. They should take the grid reference of that place, in accordance with the following question:

A day in the life of a global warming phenomenon at area X.

The letter X would represent the area that they would have chosen on the map.

This essay as abstract as it stands, would play a potentially significant role in the manner in which it would allow the learners to experience global warming in a simulated manner. The topic of the essay has accorded a life status to an entity that in real life would be regarded as lifeless. This is very critical in the sense that it makes explicit the aspect that relations within any environment including the learning environment would be characterised by an exchange of roles due to the dynamics of entanglement. In other words, the fact that the human and the nonhuman are entangled imply that the humans and the nonhumans are hybrids (Chakrabarty, 2003) of each other. In such hybridism, the humans experience how it is to be nonhuman, while the nonhumans also experience how it is to be human. This is the basis of entanglement from which global warming as a phenomenon originates. The learners as a result would during the process of addressing the demands of the essay, vacillate between being human on one hand and being nonhuman on the other. This happens as they imagine themselves being part of a global warming phenomenon to the extent that they would be able to describe and explain the experiences that occur within such a life. As that happens, they would get to interrogate global warming as a phenomenon that is an outcome of the entanglement between the human and the nonhuman. In that way, they would have not only understood but also experienced global warming in a critical posthumanist and democratic manner.

7.3.3 Teaching climate change informed by heterogeneity

I have so far analysed how the emphasis of the presence of a flat ontology and a process of entanglement would be of essence in the teaching and learning of climate change in a critical posthumanist and democratic approach. However, in addition to the recognition of these two themes, I now wish to add another dimension: the presence of heterogeneity as a key characteristic of any environment. In the teaching and learning of climate change, the presence of heterogeneous entities as a driving force should be emphasised. In this case, I am going to use the teaching and learning of the greenhouse effect as an example from the climate change section of the curriculum. The curriculum as indicated in Table 1 above demands the causes and consequences of the greenhouse effect should be explored. Using the heterogeneity of entities as a theme in addressing this section, the teacher should ask a question such as:

> *To what extent is the greenhouse effect an outcome of the interaction of the human and nonhuman entities within the environment?*

In addressing this question, the teacher may come up with a very radical approach to group work. He/she might take his/her class outside into the school yard which has trees, rocks, buildings and so forth. He/She would then ask his/her learners to interact with the nonhumans such as the trees and the rocks and get their views regarding their experiences of global warming. This would most likely appear unreasonable to the learners at first. How would they be expected to interact with nonhumans that cannot speak in the first place? This would be awkward to the learners. The teacher would have won the day; the learners would be forced to reduce themselves to the same level as the rocks for instance, at least ontologically. Once they reach such a level, they would then be in a position to map out a language that they could use to converse with their new companions. This is when they have to adopt a cyborg pedagogy characterised by a cyborg ontology that would illuminate on them to establish their relations with the nonhuman others (Angus, Cook & Evans, 2001). The learners would be put in a position wherein they have to listen to the nonhumans speak. For instance, in their interaction with rocks, they would be able to see how the rocks would be showing signs of exfoliation, with pieces of rock on the ground, and the rock also peeling off in layers. A closer look would allow the learners to be

cognisant of how through showing such evidence of exfoliation, the rock would be talking to them, revealing the effects of repeated and alternating temperature changes that they would be experiencing as a result of global warming and the greenhouse effect. This would be a rock speaking straight to the learners, a manifestation of cyborg pedagogy and its posthumanist undertones.

As part of their assessment the teacher would perhaps ask the learners to go back to that part of their school yard every day for the next two weeks and in the process journal their conversations with the stones and trees and other nonhuman companions. This is what has been regarded as a materialist turn in pedagogy (Bozalek & Zembylas, 2017; Juelskjær, 2020; Reddington & Price, 2018). The learners would have developed a kinship with the trees, rocks and all the other nonhuman others in their attempt to follow a critical posthumanist understanding of climate change. The humanist approach to understanding climate change would be repealed and in the words of Bayley (2018) it would be undone.

This task would require each learner to make a journal entry every day on their conversation with the nonhuman others regarding their experiences of the greenhouse effect. In their submissions the learners would be free to use cartoons or any other illustrations to show how the human and the nonhuman would work alongside each other and, in that manner, cause the greenhouse effect. The journaling activity would most likely appear very complicated for the learners at the beginning since they would have to stretch their imaginations and think about being the other. Nonetheless, as time progresses chances are, they would get into a position whereby they would understand and experience the transactions taking place between the human and nonhuman factors within the collective as they cause the onset of the greenhouse effect. In that way, the learners' understanding of the greenhouse effect would be expanded and transformed from a humanist perspective towards a critical posthumanistic perspective. By understanding the significance of the nonhumans in the occurrence of the greenhouse effect, they would be able to also think abstractly about how the phenomenon may be addressed.

7.3.4 Teaching climate change informed by subjectivity

The other theme that I am going to explore here that needs to be addressed in the teaching and learning of Life Sciences to achieve critical posthuman and democratic outcomes is subjectivity. Using Braidotti's (2006) views, subjectivity is associated with and characterised by a combination of heterogeneity, openness and diversity. She says that subjectivity is "a cluster of complex and intensive … assemblages which connect and interrelate in a variety of ways" (p.16)

Augmenting to the same characteristics as Braidotti above, Hayles (1999) has described it as an:

> …amalgam, a collection of heterogeneous components, a material-informational entity whose boundaries undergo continuous construction and reconstruction. (p.3)

In the teaching and learning of Life Sciences, an understanding of subjectivity would allow learners to understand how they relate to climate change as a phenomenon to the extent that they would have to extend their humanity into a posthumanist form so that they might be able to engage with the climate change aspects such drought. Drought in this case should not be understood from a human perspective. Rather, it should be understood as a long period of no water. It affects both the human and the nonhuman. For instance, drought is associated with very high temperatures that would lead to the death of animals and plants. It would also lead to the development of dust storms that would have long term effects across the globe. A typical removal of boundaries under climate change would be for instance between how humans and nonhumans relate to each other in the understanding of the causes and consequences of drought, for instance. Using the understanding of subjectivity that has been developed in this thesis, the teacher may ask questions such as:

> *Discuss the life of a drought including how it could survive both the human and the nonhumans.*

Such a question brings in a critical aspect that regards a drought as a living entity. This may be new to the learners, since they generally regard drought as a non-living phenomenon. The question further brings into focus how the human and the nonhumans subjectively relate to each other as they share lives with a drought

phenomenon. It brings about a posthuman subjectivity parameter that is characterised by the combination of multisource subjectivities that would tend to explain the occurrence of drought as a phenomenon. As such, it would allow for the development of an understanding that drought as a phenomenon should not necessarily be attributed to either the human or the nonhuman, but rather should be understood as a phenomenon that has footprints from both of them, and that it is an entity in the same manner that both the human and the nonhuman are entities too. As a follow-up question, the teacher might also pose the following question:

How could the human and the nonhuman work together to address drought?

Such a follow-up question has the importance of emphasising the aspect that the human and the nonhuman do not only contribute towards drought in their different ways, but they could actually work together with the drought aspect. The question brings in aspects of the material linkages that would exist between the human and the nonhuman, and the importance of harnessing such materiality in order to address the problem at hand. In such a case, subjectivity would therefore bring to surface the potential companionship that exists between the human and the nonhuman, and in this manner enable the learners to understand how to relate and operate along with nonhuman phenomena. In that case, subjectivity could be regarded as a precursor to entanglement but nonetheless, it would be important in its own right especially due to its emphasis of how entities' experiences would be subjective to the experiences of other entities.

In the teaching and learning of Life Sciences, subjectivity therefore creates a zone of commonality for instance between different objects for instance humans and naturals phenomena. In that way, it would allow the learners more opportunity to explore the dynamics of the droughts. Due to its creation of a zone of commonality and convergency, it would permit a close analysis of how the commonality may be restored in cases of transgression, and how it may be preserved.

In some way, subjectivity allows for the application of theories such as Bogost's (2012) alien phenomenology into the planning of the teaching and learning of Life Sciences. Due to its creation of a buffer zone of workable space between seemingly different entities, it would essentially allow the different entities to experience each other's phenomena and consequently avoid the disruption of each other's operations. For

instance, subjectivity would allow learners to hypothesise what it would mean to be part of a drought phenomenon in their exploration of droughts as an aspect of climate change. Such hypothesising which has been referred to as alien phenomenology by Ian Bogost is what might be essential in the addressing of the transgression of complex planetary boundaries such as Climatic Change Planetary Boundary. I argue therefore that subjectivity allows for the development of equivocality which as explained by Neill and Rose (2007) promotes the acceptance of ambiguity and tolerates difference and complexity during interaction. In that way, subjectivity promotes the development of heterogeneous assemblages and illuminate how those assemblages tend to experience an implosion of exchanges among the individual entities forming the assemblages, in the process expanding their networks in a rhizomatic matter as suggested by Deleuze and Guattari (1987). In essence therefore, the teaching and learning of Life Sciences needs to follow a subjective pattern so as to afford vitality to all the entities, and thus bring democracy to all the entities within the collective since their entanglement with the other entities would not be predetermined by other reasons which might overshadow the aspect that their being is determined by their interactions and intra-actions. The teacher should consider assessment approaches that lead to discovery learning by the learners to achieve these possible rewards through adopting an open attitude in the teaching and learning Life Sciences. A typical example of such a task would start with a teacher providing a minimum background of a drought phenomenon. Following that the teacher would give a project to the learners to work in pairs. A typical question would be:

> *Carry out a project to assess the impact of drought on both the humans and the nonhumans. Suggest ways of how both of them could be saved from the effects of drought.*

A task such as this one would allow the learners to observe that drought indeed affects both the human and the nonhuman. To that extent, they would be able to notice by carrying out their task, the manner in which both the human and the nonhuman are subjective to the effects of drought. In that case, they would understand the drought phenomenon in a critical posthumanist and democratic manner.

7.3.5 Teaching climate change informed by materialism

The other critical theme that has to be used in this study is materialism. As discussed in the study, materialism emphasises the entanglement of all entities irrespective of them being human or nonhuman. It is based on the assumption that all entities are basically matter in form. The recognition of all entities as being matter is important in the sense that it open avenues for all entities to work and link with each other. It is this assumption that allows it to link the entities that would normally be regarded as mutually exclusive. In the teaching and learning of climate change, an exemplary issue that has to be discussed could be the issue of how the human and the nonhuman entities are materially entangled together leading to the onset of the greenhouse phenomenon. Applying the theme on the teaching and learning of the greenhouse effect, a teacher could pose a question such as:

> *Analyse the material linkages between the human and the nonhuman that influence the development of the greenhouse effect phenomenon.*

During the undertaking of such a task, learners would come to experience how the greenhouse phenomenon is a combination of the materialities of unscrupulous industrial and land use patterns by mankind. The materialities would be of both the human and the nonhuman as they interact. The ultimate result is the release of unwanted gases into the atmosphere as a result of the disturbances in their cycle patterns. From a new materialist perspective, the teaching and learning of the greenhouse phenomenon would emphasise that there is a materialist connection between the human and the nonhuman as they co-exist within the environment. The teacher could ask a further question such as:

> *Explain how the material connection between the human and the nonhuman agencies accentuate the greenhouse effect.*

Such a task could make the learners understand that due to the materiality that the human and the nonhuman share, they therefore share some agency among them.
In the discussion regarding the greenhouse effect, the effect should itself be considered to have agency, the same agency that it would pass on through its effects

when it affects the atmospheric conditions. This is related to the other dimension of materialism which focuses on the vibrancy of matter (Bennett, 2010) which assumes that due to the possession of potential agency, matter is vibrant and intelligent due to its ability to self-organise. In this study, the issue to address would then regard how the vibrancy and intelligence of matter could be integrated and applied in the teaching and learning of climate change. I argue that the recognition of the vibrancy and intelligence of matter would lead to the rejection of the broadly humanism-based approaches that confine vibrancy to animate and mostly humans animals. An assessment task based on the discussion of the vibrancy of matter could be led by the following question:

> *With the aid of diagrams discuss how the intelligence of both human and nonhumans could be used to explain the concept of carbon footprint.*

Such a question without explaining that it refers to the humans and nonhumans in their general material form forces the learners to think deeply about how nonhumans could be intelligent as well. This would make them realise that intelligence is not confined to the humans, but rather like all other forms of agency, would be distributable across all the entities within the environment. Further to that, the learners would be able to pick up that the carbon footprint as an entity in its own right, would be composed of both the human and the nonhuman entities that would be entangled together and sharing various episodes of intelligibility. By gaining such an understanding, the learners would have understood the concept of the carbon footprint from a critical posthumanist perspective.

A critical aspect that has to be managed to make it explicit to the learners would be how irrespective of the intelligence of the nonhuman matter, humans have apparently used language to subdue the nonhumans. However, on the contrary, the nonhumans have a way to respond. In the teaching and learning of climate change a typical example would about the effect of the pumping of carbon dioxide into the atmosphere, and how the atmosphere being both vibrant and intelligent a matter as suggested by Bennet, has responded, resulting for instance in the manifestation of the global warming phenomena. Learners should be asked questions such as:

How does the atmosphere respond to the action of humans when they release carbon dioxide into the atmosphere?

Such a question places the humans and the nonhumans on par in terms of the ability to act and to react to each other. This would indeed be a result of their vibrancy and intelligence. By addressing such a question, the learners would understand the essence of the intelligibility and vibrancy of matter to the extent that they would begin to realise that it is not only humans that have the ability to respond, but that nonhumans could do the same. This has the potential to make the learners understand the depth of the materiality of the humans and nonhumans as they co-operate materially within the environment.

7.3.6 Teaching climate change through the microphysics of becoming

Another critical theme that needs to be discussed is what Deleuze and Guattari (1988) refer to as the microphysics of becoming. The microphysics of becoming is a hyper-imaginative space that asks for the envisioning of a commonly shared being and space that exists between and among all the entities, irrespective of their origin or nature. Regarding the teaching and learning of climate change the concept of becoming allows the learners to imaginatively engage with the concept. By experiencing a theme of becoming, the learners would be able to commute among the various roles that exist during climatic change phenomena as drought, from the causes to the consequences. By being able to assume such diverse roles, they would be able to fully understand and be conversant with what it means to be a drought. The learners would be in a position to imagine themselves as a part of the drought and in the process, they would become entangled with its becoming and thus experience it. The teacher could ask a question such as:

What does becoming a drought imply for both the human and the nonhuman?

