

# Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers

By

Riaan Kazan Khan

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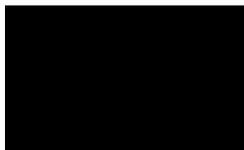
**November 2021**

Supervisor: Professor R. Mudaly

## Declaration

I, Riaan Kazan Khan, declare that this dissertation is my own work. I also declare that it has not been submitted for degree purposes at any other university, and that I have indicated and acknowledged all the sources used accordingly.

Student's Signature



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Date

18/11/2021

Supervisor's Signature



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Date

15 April 2022

## **Dedication**

I dedicate this thesis to God Al-Aleem (The All-Knowledgeable)

In the Name of Allah—the Most Compassionate, Most Merciful.

All praise is for Allah—Lord of the worlds,

The Most Compassionate, Most Merciful

Master of the Day of Judgement.

You alone we worship and You alone we ask for help

Guide us to the straight path,

The Path of those You have blessed—not those You are displeased with, or those who are astray.

*Qur'an 1: 1-7*

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## **Abstract**

Curriculum and Assessment Policy Statements of 2010, was established after 1994 to deal with several things such as gender and racial inequalities in education. However, women and individuals of non-western descent continue to be under-represented in Science, Technology, Engineering, and Mathematics (STEM) careers, while white, euro-western men dominate in these fields. This study provided an opportunity to pre-service teachers to analyse the school science curriculum in South Africa. To develop a lesson plan based on a unit of work in the science curriculum in which they could incorporate scientists of non-western descent. This qualitative study was located in critical and decolonial theory. Data generation involved; document analysis of lesson plans which pre-service teachers were instructed to develop within groups and individual interviews which were conducted via WhatsApp. Participants were sampled from the registered stream of students in the Natural Sciences 211 module of the first semester of the 2020 academic year. The implication of the findings was that white euro-western male scientists continue to be perpetuated as the holders of scientific knowledge in school science education. This study concludes by proposing that curriculum designers portray males and females of non-western descent as equal producers of scientific knowledge, therefore addressing the colonial nature of the school science curriculum. In this way, more conducive environments for science teaching and learning will be attained, and possibly advance female and non-western representation and participation in STEM fields.

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# CHAPTER 1: Research Description

Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers.

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## 1.1 Introduction and background

Based on my frustration with the superordinate status of the west and its consequent capitalisation, I have used lower case for the words 'white', 'western' and 'male' throughout my dissertation.

According to Machin and Mayr (2012) the textbooks that students use are considered as tools which inform the social structures in maintaining political ideologies in that society. Textbooks possess the ability to perpetuate ideologies in subtle ways (Fairclough, 2003). In this study the ideology-about "legitimate" knowledge holders depicted in science textbooks and other curriculum-related documents will be troubled. Pingel (2010) states that education policies within a country inform the authors and publishers of textbooks on how to design textbooks and covertly, political ideologies are perpetuated. In this study the political ideology relates to the construction of a legitimate knowledge holder- and this is done by examining the inclusion of less recognised scientists in the school science curriculum. The argument then would be that the exclusion of scientists from particular settings could signal their unimportance, and a lack of legitimacy of their work. In this way certain groups of scientists who profess particular knowledge within particular frameworks are privileged over others.

In addition to particular content knowledge, texts are laden with assumptions. "What is 'said' in a text is 'said' against a background of what is 'unsaid', but taken as given" (Fairclough, 2003, p. 11). This argument confirms that texts can be purposefully used to express and enforce ideologies that are not apparent to readers. An example of this would be that most physical sciences textbooks give full credit of the invention of the telephone to Alexander Graham Bell, who was born in Scotland, but little to no mention is made of the work of Lewis Howard Latimer, an

African American of non-western descent. Latimer helped draft the patent for Bell's design of the telephone and was also involved in the field of incandescent lighting, a particularly competitive field, thus working side by side with Hiram Maxim and Thomas Edison. Hence this study explores representations of scientists of non-western descent in school science textbooks to uncover disparities in ideologies, in order to reveal their possible impact on boys and girls as lifelong students.

Fataar (2018) describes the current status of higher education institutions in South Africa based on the 2015 UKZN student protests:

The politics of knowledge in South African universities has recently witnessed a radical discursive rupture. The call for decolonising education was a cornerstone of students' recognition struggles at universities. Mobilising on the basis of their demand for free education, learners across the university sector expressed the need for change in university knowledge and curricula in the light of what they described as their exposure to Eurocentric, racist, and sexist knowledge at untransformed institutions. They argued that such a knowledge orientation is at the heart of their experience of alienation at the university. They suggested that only the complete overhaul of the curriculum on the basis of a decolonising education approach would provide them the type of educational access that addresses their emerging African-centred humanness. (p. 6)

The decolonisation of education means that countries must develop independently with respect to the procurement of knowledge skills, values, beliefs and habits (Wingfield, 2017). Wingfield (2017) argues that the term 'decolonisation' is being gravely misconstrued among students in South Africa. A student at the University of Cape Town stated that: For decolonised education to be presented, the current system must be deposed and the people it's supposed to serve must define it for themselves (Wingfield, 2017). This view is not isolated. Many students hold the same idea of what is meant by decolonisation and this is very dangerous. It is dangerous because if higher education institutions submit to the stance that students have about decolonisation, this would mean according to Wingfield (2017) that South Africa discards all the developments of modern medicine, education and science that

originated elsewhere in the world. This would, for example, mean denying the use of penicillin, the yellow fever vaccination and HIV ART drugs. None of these was developed in Africa.

Historically, the knowledge possessed by people of non-western descent has been devalued (Le Grange, 2014; Le Grange, 2016; Le Grange, 2018), thereby elevating knowledge possessed by people of western descent as the only source of knowledge or as the only source of relevant knowledge. In a recent Webinar according to Peters (2021), Professor Fulufhelo Netswera, the Executive Dean of the Faculty of Management Sciences at the Durban University of Technology (DUT), says that all other cultures have been marginalised, irrespective of whether they had significant developments in medicine, or other disciplines, to share. He emphasised that a decolonial project is a critical project for everyone because it conveys to people that one's contribution to the development of humanity is not only informed by one's skin colour and geography, but one's intellectual capabilities as well. The webinar was further addressed on the subject by Prof Gift Mheta, Writing Centre Manager, with his presentation entitled: *Decolonising Post-Graduate Studies (PSG) in Africa: An Institutional Perspective*. He explained the linguistic analysis of decolonisation, saying: "Decolonisation is a process that involves dealing with the effects of colonisation. It is a process that involves careful planning, listening to many voices, reflecting on what is possible in a particular context, and implementing, and reviewing of all actions." (Peters, 2021). An additional perspective on *Decolonising post-graduate studies in Africa with an academic's personal experience* was DUT's Dr Emem Anwana. She spoke on the decolonisation of university education in Africa, elaborating on the 'first wave'. In the mid-1960s with the first round of military *coups d'état* and the beginning of academics seeking to account for the failure of governance on the continent (Peters, 2021).