When they address such a question, the learners would mostly engage in discovery learning where they would engage deeply with their imagination. Through an analysis of becoming a drought, they would explore the experiences of both the human and the

nonhuman, in the process commuting between the two roles as making connections as they do. Such a deep level of understanding might have the potential for learners to be able to fully understand the drought as a phenomenon that has both human and nonhuman parameters. As such, it will also give them an opportunity to idealise solutions to the phenomenon in terms of human and nonhuman parameters.

The other key theme that warrants a discussion regarding its applicability in this study is companionship. Companionship is based on the view that all the entities within the collective could possibly be in some friendship and relationship with each other. The companionship theme rejects the human assumption that nonhumans are passive and inert. As discussed in this thesis, companionship assumes that both humans and nonhumans have an equal significance within the environment and actually depend on each other. In other words, they depend on each other and share a lot of things.

The implications of this theme from a pedagogical perspective is that as learners are engaged with learning the concept for instance of methane emissions, they would need to analyse the companionship trends that would be in existence and how they relate to both the human and the nonhuman. To bring to light these dynamics, the teacher may give the learners a case study of methane emission from an industrial area near their home. The learners would then be required to journal the companionship trends between the human and the nonhuman entities within a period of a month. The activity might be guided by the following question:

> *Imagine a fertilizer factory near your home emits a lot of methane into the atmosphere. Over a period of a month make a journal entry every day of the companionship trends between the human and the nonhuman as this happens.*
>
> *After completing the journaling answer the following question:*
>
> *Evaluate the companionship between humans and nonhumans with regard to desertification.*

The nature of this task makes it quite clear that there is a companionship that exists between the human and nonhumans. The assumed knowledge is that learners are aware that the emission of methane into the atmosphere causes air pollution. What the task seeks to achieve is that there exists companionship between the human and the nonhuman in terms of both the release of methane and the consequences

associated with that very release. Through the journaling activity, the learners would be assuming the roles of both the humans and the nonhumans; they see themselves being the rising temperature due to the pollution, the diseases that are caused by the emissions and also as humans who need to be productive through producing methane commercially. At the end of the day, their learning of the emission of methane would be embodied with many other entities. They would then be able to see that it is beyond the humanist view of simply seeing it as an industrial affluent. They would be able to navigate the relationship between some many aspects, human and nonhuman. From the government policy on environmental pollution, to how methane combines with other gases and flow into review causing water pollution, to the climate change that would be caused by very industrial activity that seeks to enhance human life. In that case, a simple case on the emission of methane into the atmosphere would become an embodied activity that is determined in various ways by the entanglement between human and nonhuman.

The teacher could give a follow up task with the following question:

> *How would you use the companionship between the human and the nonhuman to address the emission of methane into the atmosphere?*

This follow up question would now wish to open the learners' thinking to address how the emission of methane into the atmosphere could be addressed in a critical posthumanist manner through which both the human and the nonhuman would work towards a solution together.

7.4 CONCLUSION

The problem that this study wanted to address was the humanist orientation of the organisation, teaching and learning of Life Sciences in South Africa. The argument behind the problem is that this humanist orientation has the potential to contribute to the Anthropocene. The humanist orientation in the subject fosters the human/nonhuman dichotomisation scale in favour of the humans. By doing that, all the subjugated humans and the nonhumans are regarded as subalterns (Spivak, 1988). As a result of this humanist orientation, and the consequent inferiorisation of the nonhumans, the approach used in Life Sciences has a restricted view of

democracy that only considers the interests of the humans. It is this restricted view of democracy that has the potential to cause the Anthropocene. I therefore throughout the study sought to find a way of expanding the view of democracy that is used in the Life Sciences so that it also includes the nonhumans. This is the basis of my critical posthumanist approach that I synthesised.

In the study I developed a critical posthumanist and democratic pedagogical theory that could be used in the teaching and learning of Life Sciences. The need for such an approach was for such teaching and learning to address the Anthropocene. Throughout the chapters from chapter 2 to chapter 5, I was extracting themes from each of the chapters, and used those extracted themes to develop a pedagogical theory. However, when I got to Chapter 6 where I had to synthesise all the extracted themes into a single coherent theory, I realised that there was some overlap in some of the themes. To deal with the overlaps, I had to group all the related themes into one broader theme. Consequently, I ended with only six themes viz:

(i) flat ontology

(ii) entanglement

(iii) heterogeneity

(iv) subjectivity

(v) materialism

(vi) microphysics of becoming

My discussion of the application of the critical posthumanist and democratic pedagogical theory in the teaching and learning of Life Sciences has therefore been based on the application of each of these six themes which make the foundation of the theory.

In this chapter, I have looked at how the Critical Pedagogical and Democratic Pedagogical Theory could be applied in the teaching and learning of the climate change section from the Life Sciences curriculum in South Africa. To achieve this, I used the themes that I developed in Chapter 6 as the yardsticks to implement the theory. As such, the work covered in Chapter 6 sought to address the sub-question:

What is critical posthumanism?

Chapter 6 has been synthesised from the themes extracted from Chapter 3, Chapter 4 and Chapter 5 are in the process of synergising a critical posthumanist and democratic pedagogical theory.

In chapter 6 I also addressed the sub-question:

> *How could a critical and democratic pedagogy be developed in the life sciences?*

I answered this question through referring to Latour's concept of due process. Applying this process, I then maneuvered a way through which I could introduce democracy into a critical posthumanist theory.

In chapter 7, I then dealt with the sub-question:

> *How does posthumanist democracy address the problematic of the Anthropocene?*

This sub-question is key to answering the main question:

> *How could a critical and democratic posthumanist pedagogy in the Life Sciences address the devastating effects of the Anthropocene?*

I addressed both of them in Chapter 7. I used the themes that I derived from Chapter 6 to address these questions. The main themes that came out of Chapter 6 that I used in Chapter 7 include flat ontology, entanglement, heterogeneity, subjectivity, materialism and microphysics of becoming. The discussion of all the themes was based on the Climate Change section of the CAPS Life Sciences curriculum of South Africa. Following that section of the curriculum I discussed how the sections of the curriculum could be taught in a critical posthumanist and democratic manner in order to address the Anthropocene. The discussion of the application of each theme was accompanied by examples of a pedagogical approach that would be informed by critical posthumanist and democratic approaches. In each case, the pedagogical approaches would emphasise the entanglement between the human and the nonhuman, and the extent to which the approach would promote the accordance of a fair opportunity for all the voices to be heard.

Throughout this chapter, the emphasis was on how both the human and the nonhuman could be regarded as being ontologically on par and with affinity for each other. To

that extent, democracy would be experienced in the manner in which the content could be taught and understood. On the other hand, the placing of the human and the nonhuman on par would form a foundation of critical posthumanism of which is what is needed to address the Anthropocene that is commonplace in the manner in which Life Sciences as a subject is taught. By placing the human and the nonhuman as ontological equals, the manner through which the subject is taught is re-invented to follow a critical posthumanist and democratic approach. It is this approach that has the potential to address the Anthropocene.

REFERENCES

AAAS. (1989). *Project 2061: Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

Abd-El-Khalick, F., & Lederman, N.G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22, 665-701.

Abram, D. (1996). *The spell of the sensuous: Language and perception in a more than human world*. Pantheon: New York.

Abramson, D. M., & Redlener, I. (2012). Hurricane Sandy: lessons learned, again. *Disaster medicine and public health preparedness*, 6(4), 328-329.

Afroz, R., Hassan, M. N., & Ibrahim, N. A. (2003). Review of air pollution and health impacts in Malaysia. *Environmental research*, 92(2), 71-77.

Agnihotri, R., & Dutta, K. (2013). *Anthropogenic Climate Change: Observed Facts, Projected Vulnerabilities and Knowledge Gaps*. In R. Sinha & Ravindra (Eds.), *Earth System Processes and Disaster Management* (pp. 123-137). Berlin: Springer.

Aikenhead, G.S. (1994). The social contract of science: Implications for teaching science. In J. Solomon & G. Aikenhead (Eds.), *STS education: International perspectives on reform*. New York: Teachers College Press, pp. 11-20.

Aikenhead, G. S. (2006). *Science education for everyday life: evidence-based practice*. New York: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education* (pp. 881-910). London: Lawrence Erlbaum Associates.

Alaimo, S. (2014) Thinking as the stuff of the world. O-Zone: *A Journal of Object-Oriented Studies*, 1.

Aliakbari, M., & Faraji, E. (2011). Basic principles of critical pedagogy. *2nd International Conference on Humanities, Historical and Social Sciences IPEDR 17 (2011) IACSIT Press, Singapore.*

Aloni, N. (2013). Empowering dialogues in humanistic education. *Educational Philosophy and Theory*, *45*(10), 1067-1081.

Anderson, A.B. (Ed.). (1990). *Alternatives to deforestation: Steps toward sustainable use of the Amazon Rain Forest.* New York: Columbia University Press.

Anderson Ravindran, N. (2019). *Exploring Posthuman Conundrums and Policy Recommendations for Fostering Peaceful Co-Existence With Sapio-Sentient Intelligences* (Doctoral dissertation).

Anderson, R. D., & Helms, J. V. (2001). The ideal of standards and the reality of schools: Needed research. *Journal of research in science teaching*, 38(1), 3-16.

Anderson, D. M., Burkholder, J. M., Cochlan, W. P., Glibert, P. M., Gobler, C. J., Heil, C. A., ... & Trainer, V. L. (2008). Harmful algal blooms and eutrophication: examining linkages from selected coastal regions of the United States. *Harmful Algae*, 8(1), 39-53.

Andrady, A. L., Aucamp, P. J., Austin, A. T., Bais, A. F., Ballare, C. L., Bjorn, L. O., ... & de Gruijl, F. R. (2012). Environmental effects of ozone depletion and its interactions with climate change progress report, 2011. *Photochemical and Photobiological Sciences*, 11 (1), 13-27.

Angus, T., Cook, I., & Evans, J. (2001). A manifesto for cyborg pedagogy?. *International Research in Geographical and Environmental Education*, 10(2), 195-201.

Apple, M. W. (2006). 'Critical education, politics and the real world. In L.Weis, C.McCarthy & G. Dimitriades (Eds.), *Ideology, curriculum, and the new sociology of education: revisiting the work of Michael Apple*. New York: Routledge.

Ares, N. (2006). Political aims and classroom dynamics: Generative processes in classroom communities. *Radical Pedagogy*, 8 (2): 12-20.

Arora, M., Casas-Mulet, R., Costelloe, J. F., Peterson, T. J., McCluskey, A. H., & Stewardson, M. J. (2017). *Impacts of Hydrological Alterations on Water Quality.* In A. Horn, A. Webb, M. Stewardson, B. Richter & M. Acreman (Eds.), *Water for the Environment* (pp. 101-126). London: Academic Press.

Åsberg, C., & Neimanis, A. (2013). Bodies of the Now: Feminist Values in Posthuman Times. *Full text of talk given at Visions of the NOW: Stockholm Festival for Art & Technology*.

Asenbaum, H. (2020). The politics of becoming: Disidentification as radical democratic practice. *European Journal of Social Theory*, 1368431020935781.

Ashley, M. J. (1989). *Ideologies and schooling in South Africa*. Rondebosch: Sata.

Ashmore, M., Wooffitt, R., & Harding, S. (1994). Humans and others, agents and things. *American Behavioral Scientist*, 37(6), 733-740.

Atkin, M., & Helms, J. (1993). Getting serious about priorities in science education. *Studies in Science Education, 2I*, 1-20.

Austin, M., Ennis, P. J., Gironi, F., Gokey, T., & Jackson, R. (2013) (Eds.), *Speculations IV: A Journal of Speculative Realism*. Brooklyn: Punctum books.

Badat, S., & Sayed, Y. (2014). Post-1994 South African education: The challenge of social justice. *The ANNALS of the American Academy of Political and Social Science*, *652*(1), 127-148.

Baldwin, M. P., Dameris, M., & Shepherd, T. G. (2007). How will the stratosphere affect climate change? *Science*, 316(5831), 1576-1577.

Baldwin, A, & Erickson, B. (2020). Introduction: Whiteness, Coloniality, and the Anthropocene. *Environment and Planning D: Society and Space* 38, 3–11.

Balibar, E. (1997). *Spinoza: From individuality to transindividuality*. Delft: Eburon.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and children*, 46(2), 26-29.

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of women in culture and society*, *28*(3), 801-831.

Barad, K. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. Durham: Duke University Press.

Barad, K. (2012). Thinking with intra-action. In A. Y. Jackson & L. Mazzei (Eds.), *Thinking with theory in qualitative research. Viewing data across multiple perspectives* (pp.118-136). New York: Routledge.

Barad, K. (2014). Diffracting diffraction: Cutting together-apart. *Parallax*, 20(3), 168-187.

Barnosky, A. D., Matzke, N., Tomiya, S., Wogan, G. O., Swartz, B., Quental, T. B., ... & Mersey, B. (2011). Has the Earth's sixth mass extinction already arrived? *Nature*, 471(7336), 51-57.

Barton A., Hales B., Waldbusser G. G., Langdon C.& Feely R. A. (2012) The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. *Limnol. Oceanogr*. 57(3), 698-710.

Bauer, A.M., & Ellis, E.C. (2018). The Anthropocene Divide. *Current Anthropology*, 59 (2), 209–227.

Bayley, A. (2018). Posthumanism, decoloniality and re-imagining pedagogy. *Parallax*, 24, 243-253.

Bengtsson, S. (2018).'*Ethics exists in communication: Human-machine ethics beyond the Actor-Network',* Media[at]LSE Working Paper Series, London School of Economics.

Bevilaqua F, Giannetto E (1998) The history of physics and European physics education. In: Fraser BJ, Tobin KG (Eds.), *International handbook of science education*. Kluwer Academic Publishers, pp 981–999

Bennett, J. (2010). *Vibrant matter: A political ecology of things*. Durham: Duke University Press.

Benton, M. J., & Twitchett, R. J. (2003). How to kill (almost) all life: the end-Permian extinction event. *Trends in Ecology & Evolution*, 18(7), 358-365.

Berggren, W. A. (1998). The Cenozoic Era: Lyellian (chrono) stratigraphy and nomenclatural reform at the millennium. *Geological Society, London, Special Publications*, 143(1), 111-132.

Berkowitz, M. H. (1975). *A humanistic philosophy of education as applied to the teaching of an introductory psychology course*. Masters' Thesis. Massachusetts: University of Massachusetts.

Berlin, I. (1969). *Four Essays on Liberty.* Oxford: Oxford University Press.

Bhattacharya, R., Pal, S., Biswas, G., Karmakar, S., & Banik, R. (2012). An estimation of heat stress in tropics. *Int J Eng Sci Tech*, 4(10), 4302-7.

Blackburn, J. (2000). Understanding Paulo Freire: Reflections on the origins, concepts, and possible pitfalls of his educational approach. *Community Development Journal,* 35(1), 3-15.

Blackham, H.J.(1965). *Objections to Humanism*. London: Penguin.

Bledin, J., & Shewmake, S. (2004). Research programs, model-building and actor-network-theory: Reassessing the case of the Leontief Paradox. *Journal of Economic Methodology*, 11(4), 455-476.

Blok, A., & Jensen, T. E. (2011). *Bruno Latour: Hybrid thoughts in a hybrid world*. London: Routledge.

Bloomfield, B. P., & Vurdubakis, T. (1997), Paper traces: inscribing organizations and information technology. In B. Bloomfield, R. Coombs, D. Knights & D. Littler (Eds.), *Information technology and organizations: strategies, networks, and integration* (pp. 85-111). Oxford: Oxford University Press.

Blyth, C., & Meiring, R. (2018). A posthumanist approach to environmental education in South Africa: implications for teachers, teacher development, and teacher training programs. *Teacher Development*, 22(1), 105-122.

Bobbio, N. (1987). *The future of democracy: a defence of the rules of the game*. Minneapolis: University of Minnesota Press.

Bogost, I. (2012). *Alien phenomenology, or, what it's like to be a thing*. Minnesota: University of Minnesota Press.

Bohman, J. (2001). Critical Theory: Frankfurt School. In N. J. S. B. Baltes (Ed.), *International Encyclopaedia of the Social & Behavioral Sciences* (pp. 2986-2990). Oxford: Pergamon.

Bolter, J. D. (2016). Posthumanism. In K. B, Jensen, R. T. Craig, J. D. Pooley & E. W. Rothenbuhler (Eds.), *The International Encyclopaedia of Communication Theory and Philosophy* (pp.1-8). Hoboken: John Wiley & Sons Inc.

Bostic, H. (2016).“The Humanities Must Engage Global Grand Challenges.” *Chronicle of Higher Education*. (2016, March 30). Retrieved from https://www.chronicle.com/article/the-humanities-must-engage-global-grand-challenges/

Bostic, H., and M. Howey. 2017.“The Anthropocene Needs the Liberal Arts.” *Anthropocene* 18, 105–110.

Botes, A. (2002). Concept analysis: Some limitations and possible solutions. Curationis, 25(3), 23-27.

Botha, R. J. (2016). Inquiry-based learning: improving South African schools. *Journal of Sociology and Social Anthropology*, 7(2), 76-83.

Boussebaa, M., & Morgan, G. (2014). Pushing the frontiers of critical international business studies: the multinational as a neo-imperial space. *Critical perspectives on international business*. 10(1/2), 96-106.

Bouwer, L. M. (2012). Projections of future extreme weather losses under changes in climate and exposure. *Risk Analysis*, 33(5), 915-930.

Bowles, S., & Gintis, H. (1976). *Schooling in capitalist America* (Vol. 57). New York: Basic Books.

Bozalek, V., & Zembylas, M. (2017). Towards a response-able pedagogy across higher education institutions in post-apartheid South Africa: An ethico-political analysis. *Education as Change*, 21(2), 62-85.

Braidotti, R. (2006). Posthuman, all too human: Towards a new process ontology. *Theory, culture & society*, 23(7-8), 197-208.

Braidotti, R. (2013). Posthuman humanities. *European Educational Research Journal*, 12(1), 1-19.

Braidotti, R. (2018). *The posthuman*. Cambridge: Polity Press.

Braidotti, R. (2017). Critical Posthuman Knowledges. *South Atlantic Quarterly*, 116(1), 83-96.

Braidotti, R. (2019). A theoretical framework for the critical posthumanities. *Theory, Culture & Society*, 36(6), 31–61.

Bray, W. (2000). *Human Rights in Education*. Pretoria: Centre for Education, Law and Policy (CELP).

Broer, T., Nieboer, A. P., & Bal, R. A. (2010). Opening the black box of quality improvement collaboratives: an Actor-Network theory approach. *BMC Health Services Research*, 10(1), 1-9.

Brondizio, E. S., O'Brien, K., Bai, X., Biermann, F., Steffen, W., Berkhout, F., ... & Chen, C. T. A. (2016). Re-conceptualizing the Anthropocene: A call for collaboration. *Global Environmental Change*, 39, 318-327.

Brown, L. R. (2007). *Water tables falling and rivers running dry*. Washington DC: Earth Policy Institute.

Brown, L. R., & Halweil, B. (1998). China's water shortage could shake world food security. *World watch*, 11(4), 10-21.

Brown, S. D. (2002). Michel Serres: Science, translation and the logic of the parasite. *Theory, culture & society*, 19(3), 1-27.

Brown, F.H., Nash, B.P., Fernandez, D.P., Merrick, H.V., Thomas, R.J. (2013). Geochemical composition of source obsidians from Kenya. *J. Archaeol*. *Sci*. 40, 3233–3251.

Bryant, L.R. (2011). *The Democracy of Objects.* Michigan: Open Humanities Press.

Burns, N., & Grove, S. K. (1993). The practice of nursing research. *Conduct, critique & utilization*. St. Louis: Elsevier Saunders

Butchart, S. H., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P., Almond, R. E., ... & Carpenter, K. E. (2010). Global biodiversity: indicators of recent declines. *Science*, 328(5982), 1164-1168.

Butler, J. (2016). *Frames of war: When is life grievable?* London: Verso Books.

Buytaert, W., Célleri, R., de Bièvre, B., Cisneros, F., Wyseure, G., Deckers, J., & Hofstede, R. (2006). Human impact on the hydrology of the Andean páramos. *Earth-Science Reviews*, 79(1-2), 53-72.

Callon, M. (1984). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. *The sociological review*, 32(1_suppl), 196-233.

Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and fishermen of St. Brieuc Bay. In M. Callon & J. Law (Eds.), *Power, Action, Belief A New Sociology of Knowledge?* (pp.196-233). London: Routledge & Kegan Paul.

Callon, M. (1991). *Techno-economic network and irreversibility.* In J. Law (Ed.), A sociology of monsters: Essays on power, technology and domination (pp. 132–161). New York: Routledge.

Callon, M. (1993) (Lecture). “Social ordering”. *University of Illinois, 7 May. Urbana-Champaign, IL*.

Callon, M. (2007). Some elements of a sociology of translation. *The Politics of Interventions*, 57-78.

Callon, M., & Latour, B. (1981). Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so. In K.C. Knorr & A. Cicourel (Eds.), *Advances in social theory and methodology: Toward an integration of micro-and macro-sociologies* (pp. 225-205). London: Routledge & Kegan Paul.

Callon, M., & Law, J. (1982). On interests and their transformation: enrolment and counter-enrolment. *Social studies of science*, 12(4), 615-625.

Carey, J. (1997). “A republic, if you can keep it”: Liberty and public life in the age of Glasnost. In E.S. Munson & C. A. Warren, (Eds.), *James Carey: A critical reader* (pp. 207-227). Minneapolis: University of Minnesota Press.

Castree, N. (2014). The Anthropocene and the environmental humanities: extending the conversation. *Environmental Humanities*, 5(1), 233-260.

Castree, N. (2016). Anthropocene and planetary boundaries. In D. Richardson, N, Castree, M.F. Goodchild, A. Kobayashi, W. Liu & R. A. Marston (Eds.), *International Encyclopaedia of Geography: People, the Earth, Environment and Technology*. Oxford: John Wiley & Sons.

Chakrabarty, A. M. (2003). Crossing species boundaries and making human-nonhuman hybrids: Moral and legal ramifications. *American Journal of Bioethics*, 3(3), 20-21.

Changnon, S. A. (2003). Shifting economic impacts from weather extremes in the United States: A result of societal changes, not global warming. *Natural Hazards*, 29(2), 273-290.

Chernilo, D. (2017). The question of the human in the Anthropocene debate. *European Journal of Social Theory*, 20(1), 44-60.

Chiew, F. H., Piechota, T. C., Dracup, J. A., & McMahon, T. A. (1998). El Nino/Southern Oscillation and Australian rainfall, streamflow and drought: Links and potential for forecasting. *Journal of Hydrology*, 204(1-4), 138-149.

Chisholm, L. (2012). Apartheid education legacies and new directions in post-apartheid South Africa. *Storia delle donne*, *8*, 81-103.

Cho, S. (2012). *Critical pedagogy and the language of possibility*. London: Routledge.

Cicerone, R., Orr, J., Brewer, P., Haugan, P., Merlivat, L., Ohsumi, T., ... & Pörtner, H. O. (2004). The ocean in a high CO2 World. EOS, *Transactions of the American Geophysical Union*, 85, 351-353. doi:10.1029/2004EO370007.

Clark, A. 2015. *Never Ending Story: From Evaluation to On-going Engagement. Exploring Young children's Perspectives of Fevered Sleep Performances*. Research report for Fevered Sleep, London. Retrieved October 10, 2020. http://www.feveredsleep.co.uk/wp-content/uploads/delightful-downloads/2015/11/Full-report-and-case-studies-Never-Ending-Story-by-Dr-Alison-Clark-1.pdf

Cohen, J. E. (1995). Population growth and earth's human carrying capacity. *Science*, 269(5222), 341-346.

Colebrook, C. (2012). "Destroying Cosmopolitanism for the Sake of the Cosmos". In R. Braidotti, P. Hanafin & B, Blaagaard (Eds.), *After Cosmopolitanism* (pp.166-182). Ann Arbor: Open Humanities Press.

Collins, R. (1971). Functional and conflict theories of educational stratification. *American sociological review*, 36,1002-1019.

Cominelli, E., Galbiati, M., Tonelli, C., & Bowler, C. (2009). Water: the invisible problem: Access to fresh water is considered to be a universal and free human right, but dwindling resources and a burgeoning population are increasing its economic value. *EMBO reports*, 10(7), 671-676.

Condie, K. C. (2004). Supercontinents and superplume events: distinguishing signals in the geologic record. *Physics of the Earth and Planetary Interiors*, 146(1-2), 319-332.

Conquergood, D. (1998). Beyond the text: Toward a performative cultural politics. In S.J. Dailey (Ed.), *The future of performance studies: Visions and revisions* (pp.25-36.) Annandale: National Communication Association.

Copson, A. (2015). What Is Humanism?. *The Wiley Blackwell handbook of humanism*, 1-33.

Contant, T. L., Tweed, A. L., Bass, J. E., & Carin, A. A. (2018). *Teaching science through inquiry-based instruction*. New York: Pearson.

Coole, D. and S. Frost. (2010). *New materialisms: Ontology, agency, and politics*. Durham, NC: Duke University.

Copson, A., & Grayling, A. C. (Eds.). (2015). *The Wiley Blackwell handbook of humanism*. Chichester: Wiley Blackwell.

Corlett, R. T. (2015). The Anthropocene concept in ecology and conservation. *Trends in ecology & evolution*, 30(1), 36-41.

Coumou, D., & Rahmstorf, S. (2012). A decade of weather extremes. *Nature climate change*, 2(7), 491-496.

Cowan, D., Morgan, K., & McDermont, M. (2009). Nominations: an actor-network approach. *Housing Studies*, 24(3), 281-300.

Craft, C., Clough, J., Ehman, J., Joye, S., Park, R., Pennings, S., ... & Machmuller, M. (2009). Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment*, 7(2), 73-78.

Cressman, D. (2009). *"A Brief Overview of Actor-Network Theory: Punctualisation, Heterogeneous Engineering & Translation*." ACT Lab/Centre for Policy Research on Science and Technology (CPROST), School of Communication, Simon Fraser University, Burnaby, British Columbia, Canada. Retrieved from http://blogs.sfu.ca/departments/cprost/wpcontent/uploads/2012/08/0901.pdf.

Cross, M., Mungadi, R., & Rouhani, S. (2002). From policy to practice: Curriculum reform in South African education. *Comparative education*, *38*(2), 171-187.

Crutzen, P. J. (2002). The "Anthropocene". *Journal de Physique IV (Proceedings)* 12(10), 1-5.

Crutzen, P. J. (2006). The "Anthropocene". In E. Ehlers & T. Krafft (Eds.), *Earth system science in the Anthropocene* (pp. 13-18). Heidelberg: Springer.

Crutzen, P. J., & Stoermer, E. F. (2000). Global change newsletter. *The Anthropocene*, 41, 17-18.

Curren, R., & Metzger, E. (2019). Education in the Anthropocene: A Pragmatic Approach. *On Education. Journal for Research and Debate*, 2(1), 1-7.

Dagar, B. S., Panda, P. K., Pradhan, R., Sharma, M. C., Anand, C. L., Pandit, P. N., & Kumar, S. (2018). *Unit-4 Democratic Principles in Education*. IGNOU. Retrieved on 12 December 2019 from http://www.egyankosh.ac.in/bitstream/123456789/46965/1/Unit-4.pdf

Dahl, R. A. (1956). Hierarchy, democracy and bargaining in politics and economics. In H. Eulau, S.J. Eldersveld & M.S. (Eds.), *Janowitz Political Behaviour: A Reader in Theory and Research.* Glencoe: Free Press.

D'Ambrosio, U. (1990). The role of mathematics education in building a democratic and just society. *For the learning of mathematics*, 10(3), 20-23.

Darling-Hammond, L. (1996). The right to learn and the advancement of teaching: Research, policy, and practice for democratic education. *Educational Researcher*, 25(6), 5-17.

Davidson, C. B. (1987). The Montreal Protocol: The First Step Toward Protecting the Global Ozone Layer. *NYUJ Int'l L. & Pol.*, 20, 793.