Dr Emem Anwana said,

The military regimes and authoritarian rulers that followed from the independent struggles became suspicious of intellectual independence and began crackdowns on academia. As a result, institutions that would have otherwise been at the forefront of independent Africa's intellectual revival were forced to revert to their colonial roots. This compelled academia to look

more to the West, rather than to domestic settings, in finding solutions to problems. (Peters, 2021)

## **1.2 Purpose of this study**

The literature reveals that several studies have been conducted locally and globally on decolonising the curricula of Higher Education Institutions in STEM fields. The purpose of this study, then, is to refocus on schools and examine school science textbooks, i.e. whether these books include the identities and work of scientists of non-western descent or not, and the consequent ideological implications.

## **1.3 Rationale for the study**

“As a first step to (re)imaging humanity and de-normalizing the Vitruvian man, we need to de-Europeanize the world and center Africa [and other localities] as” (Prinsloo, 2020, p.89) “legitimate historical unit[s] of analysis and epistemic site[s] from which to interpret the world while at the same time globalizing knowledge from Africa [and other localities]” (Ndlovu-Gatsheni, 2018, p. 4).

The above is my problem statement that highlights the problem, of the colonised elements and the need to find solutions in order to decolonise the school science curriculum.

The need for this study was prompted by several factors. The first is ideological and lies in a quest for a science education to which pre-service teachers (and their students) can relate, in other words, a more relevant science education. According to the Curriculum Assessment Policy Statement document, the first general aim of the South African curriculum is “this curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives” (Curriculum Assessment Policy Statements, CAPS, 2011, p. 4). However, the ideology underpinning the curriculum might not resonate with the worldviews of diverse student populations in South Africa, and the realisation of this broad aim could be a challenge.

The second reason is based on the UKZN Transformation Charter, which states that race and gender representation will be evident in all structures; thus, for race and gender to be apparent in all structures, the Euro-centric shackles of the school curriculum must be dismantled. For this dismantling to take place, attention needs to be drawn to teacher education, specifically pre-service teachers, about the colonised elements within the science curriculum, whilst enabling them to modify and incorporate non-western elements into the science curriculum, which would form the basis in achieving the goals set out by the UKZN Transformation Charter.

The third reason is based on my own reflections and awareness of the school science curriculum's euro-centric and colonised nature. I have become aware of how other sources of knowledge production have been ignored throughout history, thereby asserting European and western white males as the primary source of knowledge production that is valuable.

The fourth reason is based on my personal experience and interactions with many experienced teachers. From anecdotal evidence, teachers are unaware of Eurocentric elements' which continue the legacy of coloniality using the science curriculum. Teachers appear to accept the science curriculum, which privileges white, Euro-western men over their non-Euro-western counterparts, as normal.

Teachers normalise the location of white men from Europe and North America at the centre of the discovery of new technologies and new scientific knowledge (Le Grange, 2014). Therefore, the curriculum is not inclusive of all ethnicities of knowledge producers, and many teachers unquestioningly accept this epistemic injustice. This study aims to disrupt such compliance by engaging pre-service teachers in thinking about other scientific knowledge producers, conducting text and media searches for scientists of non-western descent, and acting on this by planning how the work of these scientists could be included in the teaching of school science. By targeting pre-service teachers, they can be equipped to work in ways which are different in science classrooms when they become practising teachers.

#### **1.4 The gap in the literature and significance of the study**

This study will be important because it will enhance awareness of scientists of non-western descent to teachers, curriculum designers and those who are entrusted with selection of school textbooks. On an annual basis science teachers evaluate the textbook catalogue released by the Department of Basic Education (DBE). It is therefore vital that teachers critically study textbooks in order to make informed selections.

Current literature on research about the decolonisation of education focuses mainly on Higher Education. The literature reviewed for this study using the search engine Google Scholar did not yield information related to decolonisation in Basic Education or the current school science curricula.

This lack of research in the decolonisation of these curricula reveals a lacuna in the research field on decolonising education. Studies related to identifying scientists of non-western descent appear to be scarce. By identifying these non-western scientists, work towards the science curriculum's decolonisation can be filtered into primary and secondary school curricula.

#### **1.5 Location of the study**

This study was conducted in South Africa. The research site is UKZN Edgewood Campus. Those students emerging from this campus are the same students that have been graduated from the current colonised science curriculum. Majority of the students are black and come from middle to low income households. Textbooks which are used by science students from secondary schools in the province of KwaZulu - Natal were examined.

#### **1.6 Research Design**

This study was conducted by pre-service teachers who followed the qualitative approach to gain an understanding of how scientists of non-western descent can be included in the science curriculum. The critical paradigm was used as a worldview to guide the study. Taylor and Medina (2013) state that the critical paradigm advantageous because its objective is to detect, assist, and challenge gross power

imbalances in society. Due to the COVID-19 pandemic the design of this study had to adapt to COVID-19 protocols. Data generation involved document analysis of lesson plans, which pre-service teachers were instructed to develop within groups and individual interviews which was conducted via WhatsApp. Participants were sampled from the registered stream of students in the Natural Sciences 211 module of the first semester of the 2020 academic year. The participatory design allowed pre-service teachers the freedom to address the euro-centric bias in the curriculum.

## **1.7 Research Objectives**

The objectives of this study are:

### **Main Objective**

To explore how pre-service teachers work towards decolonising a unit of work in the science curriculum by including scientists of non-western descent.

### **Sub-objectives:**

- To explore which scientists of non-western descent pre-service teachers select to include in a unit of work in the science curriculum, and why they do so
- To explore how pre-service teachers plan to include the contributions of these scientists into a unit of work in the science curriculum
- To explore the challenges that pre-service teachers encounter in working toward decolonising the curriculum by making it more inclusive of non-western scientists.

## **1.8 Research Questions**

### **Questions to be asked**

#### **Main research question:**

How do pre-service teachers decolonise a unit of work in the science curriculum by incorporating scientists of non-western descent?

#### **Sub-questions:**

- Which scientists of non-western descent do pre-service teachers select to include in the science curriculum, and why they do so?
- How do pre-service teachers plan to include the contributions of these scientists into the existing science curriculum?

- What challenges do pre-service teachers encounter in working towards decolonising the curriculum by making it inclusive of non-western scientists?

## **1.9 Overview of chapters**

Chapter one sets the scene for the study. I introduced chapter one by outlining the current state of South African Higher Education Institutions to demonstrate discourses and debates which have peppered the post-school education landscape and the decolonisation of curricula. I have also highlighted how the current policy of education, Curriculum and Assessment Policy Statements (CAPS), endorses textbooks that exclude scientists of non-western descent. The purpose, rationale and significance of the study were also delineated. I have introduced the research objectives and research questions here. I concluded chapter one by providing a brief outline of the research design for the study and a few insights into the study's findings.

In chapter two, I discussed the literature that I reviewed to locate the study within the ongoing education dialogue and identified some research gaps. Both local and international literature was reviewed.

In chapter three, I discussed the methodological approach that I adopted. I provided details of the paradigm, design, and sample for the study. The data generation methods and instruments are discussed in detail. I also outlined how rigour was achieved through applying the principles of trustworthiness.