Davis, J., Moulton, A. A., Van Sant, L., & Williams, B. (2019). Anthropocene, capitalocene,… plantationocene?: A manifesto for ecological justice in an age of global crises. *Geography Compass*, *13*(5), e12438.

de Castro, E. B. V. (2004). Exchanging perspectives: the transformation of objects into subjects in Amerindian ontologies. *Common knowledge*, 10(3), 463-484.

De Vries, W., Kros, J., Kroeze, C., & Seitzinger, S. P. (2013). Assessing planetary and regional nitrogen boundaries related to food security and adverse environmental impacts. *Current Opinion in Environmental Sustainability*, 5(3-4), 392-402.

Degener, S. C. (2001). Making sense of critical pedagogy in adult literacy education. *Annual review of adult learning and literacy*, 2(1), 26-62.

Dietz, T., Shwom, R. L., & Whitley, C. T. (2020). Climate change and society. *Annual Review of Sociology*, *46*, 135-158.

Dekkers, J., & De Laeter, J. (2001). Enrolment trends in school science education in Australia. *International Journal of Science Education*, 23(5), 487-500.

Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. Minneapolis: University of Minnesota Press.

Deleuze, G. (1991). *Empiricism and Subjectivity: An Essay on Hume's Theory of Human Nature*. New York: Columbia University Press.

Deleuze, G.(1995). *Negotiations*. New York: Columbia University Press.

Deleva, A., & Grigorov, I. (2011). Lower troposphere observation over urban area with lidar at 1064 nm. *International Journal of Navigation and Observation*, 2011, 1-8.

Denzin, N. K. (2009). Critical pedagogy and democratic life or a radical democratic pedagogy. *Cultural Studies? Critical Methodologies*, 9(3), 379-397.

Department of Basic Education (DBE). (2011). *Curriculum and Assessment Policy Statement (CAPS)*. Pretoria: Government Printers.

Department of Education. (2001). *Department of Education manifesto on values, education and democracy*. Pretoria: Government Printers.

Deseriis, M. (2015) *Improper Names: Collective Pseudonyms from the Luddites to Anonymous*. Minneapolis: University of Minnesota Press.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York: Macmillan.

Dewey, J. (1934). Art as experience. *Hereafter ART*, *21*, 75-78.

Dewey, J. (1980). The need for an industrial revolution in an industrial democracy. *The Middle Works*, 10, 137-143.

Diamanti-Kandarakis, E., Bourguignon, J. P., Giudice, L. C., Hauser, R., Prins, G. S., Soto, A. M., ... & Gore, A. C. (2009). Endocrine-disrupting chemicals: An Endocrine Society scientific statement. *Endocrine reviews*, 30(4), 293-342.

Diamond, C. (2001). *Injustice and Animals.* Durham: Duke University Press.

Diniz, E. M. (2007). Lessons from the Kyoto protocol. *Ambiente & sociedade*, 10(1), 27-38.

Donald, D., Lazarus, S., & Lolwana, P. (2000). Educational Psychology in Social Context. Challenges of development, social issues and special needs in Southern Africa. Oxford: University Press.

Doney, S. C., Fabry, V. J., Feely, R. A., & Kleypas, J. A. (2009). Ocean acidification: the other CO_2 problem. *Annual Review of Marine Science*,1(1), 169-192.

Dora, C., Haines, A., Balbus, J., Fletcher, E., Adair-Rohani, H., Alabaster, G., ... & Neira, M. (2015). Indicators linking health and sustainability in the post-2015 development agenda. *The Lancet*, 385(9965), 380-391.

Doran, P. T. & Zimmerman, M. K. (2009). Examining the scientific consensus on climate change. Eos. *Transactions American Geophysical Union*, 90(3), 22-23.

Dove, S. G., Kline, D. I., Pantos, O., Angly, F. E., Tyson, G. W., & Hoegh-Guldberg, O. (2013). Future reef decalcification under a business-as-usual CO2 emission scenario. *Proceedings of the National Academy of Sciences*, 110(38), 15342-15347.

Doyle, C., & Singh, A. (2006). *Reading & Teaching Henry Giroux* (Vol. 4). New York: Peter Lang.

Droser, M. L., Bottjer, D. J., Sheehan, P. M., & McGhee Jr, G. R. (2000). Decoupling of taxonomic and ecologic severity of Phanerozoic marine mass extinctions. *Geology*, 28(8), 675-678.

Duchesne, S., & McMaugh, A. (2016). *Educational psychology for learning and teaching*. South Melbourne: Cengage Learning Australia.

Edwards, C.H. (2008). *Classroom discipline & management*. New Jersey: John Wiley and Sons.

Edwords, F. (1984). The Humanist Philosophy in Perspective. *Humanist*, *44*(1), 17.

Elkins, J. W. (1999). *Chlorofluorocarbons (CFCs). The Chapman and Hall encyclopaedia of environmental science*: Boston: Kluwer Academic Publ, 78-80.

Ellis, E. C. (2011). Anthropogenic transformation of the terrestrial biosphere. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 369(1938), 1010-1035.

Ellis, E., M. Maslin, N., Boivin, A., & Bauer, A. (2016).“Involve Social Scientists in Defining the Anthropocene”. *Nature News,* 540 (7632), 192-193.

Ellsworth, E. (1992). Why doesn't this feel empowering? Working through repressive myths of critical pedagogy. In C. Luke & J. Gore (Eds.), *Feminisms and critical pedagogy* (pp. 90-119). New York: Routledge.

Elser, J. J. (2012). Phosphorus: a limiting nutrient for humanity? *Current opinion in biotechnology*, 23(6), 833-838.

Ericksen, P. J., Ingram, J. S., & Liverman, D. M. (2009). Food security and global environmental change: emerging challenges. *Environ Sci Policy 2009*, 12(4), 373–377.

Ezer, H., Millet, S., & Patkin, D. (2006). Multicultural perspectives in the curricula of two colleges of education in Israel: 'The curriculum is a cruel mirror of our society'. *Teachers and Teaching: theory and practice*, 12(4), 391-406.

Falkenmark, M., & Lundqvist, J. (1998). Towards water security: political determination and human adaptation crucial. *Natural Resources Forum*, 22(1), 37-51.

Fankhauser, S. (1995). *Valuing Climate Change: The Economics of the Greenhouse*. London: Earthscan.

Fankhauser, S. (2009). *The range of global estimates. Assessing the costs of adaptation to climate change*: *A review of the UNFCCC and other recent estimates.* London: Wheeler.

Faraon, M. (2018). Concept-driven design for democracy: advancing co-creative media to support citizen participation and democratic engagement. *eJournal of eDemocracy & Open Government*, 10(1), 23-49.

Fauchereau, N., Trzaska, S., Rouault, M., & Richard, Y. (2003). Rainfall variability and changes in southern Africa during the 20th century in the global warming context. *Natural Hazards*, 29(2), 139-154.

Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, 1-26.

Fayolle, A., & Lamine, W. (2013). A social network approach to a better understanding of the survival-growth phase of innovative new ventures. In A. Fayolle (Ed.), *Conceptual Richness and Methodology Diversity in Entrepreneurship Research* (pp. 232-256).Cheltenham: Edward Elgar Publishing.

Fedosejeva, J., Boce, A., Romanova, M., Ilisko, D., & Ivanova, O. (2018). Education for Sustainable Development: The Choice of Pedagogical Approaches and Methods for The Implementation of Pedagogical Tasks in The Anthropocene Age. *Journal of Teacher Education for Sustainability*, *20*(1), 157-179.

Fenwick, T. J. (2010). (un) Doing standards in education with actor-network theory. *Journal of Education Policy*, 25(2), 117-133.

Fenwick, T., & Edwards, R. (2010). *Actor-network theory in education*. New York: Routledge.

Fenwick, T., & Edwards, R. (2011). Introduction: Reclaiming and renewing actor-network theory for educational research. *Educational Philosophy and Theory*, 43(1), 1-14.

Fielding, M., & Moss, P. (2012). *Radical democratic education*. London: Routledge.

Firdaus, F. A., & Mariyat, A. (2017). Humanistic approach in education according to Paulo Freire. *At-Ta'dib*, *12*(2), 25-48.

Fischman, G. E., & McLaren, P. (2005). Rethinking critical pedagogy and the Gramscian and Freirean legacies: From organic to committed intellectuals or critical pedagogy, commitment, and praxis. *Cultural Studies? Critical Methodologies*, 5(4), 425-446.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Helkowski, J. H. (2005). Global consequences of land use. *Science*, 309(5734), 570-574.

Foley, P. C. (2007). A Case for and of critical pedagogy: Meeting the challenge of liberatory education at Gallaudet University. *American Communication Journal*, 9(4), 1-21.

Foster, W. J., & Twitchett, R. J. (2014). Functional diversity of marine ecosystems after the Late Permian mass extinction event. *Nature Geoscience*, 7(3), 233-238.

Frankfurt School. (2008). In W. A. Darity (Ed.), *International Encyclopaedia of the Social Sciences* (2nd ed., Vol. 3, 188-189). Detroit: Macmillan.

Frederick, W.A. (1991). Science and technology education: An engineer's perspective. In S.K. Majumdar, L.M. Rosenfeld, P.A. Rubba, E.W. Miller & R.F. Schmalz (Eds.), Science education in the United States: Issues, crises and priorities. Easton, PA: The Pennsylvania Academy of Science, pp. 386-393.

Freire, P. (1970). *Pedagogy of the Oppressed.* New York: Herder and Herder.

Freire, P. (1973). *Education for critical consciousness* (Vol. 1). New York: Bloomsbury Publishing.

Freire, P. (1985). *The politics of education: Culture, power, and liberation*. London: Greenwood Publishing Group.

Freire, P., & Macedo, D. (1987). *Literacy: Reading the word and the world*. Massachusetts: Bergin & Garvey Publishers.

Füssel, H. M., Heinke, J., Popp, A., & Gerten, D. (2012). *Climate change and water supply.* In In O. Edenhofer, J. Wallacher, H. LotzeCampen, M. Reder, B. Knopf & J. Muller (Eds.), *Climate Change, Justice and Sustainability* (pp. 19-32). Dordrecht: Springer.

Gabel, S. (2002). Some conceptual problems with critical pedagogy. *Curriculum Inquiry*, 32(2), 177-201.

Gale, S. J., & Hoare, P. G. (2012). The stratigraphic status of the Anthropocene. *The Holocene*, 22(12), 1491-1494.

Galloway, A. (2013). The poverty of philosophy: Realism and post-Fordism. *Critical Inquiry*, 39(2), 347-366.

Galston, W. (2000). Democracy and Value Pluralism. *Social Philosophy and Policy,* 17(1), 255-268.

Garoian, C. R., & Gaudelius, Y. M. (2001). Cyborg pedagogy: Performing resistance in the digital age. *Studies in Art Education*, 42(4), 333-347.

Gaskell, J. S. (1992). *Gender matters from school to work*. Philadelphia: Open University Press.

Gherardi, S., & Nicolini, D. (2005). Actor-networks: ecology and entrepreneurs. In B. Czarniawska & T. Hernes (Eds.), *Actor-Network Theory and Organizing*. Copenhagen: Liber & Copenhagen Business School Press.

Gibbard, P. L., & Walker, M. J. C. (2014). The term 'Anthropocene' in the context of formal geological classification. *Geological Society, London, Special Publications*, 395(1), 29-37.

Gillings, M. R., & Hagan-Lawson, E. L. (2014). The cost of living in the Anthropocene. *Earth Perspectives*, 1(1), 1-11.

Gillings, M. R., & Stokes, H. W. (2012). Are humans increasing bacterial evolvability? *Trends in ecology & evolution*, 27(6), 346-352.

Gilman, E. L., Ellison, J., Duke, N. C., & Field, C. (2008). Threats to mangroves from climate change and adaptation options: a review. *Aquatic botany*, 89(2), 237-250.

Giroux, H. (1983). Theories of reproduction and resistance in the new sociology of education: A critical analysis. *Harvard educational review*, 53(3), 257-293.

Giroux, H. (1997). *Pedagogy and the politics of hope: Theory, culture, and schooling*. Boulder: Westview.

Giroux, H. (2003). Critical Theory and Educational Practice. In A. Darder, M. Baltodano & R. D. Torres (Eds.), *The critical pedagogy reader* (pp. 27-56). New York: Routledge.

Giroux, H. (2010). Lessons from Paulo Freire. *The Chronicle of Higher Education*, *57*(9), B15-B16.

Giroux, H. (2018). *Pedagogy and the politics of hope: Theory, culture, and schooling: A critical reader*. New York: Routledge.

Giroux, H. A. (1988). *Teachers as intellectuals: Toward a critical pedagogy of learning.* Westport: Bergin and Garvey.

Giroux, H. A. (1998). Education in unsettling times: Public intellectuals and the promise of cultural studies. In D. Carlson & M. Apple (Eds.), *Power, Knowledge, Pedagogy: The meaning of democratic education in unsettling times* (pp.41-60). Boulder: Westview Press.

Giroux, H. A., & Giroux, S. S. (2006). Challenging neoliberalism's new world order: The promise of critical pedagogy. *Cultural studies? Critical methodologies*, 6(1), 21-32.

Glasnost. In E. Munson & C. Warren (Eds.), *James Carey: A critical reader* (pp. 207-227). Minneapolis: University of Minnesota Press.

Gleick, P. H. (1998). The human right to water. *Water policy*, 1(5), 487-503.

Golumbia, D. (2016). "Correlationism": The Dogma that Never Was. *Boundary* 2, 43(2), 1-25.

González, G.R. (2013). *The use of Actor-Network Theory and a practice-based approach to understand online community participation*. [Unpublished doctoral dissertation].University of Sheffield.

Gonçalves, F. A., & Figueiredo, J. (2012). How to recognize an Immutable Mobile when you find one: Translations on innovation and design. In A. Tatnall (Ed.), *Social Influences on Information and Communication Technology Innovations*. *International Journal of Actor-Network Theory and Technological Innovation (IJANTTI)*, *2*(2), 39-53.

Gordon, B. (1985). Teaching teachers: "Nation at risk" and the issue of knowledge in teacher education. *The Urban Review,* 17(1), 33-46.

Gough, A. (2004). Blurring boundaries: Embodying cyborg subjectivity and methodology. *Educational research: Difference and diversity*, 113-127.