In chapter four, I presented the findings of the study.

In chapter five, I presented the summary of the findings and intersect these with literature I also provided limitations and recommendations for further research.

## **1.10 Conclusion**

In this chapter (chapter one), I have laid the background for the study and then outlined the purpose, rationale, and significance thereof. I then presented the research objectives and questions. I also highlighted the research design, which informed the way that I generated data. I then provided the outline of the remaining chapters. In the next chapter, I discussed the literature that I reviewed.

## CHAPTER 2: Literature Review

Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers

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This review begins with the discourses and debates which echo the call for decolonisation. I then look backwards at the historical effects of colonisation and focus more closely on the South African context. Next studies on decolonisation and the curriculum are presented. Against this background, studies on school science textbooks are reviewed. Finally, theoretical perspectives which inform this study are argued for.

### 2.1 Introduction and background: The call for decolonisation

The dawning of the democratic order in South Africa paved the way for a social justice framework to underpin the new school curriculum. However, researchers like Molefe (2016), Le Grange (2014), and Mudaly (2018) have critiqued the South African curriculum as still being rooted in colonial worldviews during the post-apartheid era. Adding to the discourse on decolonising science education, Boisselle (2016, p. 9) concludes that “Within a postcolonial space, science education that does and teaches science by including and respecting the community in which it occurs can create opportunities for cultural mediation that can help to craft relevant science curricula in a postcolonial space.”

Molefe (2016, p. 32) extends the decolonisation discourse by underscoring the importance of “ending the domination of western traditions, histories, and figures.” According to Mudaly (2018), exploring who produces knowledge is significant in decolonising science education. Kruger and Fataar (2017) call for a plurality of voices to re-imagine how we can view the curriculum using a decolonial lens. Decolonisation of the curriculum can be done by bringing together people of different cultures, races, nationalities, and experiences to collaborate to rethink how we can decolonise the curriculum. “Decolonisation allows ‘de-linking’ beyond current knowledge systems to reconceptualise the purpose of higher education through a

decolonised curriculum development process” (Moosa, 2018, p.65). Kincheloe (2008) described the importance of critiquing monocultural perspectives of who is the legitimate knower in academia. In this study, the *who* of knowledge production will be inspected. The purpose of this study is to diversify the composition of the *who* of knowledge production in textbooks and a part of the curriculum, thus disrupting the notion that scientists of western descent are the only legitimate producers of knowledge.

This study aims to find out which scientists of non-western descent pre-service teachers select to include into the science curriculum and why they select these scientists. These scientists' contributions will be examined. In line with my intention to depart from a colonial framework, I have learned that what knowledge is produced is inextricably linked to who produces it. The broader purpose is to examine how a part of the school science curriculum can be decolonised by including scientists of non-western descent and their knowledge productions. In this study, decolonisation of the curriculum involves troubling the current privileging of individuals or cultures in the curriculum to suggest a more equitable representation of knowledge holders. It focuses on engaging pre-service teachers in the decolonisation of the curriculum by re-focusing on the “who” of knowledge production.

## **2.2 Historical Perspectives of Colonisation**

Sefa Dei (2016) states history and eurocentric science have always been tools of colonisation. Grosfoguel (2013) provides historical examples of how intellectual colonisation has emerged. He has called these historical examples the ‘four epistemicides of the long 16th century’.

The four epistemicides are: (1) the conquest of Al-Andalus, and the expulsion of Muslims and Jews from Europe, (2) the conquest of the Indigenous Peoples of the Americas started by the Spanish, continued by the French and the English and still underway today, (3) the creation of the slave trade that resulted in millions being killed in Africa and at sea, and more being totally dehumanized by enslavement in the Americas and (4) the killing of millions of Indo-European

women, mostly through burning at the stake as witches because their knowledge practices were not controlled by men. (Hall & Tandon, 2017, p. 11)

According to Hall and Tandon (2017), these conquests converted Europe from being on the sidelines of an earlier dominant Islamic center of intellectual power to be the global focal point. I have highlighted these four conquests because they were not only military in nature but also epistemological.

At the pinnacle of the Al-Andalus Empire in Europe, the city of Cordoba had a library of 500,000 books. This was at a time when other intellectual centres in Europe would have had libraries of between 5,000 and 10,000 books. The Spanish burned the library in Cordoba, and libraries elsewhere. They destroyed most of the codices in the Mayan, Inca and Aztec empires as well. Women's knowledge, which was largely oral, was simply silenced, as was the knowledge of Africa. African slaves were portrayed as non-humans, incapable of western-style thought. (Hall & Tandon, 2017, p. 11)

Based on these historical events of epistemicide, it is not unreasonable to argue that science today contains colonial elements, and this is supported by Sefa Dei (2016, p. 32), who asserts "science has been colonizing by its omission of certain bodies of knowledge and by its celebration of certain bodies and knowledges". From this quote, I draw an understanding of 'certain bodies' being linked to producers of knowledge. Another reason for this study is to celebrate those 'certain bodies' that have been omitted and are not celebrated. In this study, these 'certain bodies' are the scientists of non-western descent. I raise these historical events so that I might provide a foundation in stating that if we are not critical about what knowledge is being taught, who are the producers, and how has it been produced, then this is "colonial work which science has through time been willing to serve" (Sefa Dei, 2016, p. 33). In short, if we normalise over-representation of western scientists in the science curriculum, then we are complicit in the perpetuation of - a form of insidious colonisation.

Historical events already mentioned indicate that the dominant forms of knowledge cannot be simplistically labelled as a manifestation of western knowledge (Connell,

2016). For example, it is often not emphasised that the number system used in science and mathematics is derived from Arabic, not European sources (Connell, 2016). The word algebra, the name for a vital mathematics section, is a derivative of an Arabic word which means 'completion or reunion of broken parts'. Algebra's linguistic origins are not known by many mathematics teachers, based on anecdotal evidence.

As the European scientific revolution marched on, data from the colonised world were not just mere additions, but they were fundamental to developing specific frameworks of knowledge. According to Connell (2016), modern evolutionary biology, for instance, got underway with Darwin's data-collecting in South America and the Pacific and Wallace's in the Dutch colonies in the East Indies. Einstein's general theory of relativity had its first significant test in observations of the gravitational bending of light made in the Portuguese colony of Príncipe, this society shaped by the Atlantic slave trade (Connell, 2016). Connell (2016) provides further evidence of corroboration, such as the data which had been transported to Europe by Humboldt from Spanish colonies in South and Central America, had assisted in the development of modern climate science. Atmospheric CO<sub>2</sub> accumulation was first traced by measurements in the U.S. colony of Hawaii, ideas seized from Polynesian rule half a century earlier (Connell, 2016). These exact and tragic moments in history have shaped what we call western science. The settings in which critical scientific knowledge and theories were formulated, were colonised spaces.

These instances in history support the claim that the colonised and postcolonial world have been a significant contributor in the construction of the dominant forms of knowledge in the modern era, which we quickly call 'western science' (Connell, 2016). The problem is not the absence of majority of the world (Connell, 2016), but its epistemological subservience within the conventional economy of knowledge. Incorporating scientists of non-western descent into the science curriculum will provide further evidence that these knowledge producers are not absent but are marginalised in the curriculum.