Gough, A., & Gough, N. (2017). Beyond cyborg subjectivities: Becoming posthumanist educational researchers. *Educational Philosophy and Theory*, 49(11), 1112-1124.

Gough, A. (2021). Education in the Anthropocene. In *Oxford Research Encyclopedia of Education*. Oxford: Oxford University Press.

Gratton, P. (2014). *Speculative realism: Problems and prospects*. London: Bloomsbury Publishing.

Grisci, C. L. I. (2008). Immaterial labour, rhizomatic control and subjectivity in the new technological paradigm. *RAE electronica*, 7(1), 67-89.

Gruber, N., & Galloway, J. N. (2008). An Earth-system perspective of the global nitrogen cycle. *Nature*, 451(7176), 293-296.

Gruenbaum, O. (2019). Commonwealth Update. *The Round Table*, 1-7.

Guess, T. J. (2006). The social construction of whiteness: Racism by intent, racism by consequence. *Critical Sociology*, 32(4), 649-673.

Guthrie, N. H. (2003). *Necessary Contradictions: Critical Pedagogy and Kenneth Burke's Pentad* [Unpublished doctoral dissertation]. North Carolina State University.

Guosheng, W. (2001). Science and Humanism. *Social Sciences In China*, 4.

Halverson, J. B., & Rabenhorst, T. (2013). Hurricane Sandy: The science and impacts of a superstorm. *Weatherwise*, 66(2), 14-23.

Hamilton, M. (2009). Putting words in their mouths: The alignment of identities with system goals through the use of individual learning plans. *British Educational Research Journal*, 35(2), 221-242.

Haraway, D. (1991). *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.

Haraway D. (1992) Promises of monsters: A regenerative politics for inappropriate/d others. In L. Grossberg, C. Nelson & P. Treichler (Eds.), *Cultural Studies* (pp.295–337). London: Routledge.

Haraway, D. (1994). A manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s. In Seidman, S. (Ed.), *The postmodern turn: New*

perspectives on social theory (pp. 82-115). Cambridge: Cambridge University Press.

Haraway,D.(1997).Modest−Witness@Second−Millennium.*Femaleman−Meets−Onco mouse: Feminism and Technoscience*. New York: Routledge.

Haraway, D. (2003). *The companion species manifesto: Dogs, people and significant otherness,* Chicago: Prickly Paradigm Press.

Haraway, D. (2004). The promise of monsters: A regenerative politics for inappropriate/d others. In H.C., Phillips (Ed.), *The Haraway reader* (pp. 63-124). New York: Routledge.

Haraway, D. (2015). Anthropocene, capitalocene, plantationocene, chthulucene: Making kin. *Environmental humanities*, 6(1), 159-165.

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Durham: Duke University Press.

Harman, G. (2002). *Tool-Being: Heidegger and the Metaphysics of Objects*. Chicago: Open Court.

Harman, G. (2010). *Towards speculative realism: Essays and lectures*. Park Lane: John Hunt Publishing.

Harman, G. (2011). *The Quadruple Object*. Winchester: Zero Books.

Harman, G. (2015). Object-oriented ontology. In M.Hauskeller, T.D. Philbeck, & C.D. Carbonell (Eds.), *The Palgrave Handbook of Posthumanism in Film and Television* (pp. 401-409). London: Palgrave Macmillan.

Harris, C. I. (1993). Whiteness as property. *Harvard law review*, 1707-1791.

Hart, P. (2002). Environment in the science curriculum: The politics of change in the Pan-Canadian science curriculum development process. *International Journal of Science Education*, 24(11), 1239-1254.

Hartnett, A., & Naish, M. (1993). Democracy, Teachers and the Struggle for Education: an essay in the political economy of teacher education. *Curriculum Studies*, 1(3), 335-348.

Hayes, R. D. (1991). Hidden health hazards of CFCs. *Nation*, 252(4), 123-126.

Hayles, N. K. (1999). Liberal Subjectivity Imperilled: Norbert Wiener and Cybernetic Anxiety. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. London: University of Chicago Press.

Hayles, N. K. (2008). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. Chicago: University of Chicago Press.

Hayles, N. K. (2010). After shocks: Posthuman ambivalence. *Post medieval: a journal of medieval cultural studies*, 1(1-2), 262-271.

Head, M. J., Aubry, M. P., Walker, M., Miller, K. G., & Pratt, B. R. (2017). A case for formalizing subseries (subepochs) of the Cenozoic Era. *Episodes*, 40(1), 22-27.

Heft, P. (2016). *The Philosopher's New Clothes: An Introductory Survey into Object-Oriented Ontology*. Denison: Denison University Summer Scholar Project.

Heineke, H. J., Eckelmann, W., Thomasson, A. J., Jones, R. J. A., Montanarella, L., & Buckley, B. (1998). *Land Information Systems: Developments for planning the sustainable use of land resources*. Luxembourg: Office for Official Publications of the European Communities.

Heleta, S. (2018). Decolonizing Knowledge in South Africa: Dismantling the 'pedagogy of big lies'. *Ufahamu: A Journal of African Studies*, *40*(2).

Herbrechter, S. (2012). Posthumanism, subjectivity, autobiography. *Subjectivity*, 5(3), 327-347.

Hess, J. J., Malilay, J. N., & Parkinson, A. J. (2008). Climate change: the importance of place. *American journal of preventive medicine*, 35(5), 468-478.

Hoegh-Guldberg, O., & Bruno, J. F. (2010). The impact of climate change on the world's marine ecosystems. *Science*, 328(5985), 1523-1528.

Holifield, R. (2009). Actor-Network Theory as a Critical Approach to Environmental Justice: A Case against Synthesis with Urban Political Ecology. *Antipode*, 41(4), 637-658.

Hönisch, B., Ridgwell, A., Schmidt, D. N., Thomas, E., Gibbs, S. J., Sluijs, A., ... & Kiessling, W. (2012). The geological record of ocean acidification. *Science*, 335(6072), 1058-1063.

Hooks, B. (1996). *Teaching to Transgress: Education as the Practice of Freedom*. New York: Routledge.

Horton, M., & Freire, P. (1990). *We make the road by walking: Conversations on education and social change*. Philadelphia: Temple University Press.

Huerta, L., Scott, D., and Horton, J. K. (2001*). How do we know preservice teachers are comprehending, wilting, and able to apply critical pedagogy in their classrooms?* Paper presented at the American Educational Research Association Annual Meeting. Seattle.

Huerta-Charles, L. (2007). Pedagogy of testimony: Reflections on the pedagogy of critical pedagogy. In McLaren, P., & Kincheloe, J. L. (Eds.), *Critical pedagogy: Where are we now?* (pp.249-261). Washington: Peter Lang.

Hunt, A. (1988). SATIS approaches to STS. *International Journal of Science Education*, *10*, 409-420.

Hurd, P. D. (1989). Science education and the nation's economy. In A.B. Champagne, B.E. Lovitts & B.J. Callinger (Eds.), *This year in school science: Scientific literacy* (pp. 1–14). Washington D.C: American Association for the Advancement of Science.

Inkpen, S. A., & DesRoches, C. T. (2019). Revamping the Image of Science for the Anthropocene. *Philosophy, Theory, and Practice in Biology*,11(3), 1–7

Jablonski, D. (1989). The biology of mass extinction: a paleontological view. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*, 325(1228), 357-368.

Jackson J.B.C. (2008). Ecological extinction and evolution in the brave new ocean. *Proceedings of the National Academy of Sciences*, 105, 11458–11465.

Janmohamed, A. R. (1993). Some implications of Paulo Freire's border pedagogy. *Cultural Studies, 7*(1), 107-117.

Jansen, J. D. (1998). Curriculum reform in South Africa: A critical analysis of outcomes-based education. *Cambridge journal of education*, *28*(3), 321-331.

Joldersma, C. W. (1999). The tension between justice and freedom in Paulo Freire's epistemology. In R. A. Cole (Ed.), *Issues in Web-based Pedagogy: A Critical Primer.* Westport: Greenwood Press.

Jeyaraj, J. (2014). *Critical Pedagogy in Higher Education: Insights from English language teachers* [Unpublished doctoral dissertation]. University of Otago.

Juelskjær, M. (2020). Mattering pedagogy in precarious times of (un) learning. *Matter: Journal of New Materialist Research*, 1(1), 52-79.

Kalis, A. J., Merkt, J., & Wunderlich, J. (2003). Environmental changes during the Holocene climatic optimum in central Europe - human impact and natural causes. *Quaternary Science Reviews*, 22(1), 33-79.

Kanpol, B. (1998). Critical pedagogy for beginning teachers: The movement from despair to hope. *Journal of Critical Pedagogy,* 2(1). Retrieved September 27, 2020, from http://www.lib.umwestern.edu/pub/jcp/issueII-1/knapol.html

Karl, T. R., & Easterling, D. R. (1999). Climate extremes: selected review and future research directions. *Climatic change*, 42(1), 309-325.

Kazadzis, S., Amiridis, V., Kosmopoulos, P., Marinou, E., & Tsekeri, A. (2013). *Impact of different aerosol types on the spectral solar radiation at different heights over the Mediterranean using the CALIPSO aerosol product*. *EGUGA*, 14204. Retrieved from https://ui.adsabs.harvard.edu/abs/2013EGUGA..1514204K .

Kelly, G.J., Carlsen, W.S., & Cunningham, C.M. (1993). Science education in sociocultural context: Perspectives from the sociology of science. *Science Education*, 77, 207-220.

Kessing-Styles, L, (2003), The relationship between critical pedagogy and assessment in teacher education. *Radical Pedagogy*, 5(1), 1-20.

Khan, S. R. (2013). *The ease of mobility*. London: Routledge.

Khatib, M., Sarem, S. N., & Hamidi, H. (2013). Humanistic Education: Concerns, Implications and Applications. *Journal of Language Teaching & Research*, 4(1), 45-51.

Kincheloe, J. L. (2005). *Critical constructivism primer* (Vol. 2). New York: Peter Lang.

Kincheloe, J., & McLaren, P. (1994). Rethinking critical thinking and qualitative research. *Handbook of qualitative research.* Thousand Oaks: Sage Publications.

King, J. C. (1998). What is a Philosophical Analysis? *Philosophical Studies*, 90(2), 155-179.

Knights, D., Coombs, R., & Bloomfield, B. P. (1997). *Information technology and organizations: Strategies, networks and integration.* Oxford: Oxford University Press.

Knorr-Cetina, K. D., & Mulkay, M. (1983). *Science observed: Perspectives on the social study of science*. London: Sage Publications.

Knowlton, K., Rosenthal, J. E., Hogrefe, C., Lynn, B., Gaffin, S., Goldberg, R., ... & Kinney, P. L. (2004). Assessing ozone-related health impacts under a changing climate. *Environmental health perspectives*, 112(15), 1557-1563.

Koopman, C. (2013). The formation and self-transformation of the subject in Foucault's ethics. A companion to Foucault. In C. Falzon, T. O'Leary, & J. Sawicki (Eds.), *A companion to Foucault* (pp. 526-543). Chichester: Wiley-Blackwell.

Koteswaraiah, G., & Basavanna, M. (2016). Humanistic Approach to Education. *The Academic Editor Journal of Indian Education*, *28*(3), 5.

Kuchment, L. S. (2004). The hydrological cycle and human impact on it. Water Resources Management. *Encyclopaedia of Life Support Systems (EOLSS).* Paris: Eolss Publishers.

Kueffer, C., & Kaiser-Bunbury, C. N. (2014). Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene. *Frontiers in Ecology and the Environment*, 12(2), 131-137.

Kuhn, T. (1962). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Küpers, W. (2017). From Anthropocene to Ecoscene?! Unpublished working-paper ARTEM, ICN Nancy.

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, 108(9), 3465-3472.

Langlitz, N., & Strum, S. C. (2017). Baboons and the Origins of Actor-Network Theory. *BioSocieties*, 12(1), 158-167.

Lankshear, C., & McLaren, P. (Eds.). (1993). *Critical literacy: Politics, praxis, and the postmodern*. Albany: SUNY Press.

Lather, P. (1998). Critical pedagogy and its complicities: A praxis of stuck places. *Educational Theory*, 48, 487-497.

Latour, B. (1986). Visualization and cognition. *Knowledge and society*, 6(1), 1-40.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society.* Cambridge: Harvard University Press.

Latour, B. (1988) *The Pasteurization of France*. Cambridge: Harvard University Press.

Latour, B. (1990). Technology is society made durable. *The Sociological Review*, 38(1_suppl), 103-131.

Latour, B. (1991) Technology is society made durable. In Law, J. (ed.). *A Sociology of Monsters*.(pp. 103-31). London: Routledge.

Latour, B. (1992). "Where are the Missing Masses? The Sociology of a Few Mundane Artifacts." In W.E. Bijker & J.Law (Eds.), *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge: MIT Press.

Latour, B. (1993). *We Have Never Been Modern*. Cambridge: Harvard University Press.

Latour, B. (1994) 'On Technical Mediation: Philosophy, Sociology, Genealogy', *Common Knowledge,* 3, 29–64.

Latour, B. (1995). Mixing humans and nonhumans together: the sociology of a door closer. *Social Problems*, 35, 298 - 310.

Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale Welt-Zeitschrift fur Sozialwissenschaftliche forschung und praxis*, 47(4) , 369-381.

Latour, B. (1999). "Thou Shalt Not Take the Lord's Name in Vain' – Being a Sort of Sermon on the Hesitations of Religious Speech." *Res*, 39, 215–34.

Latour, B. (2004). *Politics of nature*. Harvard: Harvard University Press.

Latour, B. (2007). *Reassembling the social: An introduction to actor-network-theory* Oxford: University Press.

Latour, B., & Woolgar, S. (2013). *Laboratory life: The construction of scientific facts*. New Jersey: Princeton University Press.

Laurance, W. F. (1999). Reflections on the tropical deforestation crisis. *Biological conservation*, 91(2-3), 109-117.

Lauth, H. J. (2015). *The matrix of democracy: A three-dimensional approach to measuring the quality of democracy and regime transformations*. Wurzburg: University of Wurzburg.

Law, J. (1984). On the methods of long-distance control: vessels, navigation and the Portuguese route to India. *The Sociological Review*, 32(1_suppl), 234-263.

Law, J. (1992). Notes on the theory of the Actor-Network: Ordering, strategy, and heterogeneity. *Systems Practice*, 5(4), 379-393.