### 2.3 Colonialism and the South African Context

This section will briefly discuss colonialism and apartheid in South Africa regarding knowledge, academia, and higher education institutions. The Slovenian philosopher Žižek (2009) shares an old story of a worker suspected of stealing in his book entitled *Violence*. Every evening when the worker leaves the factory, his wheelbarrow is carefully checked, but the guards find nothing. Eventually, the penny drops: the worker is stealing the wheelbarrows. The story argues that we often focus on objects of inquiry without seeing the carriers of the items of investigation (Le Grange, 2016). The story is relevant to my study because it examines how the curriculum is a carrier of colonialism (Le Grange, 2016). “Colonialism included the invasion and takeover of foreign lands, subjugation of indigenous peoples, economic exploitation, and the use of knowledge and education to dehumanize colonized populations, diminish their cultures and humanity and maintain structural domination” (Heleta, 2018, p. 49).

Colonialism is a political act where one party cedes power (usually under threat) to another. Historically, colonization has resulted in large economic gains for the colonizer, and economic, religious, cultural, historic, geographic, and social rape, reconfiguration, and sometimes annihilation, for the colonized. (Boisselle, 2016, p.1)

Smith (1999, p. 28) argues that “Imperialism and colonialism brought complete disorder to colonized peoples, disconnecting them from their histories, their landscapes, their languages, their social relations and their ways of thinking, feeling and interacting with the world.” This statement is supported by Heleta (2018, p. 49) who states that colonial oppression destroyed “people’s histories, lives, and dignity.” From the previous section “Historical Perspectives of Colonisation,” it becomes evident that colonialists knew that knowledge is power. They knew that by destroying and pilfering other forms of knowledge, they would have control of not only the present but the lived experiences of the colonised and their future (Heleta, 2018). Colonial education and knowledge systems played a strategic role in promoting and commanding Eurocentric worldviews while obliterating and suppressing indigenous

memories, knowledge, and worldviews (Heleta, 2018). The Eurocentric curriculum focuses on:

The idea of Europe, as a metaphor, and turns all others into bit players or loiterers without intent on the stage of world history, either too lazy to do anything ourselves or always late, and running behind to catch up with western modernity (Pillay, 2015, para. 13).

Pillay's (2015) statement speaks to the notion that no matter how hard we try or how fast we run, our contributions to knowledge production will always be compared or assessed in contrast to western knowledge, which is regarded as "naturally" superior. In this study, I focus on western knowers' dominance which is valorised by authors of science textbooks since colonial times as the epitome of knowledge, as individuals who are the sole drivers of science advancement and civilisation. As a result of the insidious, harmful effects of colonisation, after 26 years of democracy in South Africa, calls for decolonisation are increasing.

The curriculum at South African universities continues to favour and reproduce Eurocentric knowledge and worldviews while other knowledge forms and worldviews are ignored, side-lined, or devalued (Pillay, 2015). According to Hall (as cited in Heleta, 2018, p. 48), "Eurocentric knowledge remains the epitome of truth, displacing all other knowledge forms, and according to Macedo (as cited in Heleta, 2018, p. 48), this omission is ideological. It is aimed at the maintenance of structural domination." Hence, in this study, by promoting the representation of scientists of non-western descent in the curriculum, the neglect of non-western knowledge holders is addressed. Students have called for the end of dominance by white, male, western, capitalist, heterosexual, European worldviews in higher education institutions. They have called for the incorporation of other South African, African, and global perspectives, experiences, and epistemologies' into the curriculum, including teaching, learning, and research in the country (Shay, 2016). Eurocentrism, racism, segregation, and epistemic violence at South African universities were not simply products of the apartheid state; rather, these problems were initiated with the establishment of the universities built by the British colonialists who propagated colonial policies and practices that further evolved after 1948 when the Afrikaner Nationalist Party came to power (Sehoole, 2006).

The British Empire colonised India, in a similar way to South Africa. In a recent study, Sharma (2019) states that colonialism “was not only a commercial and political entrapment of the colonies and the colonized but was also an extension of socio-cultural hegemonic dominance” (p. 2). Colonial universities in South Africa were constructed by the white settlers who viewed them as symbols and disseminators of European civilization (Pietsch, 2013). Pietsch (2013) and Ramoupi (2014) share the view that the universities' primary role at that time, was to propagate white supremacy and develop the white youth to maintain a colonial society.

In 1948 when the apartheid regime governed South Africa, the epistemic violence and racism at universities were taken to another level (Heleta, 2016). During the apartheid era, tertiary education was constructed to anchor white, sovereign power and privilege (Bunting, 2004). Race shaped the higher education policy; universities were deliberately built for the use of particular racial groups. Black universities were established to train black people to serve first the colony and then the apartheid state. Black universities embarked on teaching the young black students to become servants of the white masters (Ramoupi, 2014). The teachers at the black tertiary institutions were white academics, according to Bunting (2004). These higher education institutions were governed by authoritarian white Afrikaners who had graduated from Afrikaans-medium universities. Almost twenty-five years after the inception of a post-apartheid, democratic order, the tertiary institutions have not done enough to develop curricula that represent ideals of inclusion for all citizens regardless of race, religion, gender, or any other fundamental categorical terminology (Meda, 2019).

Today Higher Education Institutions (HEIs) in South Africa continue to display similarities to the HEI's in Europe; hence Eurocentrism and white supremacy continue to be promoted. The most remarkable transformation in higher education in contemporary South African society has been the transformation in student demographics, with black students and women being the mainstream of the student body (Heleta, 2018). Jansen (2017) stated that the presence of more black African curriculum developers, who are research productive and intellectually imaginative, is

fundamental to the process of decolonising the curriculum. Alluding to decolonising teacher education curricula in particular, Sayed, Motala, and Hoffman (2017) have emphasised the importance of an African-centered approach. However, a shift in academia has lagged, with white academics still being in the majority (Badat, 2007). Badat (2007) states that another failure has been the lack of curriculum transformation. Curricula at universities continue to be Eurocentric, rooted in colonial and apartheid knowledge systems, and disconnected from the realities and lived experiences of black South Africans (Badat, 2007). This has resulted in calls to decolonise the curriculum.

## **2.4 Decolonisation and the Curriculum**

Le Grange (2016) declares, “There are no simple answers to the decolonisation of the curriculum, and therefore the process should be embarked upon thoughtfully but also be open to experimentation from which much could be learned” (p. 6). The decolonised curriculum is based on the 4Rs. These 4Rs are *relational accountability, respectful representation, reciprocal appropriation, and rights and regulation* (Le Grange, 2016, p. 9). I will focus on respectful representation in my study. Respectful representation considers how the curriculum recognises and forms space for non-western people's voices and knowledge forms (Le Grange, 2016). Hence, this speaks to the main objective, which is to explore how pre-service teachers work toward decolonising a unit of work in the science curriculum by including scientists of non-western descent. The inclusion of scientists of non-western descent will inform respectful representation.

Wolff (2016) argues that decolonisation of the curriculum should not be understood as mechanically switching one body of work for another but as a demanding of the intellectual progression of diverting whatever cultural goods we have access to, to the advantage of solving essential questions of the African continent, one of which is decolonisation. Decolonisation does not mean going back in time by moving from modernity to olden times. We are in the digital era, and decolonisation does not mean eradicating technological advancement and retrogressing to when our planet was less densely populated than it is today (Mgqwashu, 2017). It does not mean going back to olden times when Africans were hunting and gathering, and students

were learning to utilize purely informal ways where older people of the community were keepers of knowledge (Meda, 2019). Meda (2019) mentions two approaches to decolonisation; the first is radical in that we reject all that western knowledge has to offer, the second approach is relevant to this study. It suggests an integrative method of both western and indigenous knowledge; therefore, a scientist of non-western descent, regardless of the knowledge canon to which the scientist subscribes, will be included in this study. The exploration of non-western scientists who subscribe only to non-western epistemologies would be an interesting study, one with great depth and breadth, but this lies outside my research scope. The integrative approach is plausible in South Africa, where students want African theories and theorists to be foregrounded instead of persistently following a curriculum that existed during colonialism and apartheid (Meda, 2019). Therefore, in my study, it is essential and relevant to identify scientists of non-western descent and focus on the *who* of a new knowledge production paradigm.

The curriculum is predicated on inherently political questions such as: 'what is the curriculum for?; or what purposes does it serve?'; 'how is it determined?'; 'how does the curriculum change?'; 'what makes a curriculum relevant?' and, perhaps most of all, 'whose curriculum is it?' (Webbstock, 2017, p.1). Curriculum scholars have distinguished three broad perspectives on curriculum that have not received much attention with universities viz the *explicit*, *hidden*, and *null* curriculum (Le Grange, 2016, p.7). The explicit curriculum is what students are provided with, such as module frameworks, prescribed readings, assessment guidelines, and so on. Students obtain information both explicitly and implicitly from the people and places they are exposed to within the learning environment, be it a primary school, high school, or a tertiary institution. This information contains messages that encompass the values, beliefs, and expectations of the learning environment and including those of the teachers. These messages have come to be known as the hidden curriculum.

It should be noted that the hidden curriculum is not taught explicitly; instead, it is taught implicitly through the teacher's expressions, type of words used during speech, and body language. The null curriculum is what is left out, – what is not taught and learned in an institution. In this study, the colonised ideology is part of the

hidden curriculum. The exclusion of alternative knowledge systems and other knowledge producers in science is viewed as the null curriculum.

The realisation of an effective decolonised curriculum cannot be calculated simply in terms of student's marks. Teachers can determine the instructional effectiveness of an inclusive, decolonised curriculum by asking and responding to critical questions (Sefa Dei, 2016): Examples would be: Are students able to probe new and vital questions from their learning? How are students interpreting questions of ethics and social responsibility? How do students apply their knowledge from their classrooms to their communities? Are students able to identify power relations within the curriculum? How do students place social justice, equity and fairness within their understanding of sound character and moral education?

According to Sefa Dei (2016, p. 51), answers to these questions can be highly disputed, but creating a space to examine and converse about these questions is "itself productive as it potentiates the opening of students' minds and nurtures multiple ways of knowing". The decision to implement a decolonised science curriculum requires a substantial commitment to providing appropriate resources such as customised science textbooks and professional learning training for all teachers (Aikenhead & Elliott, 2010). "The intellectual reliance of South African HEIs on knowledge systems of the U.S. and Europe is undeniable" (Mudaly, 2018). Western research methods and theories have become the symbolic brass ring to reach for in most countries (Connell, 2016). Curriculum ideologies, design, models, and textbooks from the Global North have dominated the intellectual culture and practices of most HEIs in the world and have re-established the valuing of "a single [western] episteme" (Connell, 2016, p. 8). Connell (2016) pronounces that there have been attempts in the re-making of textbooks and undergraduate module study material to include non-western perspectives, as well as greater diversity of content, but this has gone unhurriedly because major publishers still focus on western perspectives. The successful enactment of decolonising the science curriculum has been hindered by inadequate teacher education, among other things, and this has implications for teacher education programmes at universities (de Beer & Petersen, 2016; Jautse, Thambe, & de Beer, 2016). In this study, including scientists of non-western descent into the curriculum provides the foundation for further customisation

of science textbooks. The task of decolonising the curriculum is massive and we, may be blinded to the fact that the curriculum does not exist on its own. This is supported by Sefa Dei (2016), who states that curriculum and instruction are interlocking to give learning the desired form. This understanding speaks to the power-related issues about the “selection and engagement of texts, the content and forms of these texts, what mode of instruction and pedagogies are used to convey or dismiss meanings of texts, and how experiences of students and teachers become central to knowledge production” (Sefa Dei, 2016, p.36). As Wiredu (as cited in Koopman, 2018) noted, the term domesticates means to present knowledge that is foreign to a person in ways that take into account the person's lived realities. In the context of this study, domestication of western science would mean including scientists of non-western descent into the curriculum so that South African students will be learning about individuals who emerge from a similar “lived reality” thereby making science relatable and relevant to everyday life.

## **2.5 School Science Today**

How do most people view science today? The substantial emphasis on empirical evidence and objectivity propagated by modern western science often prevents an in-depth consideration of other ways of knowing (Aikenhead & Jegede, 1999). The philosophy of empiricism is partially to blame for how the public often views science as a body of facts, detached from other ways of knowing (Cook, 2015). This position implies that the only real knowledge is western scientific knowledge, which can only come from positively affirming theories through rigorous science (Cook, 2015). In this view, the process of scientific inquiry has nothing to do with the social, cultural, or metaphysical realms of life (Cook, 2015).

School science has Eurocentric elements (Le Grange, 2016). It usually attempts to enculturate all students into the culture of Eurocentric academic science, brimming with its undoubted knowledge, methods, and principles (Le Grange, 2016). Many science teachers aspire to the goal that all their students become capable of thinking like a scientist, behaving like a scientist, and believing what scientists are supposed to believe (Aikenhead & Elliott, 2010). However, teachers generally do not achieve this goal, except for the small percentage of students whose worldviews align with

the worldviews pervasive within Eurocentric sciences (Aikenhead & Elliott, 2010). Most students' worldviews differ from the worldview perpetuated by conventional school science (Cobern & Aikenhead, 1998). Aikenhead (2006) highlights the disconnect between worldviews of students' self-identities (that is, who they want to become versus who they think they must evolve into to progress in science), students' perceptions of Eurocentric science, and their science teachers influences.