Law, J. (1999). After ANT: complexity, naming and topology. *The Sociological Review*, *47*(S1), 1-14.

Law, J. (2007). *Actor-network theory and material semiotics*. Version of 25th April 2007. Disponibile online all'indirizzo http://www. heterogeneities. net/publications/Law-ANTandMaterialSemiotics. pdf, (scaricato il 18 maggio 2007).

Law, J. (2002). *Aircraft stories: Decentring the object in technoscience*. London: Duke University Press.

Law, J., & Singleton, V. (2005). Object Lessons. *Organization*, 12(3), 331-355.

Law, J., & Singleton, V. (2006). *A further species of trouble? Disaster and narrative*. Lancaster: Lancaster University Centre for Science Studies.

Leistyna, P., Lavandez, M., & Nelson, T. (2004). Introduction—Critical pedagogy: Revitalizing and democratizing teacher education. *Teacher Education Quarterly*, 31(1), 3-15.

Le Quéré, C., Rödenbeck, C., Buitenhuis, E. T., Conway, T. J., Langenfelds, R., Gomez, A., ... & Gillett, N. (2007). Saturation of the Southern Ocean CO2 sink due to recent climate change. *Science*, 316(5832), 1735-1738.

Ledford, H. 2015. "Team Science." *Nature,* 525, 308–311.

Lee, N., & Brown, S. (1994). Otherness and the actor-network: the undiscovered continent. *American Behavioral Scientist*, 37(6), 772-790.

Lesk, C., Rowhani, P., & Ramankutty, N. (2016). Influence of extreme weather disasters on global crop production. *Nature*, 529(7584), 84-87.

Lewis, S. L., & Maslin, M. A. (2015). Defining the Anthropocene. *Nature*, 519(7542), 171-180.

Lichtenstein, P.M. (1985). Radical Liberalism and Radical Education: A Synthesis and Critical Evaluation of Illich, Freire, and Dewey. *The American Journal of Economics and Sociology*, 44(1), 39-53.

Lijklema, L. (1995). Development and eutrophication: experiences and perspectives. *Water Science and Technology*, 31(9), 11-15.

Likens, G. E., Driscoll, C. T., & Buso, D. C. (1996). Long-term effects of acid rain: response and recovery of a forest ecosystem. *Science*, 272(5259), 244-246.

Linde, A., Linderoth, H. & Räisänen, C. (2003). "An actor-network theory perspective on IT-projects: A battle of wills". *Action in Language, Organisations and Information Systems.* Link¨oping: Link¨oping University.

Linnenluecke, M. K., Griffiths, A., & Winn, M. (2012). Extreme weather events and the critical importance of anticipatory adaptation and organizational resilience in responding to impacts. *Business Strategy and the Environment*, 21(1), 17-32.

LippertRasmussen, K., Lippert-Rasmussen, K., Thomsen, M. R., & Wamberg, J. (Eds.). (2012). *The posthuman condition: Ethics, aesthetics and politics of biotechnological challenges* (Vol. 3). ISD LLC.

Liu, W. M. (2017). White male power and privilege: The relationship between White supremacy and social class. *Journal of Counseling Psychology*, *64*(4), 349.

Lomofsky, L., & Lazarus, S. (2001). South Africa: First steps in the development of an inclusive education system. *Cambridge Journal of education*, 31(3), 303-317.

Loosmore, G. A., & Cederwall, R. T. (2004). Precipitation scavenging of atmospheric aerosols for emergency response applications: testing an updated model with new real-time data. *Atmospheric Environment*, 38(7), 993-1003.

Loosmore, G., Hsieh, H., & Grant, K. (2004). *Calculating Sensitivities, Response and Uncertainties Within LODI for Precipitation Scavenging* (No. UCRL-TR-205282). California: Lawrence Livermore National Lab (LLNL).

Luke, T. W. (2020). Tracing race, ethnicity, and civilization in the Anthropocene. *Environment and Planning D: Society and Space*, *38*(1), 129-146.

Lynning, K. H. (2007). Portraying science as humanism – a historical case study of cultural boundary work from the dawn of the 'Atomic Age'. *Science & Education*, 16(3-5), 479-510.

Lyons, T.S. (2003). *Decisions by 'science proficient' year 10 students about post-compulsory high school science enrolment: A sociocultural exploration*. Unpublished doctoral dissertation: Armidale: University of New England.

MacCormack, P. (2016). *Posthuman ethics: Embodiment and cultural theory*. Surrey: Routledge.

Macedo, D. P. (1994). *Literacies of power: What Americans are not allowed to know*. Boulder: Westview Press.

Mackenzie, A. (2002). *Transductions: Bodies and Machines at Speed*. London: Continuum.

Madison, D. S. (2003). Performance, personal narratives, and the politics of possibility. *Turning points in qualitative research: Tying knots in a handkerchief*, 3, 469-486.

Magnani, N. (2012). Nonhuman actors, hybrid networks, and conflicts over municipal waste incinerators. *Organization & Environment*, 25(2), 131-145.

Malhi, Y. (2017). The concept of the Anthropocene. *Annual Review of Environment and Resources*, *42*, 77-104.

Mamombe, C., Mathabathe, K. C., & Gaigher, E. (2020). The Influence of an Inquiry-Based Approach on Grade Four Learners' Understanding of the Particulate

Nature of Matter in the Gaseous Phase: A Case Study. *EURASIA Journal of Mathematics, Science and Technology Education*, 16(1), 1-11.

Marder, M. (2013). *Plant-thinking: A philosophy of vegetal life*. New York: Columbia University Press.

Martin, G. (1982). Africa and the Ideology of Eurafrica: neo-colonialism or pan-Africanism? *The Journal of Modern African Studies*, 20(2), 221-238.

Maspataud, A., Ruz, M. H., & Vanhée, S. (2013). Potential impacts of extreme storm surges on a low-lying densely populated coastline: the case of Dunkirk area, Northern France. *Natural hazards*, 66(3), 1327-1343.

McKernan, J. A. (2013). The origins of critical theory in education: Fabian socialism as social reconstructionism in nineteenth-century Britain. *British Journal of Educational Studies,* 61(4), 417-433.

McLaren, P. (1989). *Life in School: An Introduction to Critical Pedagogy in the Foundation of Education*. London: Routledge.

McLaren, P. (1997). Paulo Freire's legacy of hope and struggle. *Theory, Culture & Society,* 14(4), 147- 153.

McLaren, P. (1998). Revolutionary pedagogy in post-revolutionary times: Rethinking the political economy of critical education*. Educational Theory*: 48, 431-62.

McLean, M. (2006). *Pedagogy and the university: Critical theory and practice*. London: Bloomsbury Publishing.

McLean, C., & Hassard, J. (2004). Symmetrical absence/symmetrical absurdity: Critical notes on the production of actor-network accounts. *Journal of management studies*, 41(3), 493-519.

McMichael, A. J., Campbell-Lendrum, D., Kovats, S., Edwards, S., Wilkinson, P., Wilson, T., ... & Schlesinger, M. (2004). Global climate change. In M. Ezzati, A.D. Lopez, A. Rodgers &, Murray, C.J. (Eds.), *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Due To Selected Major Risk Factors*. Geneva: World Health Organization.

McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: present and future risks. *The Lancet*, 367(9513), 859-869.

Mcphie, J. (2018). I knock at the stone's front door: performative pedagogies beyond the human story. *Parallax*, 24(3), 306-323.

Mcphie, J., & Clarke, D. A. G. (2015). A walk in the park: considering practice for outdoor environmental education through an immanent take on the material turn. *The Journal of Environmental Education*, 46(4), 230-250.

Meillassoux, Q. (2012). *After Finitude. An Essay on the Necessity of Contingency*. London: Bloomsbury.

Mendoza, B. (2018). Can the subaltern save us?. *Tapuya: Latin American Science, Technology and Society*, *1*(1), 109-122.

Menon, S., Hansen, J., Nazarenko, L., & Luo, Y. (2002). Climate effects of black carbon aerosols in China and India. *Science*, 297(5590), 2250-2253.

Meret, C. (2018). *Toward an Actor-Network Approach for Investigating Education and Learning within a Corporate University: A World of Heterogeneous Assemblages*. [Unpublished doctoral dissertation]. Universta Di Roma.

Miah, A. (2008). A critical history of posthumanism. In *Medical enhancement and posthumanity* (pp. 71-94). Dordrecht:Springer.

Michael, M. (2016). *Actor-network theory: Trials, trails and translations*. London: Sage.

Millar, R., & Osborne, J. (Eds.) (1998). *Beyond 2000: Science education for the future*. London: King's College School of Education.

Milly, P. C. D., Wetherald, R. T., Dunne, K. A., & Delworth, T. L. (2002). Increasing risk of great floods in a changing climate. *Nature*, 415(6871), 514-517.

Milne, C. E., & Taylor, P. C. (1998). Between a myth and a hard place: Situating school science in a climate of critical cultural reform. In In W.W. Cobern (Ed.), *Socio-cultural perspectives on science education* (pp. 25-48). Boston: Kluwer Academic Publishers.

Mirza, M. M. Q. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate policy*, 3(3), 233-248.

Mitchell, V. (2016). A diffractive exploration of affect: Learning, research and teaching in obstetrics. *South African Journal of Higher Education*, *30*(3), 235-254.

Mohajan, H. K. (2019). The First Industrial Revolution: Creation of a New Global Human Era. Journal of Social Sciences and Humanities, 5(4), 377–387.

Mohajan, H. K. (2020). The Second Industrial Revolution has Brought Modern Social and Economic Developments. Journal of Social Sciences and Humanities, 6(1), 1–14.

Mol, A. (2002) *The Body Multiple: Atherosclerosis in Practice*. Durham: Duke University Press.

Molina, M. J., & Rowland, F. S. (1974). Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone. *Nature*, 249(5460), 810-812.

Moore, B., Underdal, A., Lemke, P., & Loreau, M. (2001). *Amsterdam Declaration on Earth System Science*. Challenges of a Changing Earth: Global Change Open Science Conference, Amsterdam the Netherlands. http://www.igbp.net/about/history/2001amsterdamdeclarationonearthsystemscience.4.1b8ae20512db692f2a680001312.html.

Moore, J.W.(2016) (Ed.), "Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism". Oakland: PM Press.

Moore, L. J., & Moran, K. (2016). Posthumanism. *The Blackwell Encyclopaedia of Sociology* (Vols.1-4). New Jersey: John Wiley & Sons, Ltd.

Morris, J. (1978). *Instructor's Manual for Psychology and Teaching: A Humanistic View*. New York: Random House.

Morton, T. (2011). Here comes everything: The promise of object-oriented ontology. *Qui Parle: Critical Humanities and Social Sciences*, 19(2), 163-190.

Morton, T. (2013). *Hyperobjects: Philosophy and Ecology after the End of the World*. Minneapolis: University of Minnesota Press.

Mulcahy, D. (2021). Enacting affirmative ethics in education: a materialist/posthumanist framing. *Educational Philosophy and Theory*, 1-14.

Mulhall, S. (2013). *The Routledge guidebook to Heidegger's being and time*. London: Routledge.

Munck, G. L. (2016). What is democracy? A reconceptualization of the quality of democracy. *Democratization*, 23(1), 1-26.

Muñoz, J. E. (1999) *Disidentifications: Queers of Color and the Performance of Politics*. Minneapolis: University of Minnesota Press.

Murdoch, J. (1997). Towards a geography of heterogenous associations. *Progress in Human Geography*, 21 (3), 321-37.

Murdoch, J. (1998). The spaces of actor-network theory. *Geoforum*, *29*(4), 357-374.

Murdoch, J. (2001). Ecologising Sociology: Actor-Network Theory, Co-construction and the Problem of Human Exemptionalism. *Sociology*, 35(1), 111-133.

Murris, K. (2017). Reading two rhizomatic pedagogies diffractively through one another: a Reggio inspired philosophy with children for the post developmental child. *Pedagogy, Culture & Society*, 25(4), 531-550.

Murris, K. (2019). Posthuman De/Colonising Teacher Education in South Africa: Animals, Anthropomorphism and Picture-Book Art. In P. Burnard, & L. Colucci-Gray (Eds.), *Why Science and Art Creativities Matter* (pp. 52-78). Leiden: Brill Sense.

Murris, K., & Bozalek, V. (2019). Diffracting diffractive readings of texts as methodology: Some propositions. *Educational Philosophy and Theory*, *51*(14), 1504-1517.

Murris, K., & Bozalek, V. (2019). Diffraction and response-able reading of texts: the relational ontologies of Barad and Deleuze. *International Journal of Qualitative Studies in Education*, *32*(7), 872-886.

Myshak, H. (2016). Project method is means of future biotechnologists humanistic orientation. *The First Independent Scientific Journal*, 2, 9-10.

Narita, D., Rehdanz, K., & Tol, R. S. (2012). Economic costs of ocean acidification: a look into the impacts on global shellfish production. *Climatic Change*, 113(3-4), 1049-1063.

Nash, C. H., & Johnson, E. A. (1996). Synoptic climatology of lightning-caused forest fires in subalpine and boreal forests. *Canadian Journal of Forest Research*, 26(10), 1859-1874.

Nash, L. (2005). The agency of nature or the nature of agency? *Environmental History*, 10(1), 67-69.

Nash, D. (2017*). Changes in precipitation over southern Africa during recent centuries.* In Oxford Research Encyclopaedia of Climate Science. https://doi.org/10.1093/acrefore/9780190228620.013.539.

Nasurt, T. (2011). Atmospheric Aerosol Optical Properties and Climate Change in Arid and Semi-Arid Regions. In J. Blanco & H. Kheradmand (Eds.), *Climate Change–Research and Technology for Adaptation and Mitigation*. Rijeka: InTech.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington DC: National Academies Press.

National Research Council. (2011). *Informing an effective response to climate change*. Washington DC: National Academies Press.

Neill, S., & Rose, G. M. (2007). Achieving adaptive ends through equivocality: A study of organizational antecedents and consequences. *Journal of business research*, 60(4), 305-313.

Nel, E., & Binns, T. (1999). Changing the geography of apartheid education in South Africa. *Geography*, 119-128.

Nicholls, R. J., & Tol, R. S. (2006). Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 364(1841), 1073-1095.