The vast majority of any student population represents those who do not take a school science identity: this means thinking, behaving, and believing like a scientist (Aikenhead & Elliott, 2010; Higgins, 2016). Aikenhead and Elliott (2010) and Higgins (2016) corroborated the findings by Scott, Asoko, and Leach (2007) when they studied students' learning of science concepts. The researchers investigated (a) epistemological differences between scientists' ways of thinking and students' everyday ways of thinking (e.g., generalisable models versus context-specific ideas), and (b) ontological differences (e.g., energy as a mathematical tool versus energy as a concrete entity) (Aikenhead & Elliott, 2010). They concluded:

Learning science involves coming to terms with the conceptual tools and associated epistemology and ontology of the scientific social language. If the differences between scientific and everyday ways of reasoning are great, then the topic in question appears difficult to learn (and to teach). (p. 49)

Ontology is defined as the nature of reality (Scotland, 2012). As a result, the majority of students tend to experience school science as a foreign culture to varying degrees, but their teachers do not treat it that way (Costa, 1995). To be successful, students must learn to cross a cultural border between their own everyday culture and the culture of academic school science (Aikenhead, 2006). Brown and Spang (2008) state that the majority of students end up feeling isolated by the foreign language of science. This occurs despite supportive influences on students' learning (Shanahan, 2009). Thus, teachers find it challenging to achieve the enculturation of most students into a Eurocentric science. Osborne and Dillon (2008) stipulated in their research, which was conducted in Europe:

The irony of the current situation is that somehow we have managed to transform a school subject which engages nearly all young people in primary schools, and which many would argue is the crowning intellectual

achievement of European society, into one which the majority find alienating by the time they leave school. In such a context, to do nothing is not an option. (p. 27)

I highlighted several key problems in conventional school science, Aikenhead (2006) provides a basis for the need of a decolonised curriculum that is relatable to our students and which does not marginalise or alienate them.

1. While students continue to value Eurocentric science in their sphere outside of school, there is a distressing and deteriorating interest and decline of enrolment in secondary and tertiary science education (Schreiner & Sjøberg, 2007).
2. School science has a tendency to isolate students whose cultural identities diverge from the culture of Eurocentric science (described above).
3. Even though students understand scientific concepts as required in out-of-school settings (Albright, Towndrow, Kwek, & Tan, 2008; Rennie, 2007), they typically fail to learn academic science content meaningfully in school. For instance, Löfgren and Helldén (2009) conducted a 10-year longitudinal study which showed that only 20% of students achieved meaningful learning of the “molecule” concept.
4. Conventional school science is similar to mass media in that it delivers dishonest and mythical images of Eurocentric science and scientists, such as a positivistic ideology of technical rationality that supports “*the scientific method*” (Aikenhead & Elliott, 2010). Science teachers do not influence these factors; they influence one critical element: the degree to which students experience marginalisation or alienation in science classes (Aikenhead & Elliott, 2010).

Thus, future scientists, engineers, doctors, entrepreneurs, and teachers need a solid footing in an opulent, culturally varied, science education because Cajete and Suzuki (as cited in Aikenhead & Elliott, 2010, p. 9) stated that “if they continue to try to solve today’s problems with the same kind of thinking that caused the problems in the first place, the quality of life on earth is in jeopardy.”

Among the key resources to implement the curriculum in South Africa are textbooks. I turn my attention to these resources to explore how these can be more inclusive of science students.

### **2.5.1 The Importance of Textbooks within a Decolonised Curriculum**

Despite being receptacles of the intended curriculum, textbooks contain some of the hidden curriculum, shaping student's values, attitudes, and social skills (Kim, 2021). Kim (2021) states that the hidden curriculum can exhibit prejudices against particular race groups. The author further contends that textbooks, as a form of the hidden curriculum, contribute to children's personal development, shaping how they perceive themselves, ultimately affecting their academic and career choices. Textbooks also serve as a channel for achieving the intended curriculum goals in many nations (Foulds, 2013). Here in South Africa, the CAPS document (in different subjects) outlines the topics to be taught for specific grades. Still, the content curriculum is detailed in prescribed textbooks, and the educator is instructed to use a variety of textbooks to ensure maximum content coverage (DBE, 2011). In most countries, children can access the internet or, browse e-books on different websites. However, in towns and rural regions, textbooks continue to be the central support material for both students and teachers because they serve as a virtual repository of knowledge that both rely on and have proven to produce excellent results, especially in final matric examinations (Motshekga, 2013).

Textbooks direct teaching and learning because they deliver detailed subject matter (Nakagawa & Wotipka, 2016). Therefore teachers regard them as the primary source of information (Nakagawa & Wotipka, 2016). Topics to be covered for curriculum planning are summarised in the CAPS document in South African education (Motshekga, 2013). Most authors of textbooks have ensured that all the components of the curriculum are well covered in textbooks. Sections of the textbook content are organised such that all work to be taught in the term is structured to meet the requirements of the CAPS document (DBE, 2011). Therefore, textbooks are vital in order to direct the teaching and learning processes (Kim, 2021). Textbooks also improve the quality of teaching and learning (Motshekga, 2013) because their illustrations, particularly in science subjects, make the subject matter more understandable.

## 2.5.2 Evaluating and Revising Science Textbooks

Foster (2011) states that textbooks are viewed as the mechanism by which nations seek to disseminate and reinforce accounts that outline conceptions of nationhood and national identity. UNESCO (2011) states that textbooks are of value in nation-states because they hold statements that either promote their nations' ruling groups within one country and society, or censure the minority groups. The organisation further states that textbooks communicate political ideologies and justify political movements that the nation follows by infusing them with historical legitimacy. Since textbooks are regarded as the universal teaching instrument, they must be designed to be sensitive to the needs of students (Pingel, 2010).

Morgan (2012) states that textbook research was also meant to eradicate stereotypes from children's reading material so that they (children) would have a better understanding of foreign communities. He further states that effective textbook revision will help eliminate biases, misrepresentations, and hate messages.

Repoussi and Tutiaux-Guillon (2010) argue that nations use textbooks as tools of power whereby cultures and ideologies are disseminated. Pingel (2010) mentions that in addition to transmitting social norms, unprejudiced textbooks can be used to promote global understanding.

Bruillard (2011) mentions that textbooks contribute to the socialisation and acculturation of the younger generation. Foster (2011) regards textbooks as powerful cultural artefacts, embodying ideas, values, and knowledge that societies anticipate for students to know and embrace. UNESCO (2011) proposes that textbooks should offer a range of role models for all students, to illustrate that every skill is open to all genders. This document further recommends that processes of marginalisation and equality be expounded to students.

Students should be empowered to conquer the oppressive ideology of designated roles based on race, culture and gender (Kim, 2021). Students could also envisage themselves adopting roles that otherwise seemed forbidden to them. UNESCO (2011) further proposes that a quality textbook be stereotype-free to attain quality education. In addition to being effective and innovative, textbooks have to be

inclusive (Srivastava, 2014). The authors, editors, illustrators, designers, and publishers need to ensure that produced textbooks are gender-balanced and stereotype-free (Fairclough, 2013).

### **2.5.3 The Role of Textbooks in Schools**

Apart from developing the intellectual capacity of students, textbooks bring cultural awareness to students as societal members (Tomalin & Stempleski, 2013). In most societies, textbooks serve as tools for transformation because they convey culture, values, and societal beliefs (Srivastava, 2014). Children learn the concept of gender, for example, and this influences their self-image, behaviour, aspirations, and expectations, based on how the images of males and females are portrayed in textbooks (Pousa & López Facal, 2013). Other examples in textbooks where there is minimising or ignoring colonial violence and perpetuating western contributions over non-western contributions to knowledge as a norm, also affect students' self-image and future ambition.

Bruillard (2011) mentions several functions of textbooks. The first function is that they serve as a “referential”. The textbook becomes the primary document that provides the educational content in detail, thus making it instrumental in providing teaching methods and activities. The second function is that they serve an ideological and cultural function, contributing to socialisation and acculturation processes Bruillard (2011). Lastly, he mentions that textbooks play a documentary role, providing students with archives and symbols from which they develop critical thinking skills. The first function of textbooks relates to my study, as it highlights the background of the scientist as well as gender and race descriptions, which have an effect on students who adopt these scientists as “referential” points.

The development of students outside the classroom is shaped mainly by textbooks (Kim, 2021). All knowledge areas that the Department of Basic Education deems important, are embodied in the textbook. There is a reciprocal relationship between textbooks and teachers. Teachers are expected to work with students and facilitate construction of this knowledge. Generally, teachers accept this knowledge without question. Teachers are mandated to transmit the textbook knowledge as it is,

irrespective of whether it is obscured or not. This may present blurred perceptions of who students must become after schooling (Ndlovu, 2019). In my study, pre-service teachers will analyse textbooks, examine the representations of scientists, and how, this could possibly affect students.

## **2.6 Theoretical Framework**

A theoretical framework is defined as a specially designed set of lenses that a researcher uses to understand or view the world in a specific manner (Shahadat, 2014). Creswell (2009), states that a theoretical framework guides the study, reflects the researcher's stand intellectually, justifies the researcher's understanding of the concept being researched, and shapes what is viewed, and inquired (as cited in Ndlovu, 2019). According to Udo-Akang (2012), a theory is a collection of laws or relationships organised in a logical order and makes a clear explanation within a discipline. The theoretical framework provides a general representation of relationships between things in a particular phenomenon, thereby increasing or building upon knowledge effectively (Gay & Weaver, 2011). The theoretical framework provides a grounding base, or an anchor, for the literature review, and most importantly, the methods and analysis used (Grant & Osanloo, 2014). I chose theoretical frameworks based on my research objectives, methodology and phenomenon. Though according to Lysaght, "A researcher's choice of framework is not arbitrary but reflects important personal beliefs and understandings about the nature of knowledge, how it exists (in the metaphysical sense) in relation to the observer, and the possible roles to be adopted, and tools to be employed consequently, by the researcher in his/her work" (as cited in Grant & Osanloo, 2014, p. 12-13). Grant and Osanloo (2014) state that without a theoretical framework, a study's structure and vision is unclear, much like a building that cannot be built without a blueprint. By contrast, a research plan that contains a theoretical framework allows the dissertation study to be robust and structured with an organised flow from one chapter to the next.

According to the Oxford Dictionary (2019), the definition of the word 'concept' relates to an abstract idea or invention. I mention the word concept in relation to the conceptual framework, the conceptual framework is different from the theoretical

framework, and neither can be used interchangeably. These two terms can be distinguished by clarifying that a theoretical framework is derived from an existing theory (or theories) in the literature that has already been tested and validated by other researchers and is considered a generally accepted theory in scholarly literature (Grant & Osanloo, 2014). According to Merriam (2001), it is the researcher's lens with which to view and explore the world.

On the other hand, a conceptual framework is the researcher's understanding of how the research problem will best be explored, the specific direction the research will have to take, and the relationships among different variables in the study (Grant & Osanloo, 2014). The conceptual framework is best summarised as a system of concepts, assumptions, and beliefs that provide a foundation and direct the research plan (Miles & Huberman, 1994). Specifically, the conceptual framework "lays out the key factors, constructs, or variables, and presumes relationships among them" (Miles & Huberman, 1994, p. 440). Furthermore, Camp (2001) described a conceptual framework, emphasising that a conceptual framework is a construction of what has been learned to explain best the natural progression of a phenomenon that is being researched. The conceptual framework offers a logical scheme of related concepts that assist in providing a picture or visual of how ideas in a study relate to one another within the theoretical framework (Grant & Osanloo, 2014). It is not merely a series of concepts, but a way to identify and construct for the reader the specific epistemological and ontological worldview and approach to the topic of study. The conceptual framework also allows you to specify and define concepts within the problem and its investigation (Luse, Mennecke, & Townsend, 2012).

Grant and Osanloo (2014) mention an example from their work supervising dissertations where, one candidate relied on best practices in the research literature associated with special needs children's interventions. From national policies and protocols related to Response to Intervention (RtI), core principles of the Federal system (screening, diagnosis, and progress monitoring) were scrutinised in relation to parent perceptions of service provisions for their children. Thus, RtI and best practices literature served as the conceptual framework for the study. However, the theoretical framework was that of educational equity theory. In this study, the history of colonisation specifically in South Africa and the use of the educational system to

perpetuate colonised elements and ideologies within society during the apartheid era, served as the conceptual framework. However, the theoretical framework was that of critical theory and decolonial theory.

### **2.6.1 Critical Theory**

One of the established roots of this critical framework lies with South America's educational movement that is associated with Paulo Freire and his book *Pedagogy of the Oppressed* (Bertram & Christiansen, 2014, p. 47). Paulo Freire stated that solutions should not arise from the oppressors helping the oppressed, but it should arise from the oppressed helping themselves; in this case, teachers free themselves from following a dominant euro-western school science approach and support themselves by learning about alternative knowledge producers. I chose South America because its colonial history is similar to that of South Africa; therefore, the educational contexts are not significantly different. South America comprises a vast continent made up of many countries.

According to Maguire (2018), social division and the mistaking of a person's identity have reached a critical point; therefore, for a society to be just, it must create avenues for diverse and cohesive communities to prosper. To achieve this goal in our societies, education has to modify its perception of students as potential citizens and as compliant producers of the democratic communities in which they labour and inhabit (Maguire, 2018).

According to Rasmussen (1999), critical theory tends to create change in social orders, and Weston further states "it can upset and contest the existing state of affairs" (as cited in Adebayo, 2020, p. 45). Therefore, where events bring about "oppression, bondage, power relations, and unpleasant situations" (Adebayo, 2020, p. 46), the concept of critical theory challenges the status quo. Social transformation in this theory focuses on what is the source of knowledge and secondly, what would be the nature of such knowledge (Rasmussen, 1999, p. 12).

Changes in teacher's views (and possibly practices) about how particular scientists and their work is privileged, is envisaged in my study. Cohen, Manion, and Morrison

(2009) mention that critical theory focuses on change, empowerment, transformation, and emancipation; the main aim of critical research is to transform and change individuals. In this study, teachers' consciousness about the normalisation of western scientists' dominance in the curriculum is expected to be raised.

## **2.6.2 Decolonial Theory**

In this study, the Decolonial Theory was used to clarify and elaborate on possibilities of decolonising a unit of work of the science curriculum by including scientists of non-western descent as alternative knowledge producers.