Nicholson, S. E., Leposo, D., & Grist, J. (2001). The relationship between El Niño and drought over Botswana. *Journal of Climate*, 14(3), 323-335.

Noddings, N. (1984). *Caring: A feminist approach to ethics and moral education*. Berkeley: University of California Press.

Norton, B., & Toohey, K. (2004). *Critical pedagogies and language learning*. New York: Cambridge University Press.

Obol, C., Allen, I., & Bach, H. S. (2003). Environmental education policy processes in the southern African Region. *Southern African Journal of Environmental Education*, 20, 22-38.

Ohara, Y., Saft, S.& Crookes, G. (2000). *Teacher Exploration of Feminist Critical Pedagogy in Beginning Japanese as a Foreign Language Class*. Paper presented at the *University of Hawai'i*, Manoa, Hawai'i.

Okazaki, T. (2005). Critical consciousness and critical language. *Second Language Studies*, 23(2), 174-202.

Olsson, P., Moore, M. L., Westley, F. R., & McCarthy, D. D. (2017). The concept of the Anthropocene as a game-changer: a new context for social innovation and transformations to sustainability. *Ecology and Society*, 22(2),31. https://doi.org/10.5751/ES-09310-220231.

Orr, J. C., Fabry, V. J., Aumont, O., Bopp, L., Doney, S. C., Feely, R. A., ... & Key, R. M. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature*, 437(7059), 681-686.

Osborne, J., & Collins, S. (2000). *Pupils' & parents' views of the school science curriculum*. London: Kings College.

Oxfam Education (2019). *Cyclone Idai: Find out what has happened and think critically about what makes some people more vulnerable to disasters than others*. Retrieved from www.oxfam.org.uk/education/resources/fundraising-guides-for-schools.

Page, E. A. (2008). Distributing the burdens of climate change. *Environmental Politics*, 17(4), 556-575.

Pascual, M., Rodó, X., Ellner, S. P., Colwell, R., & Bouma, M. J. (2000). Cholera dynamics and El Nino-southern oscillation. *Science*, 289(5485), 1766-1769.

Paytan, A., Mackey, K. R., Chen, Y., Lima, I. D., Doney, S. C., Mahowald, N., ... & Post, A. F. (2009). Toxicity of atmospheric aerosols on marine phytoplankton. *Proceedings of the National Academy of Sciences*, 106(12), 4601-4605.

Peirce, J. J., Vesilind, P. A., & Weiner, R. (1998). *Environmental pollution and control.* Butterworth: Heinemann.

Peterson, G. M., & Galbraith, J. K. (1932). The concept of marginal land. *Journal of Farm Economics*, 14(2), 295-310.

Pétursdóttir, Þ. (2017). Climate change? Archaeology and anthropocene. *Archaeological dialogues*, *24*(2), 175-205.

Phetteplace, E. (2010). Speculative realism. *College & Research Libraries News*, 71(6), 305–313.

Pillay, J., & Ragpot, L. (2011). Values, education and democracy: manifesto or myth? [Special issue 1]. *Journal of Educational Studies*, 104-120.

Pollock, D. (1998). A Response to Dwight Conquergood's Essay: 'Beyond the Text: Towards a Performative Cultural Politics. In S.J. Dailey (Ed.), *The Future of Performance Studies: Visions and Revisions* (pp. 37–46). Annandale: National Communication Association.

Pomerol, C., Curry, D., & Donovan, D. T. (1982). *The Cenozoic era: tertiary and quaternary*. Ellis Horwood Series in Geology. Chichester: Ellis Horwood.

Popkewitz, T.S., & Fendler, L. (1999). *Critical theories in education*. New York: Routledge.

Portmann, R. W., Daniel, J. S., & Ravishankara, A. R. (2012). Stratospheric ozone depletion due to nitrous oxide: influences of other gases. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1593), 1256-1264.

Post, E. (2013). *Ecology of climate change: the importance of biotic interactions* (Vol. 68). Princeton: Princeton University Press.

Postma, D. (2016). The ethics of becoming in a pedagogy for social justice. A posthumanist perspective. *South African Journal of Higher Education*, 30(3), 310-328.

Quattrone, P., & Hopper, T. (2006). What is IT?: SAP, accounting, and visibility in a multinational organisation. *Information and Organization*, 16(3), 212-250.

Quigley, B. A. (1997). *Rethinking Literacy Education. The Critical Need for Practice-Based Change. The Jossey-Bass Higher and Adult Education Series*. San Francisco: Jossey-Bass Publishers Inc.

Rahmstorf, S., & Coumou, D. (2011). Increase of extreme events in a warming world. *Proceedings of the National Academy of Sciences*, 108(44), 17905-17909.

Ramanathan, V. C. P. J., Crutzen, P. J., Kiehl, J. T., & Rosenfeld, D. (2001). Aerosols, climate, and the hydrological cycle. *Science*, 294(5549), 2119-2124.

Ramnarain, U., & Moleki, B. (2017). Teachers' Use of Newspaper Articles in Promoting a Humanistic Perspective of Science in South Africa. *Journal of Science Teacher Education*, 28(2), 205-217.

Rancière, J. (1999) *Disagreement: Politics and Philosophy*. Minneapolis: University of Minnesota Press.

Ravishankara, A. R., Daniel, J. S., & Portmann, R. W. (2009). Nitrous oxide (N2O): the dominant ozone-depleting substance emitted in the 21st century. *Science*, 326(5949), 123-125.

Reddington, S., & Price, D. (2018). Pedagogy of New Materialism: Advancing the Educational Inclusion Agenda for Children and Youth with Disabilities. *International Journal of Special Education*, 33(2), 465-481.

Redmalm, D. (2015). Pet grief: when is non-human life grievable?. *The Sociological Review*, 63(1), 19-35.

Reiss, M.J. (2000). *Understanding science lessons: Five years of science teaching*. Milton Keynes: Open University Press.

Repetto, R., & Easton, R. (2010). Climate change and damage from extreme weather events. *Environment: Science and Policy for Sustainable Development*, 52(2), 22-33.

Restivo, S., & Zenzen, M. (2003). A humanistic perspective on science and society. *Humanity & society*, *27*(3), 240-264.

Richerson, P. J., & Boyd, R. (2001). Institutional evolution in the Holocene: the rise of complex societies. In W. G. Runciman (Ed.), *The Origin of Human Social Institutions,* (pp.197-234). Oxford: Oxford University Press Inc.

Richerson, P. J., Boyd, R., & Bettinger, R. L. (2001). Was agriculture impossible during the Pleistocene but mandatory during the Holocene? A climate change hypothesis. *American Antiquity*, 66(3), 387-411.

Rioual, P., Andrieu-Ponel, V., Rietti-Shati, M., Battarbee, R.W., de Beaulieu, J.L., Cheddadi, R., Reille, M., Svobodova, H., Shemesh, A., 2001. High-resolution record of climate stability in France during the last interglacial period. *Nature*, 413, 293 – 296.

Rioux-Dubois, A., & Perron, E. (2016). Exploring the Potential Contribution of Actor-Network Theory in Nursing Using the Integration of Nurse Practitioners as an Exemplar. *Aporia*, 8(2), 5-15.

Ritzer, G. (2008). *Sociological theory*. New York: McGraw-Hill Education.

Rivers, W. (1983). *Communicating naturally in a second language: Theory and practice in language teaching.* Cambridge: Cambridge University Press.

Robinson, S. A., & Erickson, D. J. (2015). Not just about sunburn–the ozone hole's profound effect on climate has significant implications for Southern Hemisphere ecosystems. *Global Change Biology*, 21(2), 515-527.

Rockstrom, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society,* 14(2), 1-35

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E. F., ... & Nykvist, B. (2009). A safe operating space for humanity. *Nature*, 461,472-472.

Rosenzweig, C., Iglesias, A., Yang, X. B., Epstein, P. R., & Chivian, E. (2001). Climate change and extreme weather events; implications for food production, plant diseases, and pests. *Global change & human health*, 2(2), 90-104.

Rouault, M., & Richard, Y. (2003). Intensity and spatial extension of drought in South Africa at different time scales. *Water SA*, 29(4), 489-500.

Rouault, M., & Richard, Y. (2005). Intensity and spatial extent of droughts in southern Africa. *Geophysical Research* Letters, 32(15), 1-4.

Rousseau, J.-J. (1997). *The social contract and other political writings*. Cambridge: Cambridge University Press.

Rowland, F. S. (1990). Stratospheric ozone depletion by chlorofluorocarbons. *Ambio*, 281-292.

Roziek, J. (2015), '*The Hidden Curriculum of Race as Non-human Agent'*, Paper presented at the International Congress of Qualitative Inquiry.

Ruhi, A., Catford, J. A., Cross, W. F., Escoriza, D., & Olden, J. D. (2019). Understanding the Nexus Between Hydrological Alteration and Biological

Invasions. In S. Sabater, A. Elosegi & R. Ludwig (Eds.), *Multiple Stressors in River Ecosystems* (pp. 45-64). Cambridge: Elsevier.

Running, S. W. (2012). A measurable planetary boundary for the biosphere. *Science*, 337(6101), 1458-1459.

Rutherford, T., & Holmes, J. (2008). 'The flea on the tail of the dog': power in global production networks and the restructuring of Canadian automotive clusters. *Journal of Economic Geography*, *8*(4), 519-544.

Rylance, R. (2015).“Global Funders to Focus on Interdisciplinarity”. *Nature,* 525, 313–315.

Dailey, S. J. (Ed.). (1998). *The future of performance studies: Visions and revisions*. Annandale: National Communication Association.

Sadeghi, S. (2008). Critical pedagogy in an EFL teaching context: An ignis fatuus or an alternative approach. *Journal for Critical Education Policy Studies*, 6(1), 277-295.

Saldanha, A. (2020). A date with destiny: Racial capitalism and the beginnings of the Anthropocene. *Environment and Planning D: Society and Space*, *38*(1), 12-34.

Şanlı, Ö., & Altun, M. (2015). The significance of establishing democratic education environment at schools. *Journal of educational and instructional studies in the world*, 5(2),1-8.

Sarker, S. & Sidorova, A. (2006). "Understanding business process change failure: An actor-network perspective". *Journal of Management Information Systems*, 23 (1), 51-86.

Sartori, G. (1965). *Democratic theory* (Vol. 579). Detroit: Wayne State University Press.

Sasinsky, N. (1993). *Mediation of Conflict in Non-racial Schools.* [Unpublished doctoral dissertation]. University of the Witwatersrand.

Sayes, E. (2014). Actor–Network Theory and methodology: Just what does it mean to say that nonhumans have agency? *Social Studies of Science*, 44(1), 134-149.

Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature*, 413(6856), 591-596.

Schindler, D. W. (1988). Effects of acid rain on freshwater ecosystems. *Science*, 239(4836), 149-157.

Schumpeter, J. (1962). *Capitalism, Socialism and Democracy*. New York: Harper Torchbooks.

Schlegel, P., Havenhand, J. N., Gillings, M. R., & Williamson, J. E. (2012). Individual variability in reproductive success determines winners and losers under ocean acidification: a case study with sea urchins. *PloS one*, 7(12), e53118. doi:10.1371/journal.pone.0053118.

Schmuck, R., & Schmuck, P. (1974). *A humanist psychology of education*. Palo Alto: National Press.

Schwartz, M. A., & Wiggins, O. (1985). Science, humanism, and the nature of medical practice: A phenomenological view. *Perspectives in Biology and Medicine*, 28(3), 331-361.

Scully, R. P. (2019). Idai's trail of destruction. *New Scientist*, 241(3223), 24-25.

Sears, R. R., Dávalos, L. M., & Ferraz, G. (2001). Missing the forest for the profits: The role of multinational corporations in the international forest regime. *The Journal of Environment & Development*, 10(4), 345-364.

Sehon, S. R. & Stanley, D. E. (2003). A philosophical analysis of the evidence-based medicine debate. *BMC health services research*, 3(1), 14. doi:10.1186/1472-6963-3-14.

Selbekk, L. K. (2014). *Planetary Boundary for Chemical Pollution: a review of the case chemical DDT*. [Unpublished Masters' thesis]. Institutt for biologi.

Selin, N. E., Paltsev, S., Wang, C., Donkelaar, A. V., & Martin, R. V. (2011). *Global Aerosol Health Impacts: Quantifying Uncertainties. MIT Joint Program on the Science and Policy of Global Change*. Cambridge: Massachusetts Institute of Technology.

Shannon, P. (Ed.). (1992). *Becoming political: Readings and writings in the politics of literacy education*. Portsmouth: Heinemann Educational Publishers.

Sharon, T. (2014). Towards a Non-Humanist Posthumanism: The Originary Prostheticity of Radical and Methodological Posthumanism. In T. Sharon (Ed.), *Human Nature in an Age of Biotechnology: The case for mediated posthumanism* (pp. 79-111). Dordrecht: Springer.

Shea, C. P. (1988). *Protecting life on earth: steps to save the ozone layer*. Washington: Worldwatch Institute.

Shen, S. Z., Crowley, J. L., Wang, Y., Bowring, S. A., Erwin, D. H., Sadler, P. M., ... & Zhang, H. (2011). Calibrating the end-Permian mass extinction. *Science*, 334(6061), 1367-1372.

Shih, Y. H. (2018). Towards a Pedagogy of Humanizing Child Education in Terms of Teacher-Student Interaction. *Journal of Education and Learning*, 7(3), 197-202.

Shor, I. (1993). Education is politics: Paulo Freire's critical pedagogy. In P. McLaren & P. Leonard (Eds.), *Paulo Freire: a critical encounter.* New York: Routledge.

Showstack R (2013) Scientists debate whether the Anthropocene should be a new geological epoch. *EOS*, 94:41–42

Siccardi, F. (1996). Rainstorm hazards and related disasters in the North-West Mediterranean region*. Remote Sensing Reviews*, 14(1-3), 5-21.

Sidle, C. C., & Warzynski, C. C. (2003). A new mission for business schools: The development of actor-network leaders. *Journal of Education for Business*, *79*(1), 40-45.

Simon, R. I. (1992). *Teaching against the grain: Texts for a pedagogy of possibility*. New York: Bergin & Garvey.

Skutnabb-Kangas, T., Phillipson, R., & Rannut, M. (1995). Linguistic human rights. *Overcoming linguistic discrimination.* Berlin: Mouton De Gruyter.

Smith, B. D., & Zeder, M. A. (2013). The onset of the Anthropocene. *Anthropocene*, *4*, 8-13.

Smolka, A. (2006). Natural disasters and the challenge of extreme events: risk management from an insurance perspective. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 364(1845), 2147-2165.

Snaza, N., Appelbaum, P., Bayne, S., Carlson, D., Morris, M., Rotas, N., ... & Weaver, J. (2014). Toward a post humanist education. *Journal of Curriculum Theorizing*, 30(2), 39-55.

Snaza, N., & Sonu, D. (2016). Borders, bodies, and the politics of attention. In N. Snaza, D. Sonu, S. E. Truman, & Z. Zaliwska (Eds.), Pedagogical matters: New materialisms and curriculum studies (pp. 29–42). New York: Peter Lang.

Somerville, I. (1999). Agency versus identity: actor-network theory meets public relations. *Corporate Communications: An International Journal*, 4, 6–13.

Son, S. W., Tandon, N. F., Polvani, L. M., & Waugh, D. W. (2009). Ozone hole and Southern Hemisphere climate change. *Geophysical Research Letters*, 36(15). doi:10.1029/2009GL038671.

Spinoza, B. (1994). *A Spinoza Reader: The Ethics and Other Works*. Princeton: Princeton University Press.

Spivak, G. C. (1988). Can the subaltern speak? *Can the subaltern speak? Reflections on the history of an idea*, 21-78. Amsterdam: John Benjamins Pub. Co.

Springgay, S., Truman, S. E., & Turner, C. (2019). Walking research-creation: QTBIPOC temporalities and world makings. *MAI: Feminism & Visual Culture*, *4*.

Steffen, P. J. C. (2003). How long have we been in the Anthropocene era?. *Climatic Change*, 61(3), 251-257.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2007). The Anthropocene: are humans now overwhelming the great forces of nature. AMBIO: *A Journal of the Human Environment*, 36(8), 614-622.

Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L., Molina, M., Ramanathan, V., Rockström, J., Scheffer, M., Schellnhuber, H.J. & Svedin, U. (2011a)."The Anthropocene: From Global Change to Planetary Stewardship", *Ambio,* 40(7), 739-61.

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011b). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 369(1938), 842-867.

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011c). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1938), 842-867.

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the Anthropocene: the great acceleration. *The Anthropocene Review*, 2(1), 81-98.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 736–47.

Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., ... & Schellnhuber, H. J. (2018). Trajectories of the Earth System in the Anthropocene. *Proceedings of the National Academy of Sciences*, *115*(33), 8252-8259.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2016). The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature? *Ambio: A Journal of the Human Environment*, 36,614–621.

Sterling, S. M., Ducharne, A., & Polcher, J. (2013). The impact of global land-cover changes on the terrestrial water cycle. *Nature Climate Change*, 3(4), 385-390.

Stockbruegger, J., & Bueger, C. (2017). Actor-Network Theory: Objects and actants, networks and narratives. In in D.R. McCarthy (Ed.), *Technology and World Politics* (pp. 54-71). Abingdon: Routledge.

Storni, C., Binder, T., Linde, P., & Stuedahl, D. (2015). Designing things together: intersections of co-design and actor–network theory. *CoDesign*, 11, 149–151.

Strawson, P. F. (2000). *Entity and identity: and other essays*. London: Oxford University Press.

Sundar, N. (1997). *Subalterns and sovereigns: An anthropological history of Bastar, 1854-1996*. Oxford University Press, USA.

Swartz, E. (1996). Emancipatory pedagogy: A postcritical response to 'standard' school knowledge. *Journal of Curriculum Studies,* 28(4), 397-418.

Syngedouw, E. & Heynen, N.C. (2003). Urban political ecology, justice and the politics of scale. *Antipode*, 35(5), 1331-1354.

Taguchi, H. L. (2012). A diffractive and Deleuzian approach to analysing interview data. *Feminist theory*, *13*(3), 265-281.

Tatnall, A. & Burgess, S. (2002). "Using actor-network theory to research the implementation of a BB portal for regional SMEs in Melbourne, Australia". Paper presented at the *15th International Bled Electronic Commerce Conference eReality: Constructing the eEconomy*, Slovenia.

Thobejane, T. D. (2013). History of apartheid education and the problems of reconstruction in South Africa. *Sociology Study*, *3*(1), 1-12.

Thrift, N. J. (2000). Actor-Network Theory. In R. J. Johnston, D. Gregory, G. Pratt & M. Watts (Eds.), *The Dictionary of Human Geography* (4th ed., pp. 4-6) Oxford: Blackwell.

Tie, X., & Cao, J. (2009). Aerosol pollution in China: Present and future impact on environment. *Particuology*, 7(6), 426-431.

Thoithi, W., Blamey, R. C., & Reason, C. J. (2021). Dry Spells, Wet Days, and Their Trends Across Southern Africa During the Summer Rainy Season. *Geophysical Research Letters*, *48*(5), e2020GL091041.

Tol, R. S. (2002). Estimates of the damage costs of climate change. Part 1: Benchmark estimates. *Environmental and resource Economics*, 21(1), 47-73.

Tollefson, J. (2012). Hurricane sweeps US into climate-adaptation debate. *Nature News,* 491(7423), 167-168.

Torres, C. A. (1999). Critical theory and political sociology of education: Arguments. In T. Popkewitz & L. Fendler (Eds.), *Critical theories in education: Changing terrains of knowledge and politics* (pp. 87-115). New York: Routledge.

Tsigaridis, K., Krol, M., Dentener, F. J., Balkanski, Y., Lathiere, J., Metzger, S., ... & Kanakidou, M. (2006). Change in global aerosol composition since preindustrial times. *Atmospheric Chemistry and Physics*, 6(12), 5143-5162.

Tsing, A. L., Swanson, H. A., Gan, E., & Bubandt, N. (Eds.). (2017). Arts of living on a damaged planet: Ghosts and monsters of the Anthropocene. Minneapolis: University of Minnesota Press.

Turner, R. E., & Rabalais, N. N. (2003). Linking landscape and water quality in the Mississippi River basin for 200 years. *Bioscience*, 53(6), 563-572.

Turney, C. S., Palmer, J., Maslin, M. A., Hogg, A., Fogwill, C. J., Southon, J., ... & Hua, Q. (2018). Global peak in atmospheric radiocarbon provides a potential definition for the onset of the anthropocene epoch in 1965. *Scientific reports*, *8*(1), 1-10.

Ulmer, G. L. (1985). Applied Grammatology: Post-Pedagogy from Jacques Derrida to Joseph Beuys*. Journal of Aesthetics and Art Criticism*, 44 (2),200-202.

Ulmer, J. B. (2016). Diffraction as a method of critical policy analysis. *Educational Philosophy and Theory,* 48(13), 1381-1394.

US Department of Housing and Urban Development, Washington DC (2013). *Force, Hurricane Sandy Rebuilding Task: Hurricane Sandy rebuilding strategy*. New York: The Task Force Advisory Group.

Varela, C. R. (2009). *Science for humanism: the recovery of human agency*. Abingdon: Routledge.

Valett, R. E. (1977). *Humanistic Education: Developing the Total Person*. St. Louis, Missouri: Mosby Company.

van der Leeuw, S. E. 2008. Climate and society: lessons from the past 10 000 years. [Special Issue]. *Ambio*, 14,476–482.

Van der Tuin, I. (2014). Diffraction as a methodology for feminist onto-epistemology: On encountering Chantal Chawaf and posthuman interpellation. *Parallax*, *20*(3), 231-244.

van der Zaag, A. C. (2016). On posthuman subjectivity. *Journal of Cultural Economy*, 9(3), 330-336.

Van House, N. A. (2003). Digital libraries and collaborative knowledge construction. In A. P. Bishop., N. A. Van House & B. P. Buttenfield (Eds.), *Digital library use: Social practice in design and evaluation*, 271-295. Cambridge: MIT Press.

Veugelers, W. (Ed.). (2011). *Education and humanism: Linking autonomy and humanity*. AW Rotterdam: Springer Science & Business Media.

Vicsek, L. M., Kiraly, G., & Konya, H. (2016). Networks in the social sciences: Comparing actor-network theory and social network analysis. *Corvinus Journal of Sociology and Social Policy*, 7(2), 77-102.

Visconti, G. (2014). Anthropocene: another academic invention?. *Rendiconti Lincei*, *25*(3), 381-392.

Vorosmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., & Prusevich, A. et al. (2010) Global Threats to Human Water Security and River Biodiversity. *Nature*, 468, 334-334.

Wang, Z., Akimoto, H., & Uno, I. (2002). Neutralization of soil aerosol and its impact on the distribution of acid rain over east Asia: Observations and model results. *Journal of Geophysical Research: Atmospheres*, 107(D9), 389, doi:10.1029/2001JD001040.

Waters, C. N., Zalasiewicz, J. A., Williams, M., Ellis, M. A., & Snelling, A. M. (2014). A stratigraphical basis for the Anthropocene? *Geological Society*, 395(1), 1-21.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Gałuszka, A., ... & Jeandel, C. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science*, 351(6269). doi:org/10.1126/ science.aad2622.

Watson, G. (2007). *Actor-network theory, after ANT and enactment: Implications for method.* Retrieved from www.gavan.ca/wp-content/uploads/2007/01/ANT-comp.pdf

Wellner, G. (2017). Ethics in Times of Posthumanism. *Foundations of Science*, *22*(2), 329-332.

Wetzel, F. T., Kissling, W. D., Beissmann, H., & Penn, D. J. (2012). Future climate change driven sea-level rise: secondary consequences from human displacement for island biodiversity. *Global Change Biology*, 18(9), 2707-2719.

Whiteman, G., Walker, B., & Perego, P. (2013). Planetary boundaries: Ecological foundations for corporate sustainability. *Journal of Management Studies*, 50(2), 307-336.

Whittaker, R. H., & Likens, G. E. (1975). *The biosphere and man.* Berlin: Springer.

Whittle, A., & Spicer, A. (2008). Is actor-network theory critique? *Organization studies*, 29(4), 611-629.

Wiedmann, T., & Minx, J. (2008). A definition of 'carbon footprint'. *Ecological economics research trends*, 1, 1-11.

Wigley, T. M. L. (1988). Future CFC concentrations under the Montreal Protocol and their greenhouse-effect implications. *Nature*, 335(6188), 333-335.

Williams, R. S. (2000). A modern Earth Narrative: what will be the fate of the biosphere? *Technology in Society*, 22(3), 303-339.

Willmott, H. (1998). Towards a new ethics? The contributions of poststructuralism and posthumanism. In M. Parker (Ed.), *Ethics and organizations* (pp.76-121). London: Sage Publications.

Wink, J. (2000). *Critical pedagogy: Notes from the real world*. New York: Longman.

Wolhuter, C., Janmaat, J. G., van der Walt, J. H. L., & Potgieter, F. J. (2020). The role of the school in inculcating citizenship values in South Africa: Theoretical and international comparative perspectives. *South African Journal of Education*, *40*(2), S1-S11.

Wolin, R. (2006). *The Frankfurt school revisited and other essays on politics and society*. New York: Routledge.

Woods, P. A. (2005) *Democratic Leadership in Education.* London: Paul Chapman Publishing.

World Health Organization. (2019). Weekly Bulletin on Outbreak and other Emergencies: Week 11: 11-17 March 2019. *Weekly Bulletin on Outbreaks and other Emergencies*, 1-21.

Wuebbles, D. J. (2009). Nitrous oxide: no laughing matter. *Science*, 326(5949), 56-57.

Yager, R.E. (1983). Defining science education as a discipline. *Journal of Research in Science Teaching*, *20*, 261-262.

Yamasaki, A. (2003). An overview of CO2 mitigation options for global warming—emphasizing CO_2 sequestration options. *Journal of Chemical Engineering of Japan*, 36(4), 361-375.

Yancey, K. B. (1994). *Voices on Voice: Perspectives, Definitions, Inquiry*. Urbana: National Council of Teachers of English.

Zahavi, D. (2016). The end of what? Phenomenology vs. speculative realism. *International Journal of Philosophical Studies*, *24*(3), 289-309.

Zalasiewicz, J., Waters, C., Summerhayes, C., & Williams, M. (2018). The Anthropocene. *Geology Today*, 34(5), 177-181.

Zalasiewicz, J., Williams, M., Smith, A., Barry, T. L., Coe, A. L., Bown, P. R., ... & Stone, P. (2008). Are we now living in the Anthropocene?. *Gsa Today*, *18*(2), 4.

Zalasiewicz, J., Waters, C. N., Williams, M., & Summerhayes, C. P. (Eds.). (2019). *The Anthropocene as a geological time unit: A guide to the scientific evidence and current debate*. Cambridge University Press.

Zalasiewicz, J., Waters, C. N., Williams, M., Barnosky, A. D., Cearreta, A., Crutzen, P., ... & Oreskes, N. (2015). When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International*, *383*, 196-203.

Zalasiewicz, J; Williams, M., Steffen, W., & Crutzen, P. (2010). *Environmental Science & Technology*, 44(7), 2228-2231.

Zapata Barrero, R. (2011). The reproduction of the Muslim "other" in Spain through social practices and political reactions. *Silvina Shammah Gesser and Raanan Rein (co.), The other in contemporary Spain / Practices, discourses, representations* , 219-256.

Zehavi, O. (2010). Minoracy. *Lexical Review of Political Thought*. Retrieved from http://mafteakh.tau.ac.il/en/pdf/MafteakhE01-Minoracy.pdf.

Zembylas, M. (2017). The contribution of the ontological turn in education: Some methodological and political implications, *Educational Philosophy and Theory*, 49(14), 1401-1414.

Zhao, J., Luo, Q., Deng, H., & Yan, Y. (2007). Opportunities and challenges of sustainable agricultural development in China. *Philosophical Transactions of the Royal Society B. Biological Sciences*, 363(1492), 893-904.

Zhen, Q. (2021). Exploring the early Anthropocene: implications from the long-term human-climate interactions in early China. *Mediterranean Archaeology & Archaeometry*, *21*(1).

Ziman, J. (1984). *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press.

Zucca-Scott, L. (2010). Know thyself: the importance of humanism in education. *International Education*, 40(1), 32-38.