Decoloniality is born out of a realisation that ours is an asymmetrical world order that is sustained not only by colonial matrices of power but also by pedagogies and epistemologies of equilibrium that continue to produce alienated Africans who are socialised into hating the Africa that produced them, and liking the Europe and America that rejects them. (Ndlovu-Gatsheni, 2013, p.11)

According to Ndlovu-Gatsheni (2013) decoloniality provides ex-colonised people an environment to critically assess Euro-American deceit and hypocrisy. Decoloniality exposes the fatigued epistemologies of Euro-America, thus opening an opportune moment for the delivery of decolonial epistemologies from the Global South in an effort to achieve cognitive justice. Epistemic freedom forms a strong foundation in the expansive decolonisation struggle because it facilitates the emergence of critical decolonial consciousness. "Epistemic freedom is fundamentally about the right to think, theorise, interpret the world, develop own methodologies and write from where one is located and unencumbered by Eurocentrism" (Ndlovu-Gatsheni, 2018, p.17).

Decolonisation is a comprehensive model that can be viewed from different theoretical lenses. For this study, significant constructs were drawn from deconstruction and decentering of the colonial curricula (Le Grange, 2016; 2018). From Le Grange's (2016) 4Rs, I will focus on respectful representation in my study. Respectful representation describes how the curriculum recognises and forms space

for the voices and knowledge forms of non-western people (Le Grange, 2016). Hence, this speaks to the main objective, which is to explore how pre-service teachers can work toward decolonising a unit of work in the science curriculum by including scientists of non-western descent. The inclusion of scientists of non-western descent will inform respectful representation. This inclusion involves a decentering of the colonial curricula as asserted by Le Grange (2018). Mudaly (2018) states that rediscovering and recovering is central to establishing an inclusive and just curriculum and in my study participants will work toward recovering knowledge produced by scientists of non-western descent. Hountondji (as cited in Kiti, 2013) identifies the re-centring ideology as the best approach towards decolonising the curriculum. This re-centring can be achieved through the inclusion of non-western knowledge producers into the science curriculum. Therefore, the incorporation of these non-western figures in the science curriculum speaks to decolonisation. Kiti (2013) has stated that African people have been weakened “socially, politically, religiously, technologically, economically and intellectually” (p. 1) because of their interaction with people of Euro-western descent, and this has driven African communities to the boundaries of society. Scientists of non-western descent are peripheralised in existing school textbooks.

Developing and designing local and national science curricula involves equity in knowledge representation within the curricula. In this study, it implies decentering but not excluding the Euro-western knowledge producers. The study aims to enhance respectful representation and, ultimately, non-western and western knowledge producers' co-existence in the science curriculum. This co-existence resonates with the argument by le Grange (2016, p.9) that the curriculum should be “rooted in the African context where students learn together about the origins of humankind and the epistemologies that emerged from the cradle of mankind”. This would infer that diverse students would appreciate their differences and form the need to respect and accept one another as they learn. The link between Critical and Decolonial Theory is the understanding that the oppressed are able to help themselves and by providing this opportunity of decolonising the science curriculum, the consciousness raising of the oppressed can be achieved.

## **2.7 Conclusion**

“A literature review explores previously conducted research on the same topic and identifies gaps in the literature to justify the need for additional research” (Struwig & Stead, 2013, p.30). This chapter presented the literature that I reviewed and the theoretical framework that I adopted as a lens through which to understand why specific scientists are represented in science textbooks. I organised the literature review into themes, beginning with a historical view of colonisation in South Africa, and decolonising the curriculum. I discussed school science in contemporary classrooms and turned my gaze towards school science textbooks and the effects of their ideological underpinnings - I concluded this chapter by discussing Critical and Decolonial Theory as a theoretical framework for this study. In the next chapter, I discuss the research design and methodology.

## **CHAPTER 3: Research Methodology**

Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers.

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### **3.1 Introduction**

In the previous chapter I presented the literature I had reviewed, to reveal a lacuna within the topic of decolonisation of the curriculum. I also provided details of the theoretical framework that I used as a lens, to understand the lack of representation of scientists of non-western descent in textbooks which would be analysed by pre-service teachers. I presented the research design, and methodology that I used to generate data.

This study adopted the qualitative methodology. I also provided a description of and justification for using the critical paradigm. Details of the purposive sampling that I adopted as a data generating strategy, are presented. The methods of data generation included document analysis and individual interviews, and these details are discussed in sub – section 3.6.2. The outline of the data analysis and procedures are in sub – section 3.7. Lastly, I discussed how validity, reliability and rigour are achieved through applying the principles of trustworthiness, in sub – section 3.8.

Research design relates to the research structure that shows how all major parts of the research project work together to address the central research questions (Cohen, Manion, & Morrison, 2013). Research design comprises the paradigm, research methods and instruments, and data analysis procedures. This section is organised into the following sub – themes: paradigm; research approach; sample and sampling strategy; recruitment; data generation; validity, reliability and rigour; ethical considerations.

### **3.2 Paradigm**

Bertram and Christiansen (2014) state that a research paradigm represents a specific view of the world, which informs the researcher what is acceptable to research and how this should be conducted. When exploring phenomena within a

particular paradigm the following should be considered: 'What kind of question is supposed to be asked?, What can be observed and investigated? How can data be collected?, How can findings be interpreted?.' (Bertram & Christiansen, 2014).

According to the critical paradigm reality is shaped by political, social, cultural, economic, and other dynamic forces (Pham, 2018; Riyami, 2015). In my understanding, with regards to politics, this means that the reality learners and teachers in our schools are experiencing is directly related to what politicians decide to incorporate into our curriculum. The narrative of white-western males as the only source of knowledge production continues to be perpetuated in our science textbooks. This narrative creates a false reality to our learners, thereby failing to produce learners that can think critically and problem solve. Creswell believes that "research should contain an action agenda for reform that may change the lives of participants" (as cited in Pham, 2018, p. 4). The ontological position of the critical paradigm is historical realism. "Historical realism is the interpretation that reality has been moulded by social, political, cultural, economic, ethnic, and gender values; a reality that was once deemed plastic has become crystallized" (Guba & Lincoln, 1994, p. 110). This implies a rigidity which creates dichotomies and difference. Realities are socially constructed entities that are under constant internal influence (Scotland, 2012). Knowledge is both socially built and influenced by power relations from within the social order. Cohen et al. (2009, p. 27) explains, "what counts as knowledge is determined by the social and positional power of the advocates of that knowledge". Goertz and Mahoney (2012) further claim that the ontology of the critical paradigm is that politics shape multiple beliefs and values to perpetuate the interests of only one social power, that is privileged and dominating over the other, the latter also being under-represented.

Burrell and Morgan (2017) argue that according to the critical paradigm, there are several ways of knowing the truth, and that the truth is socially constructed by communities of practice through media, institutions, and society. Hence, this study interrogated the representation of scientists of western-descent over their non-western counterparts in science textbooks. What this representation, communicates to communities about who are the advocates of power, whose interests (between

scientists of western-descent and scientists of non-western descent) are served by political ideology in textbooks, and whose interests are negated, is made visible. The critical paradigm is anti-foundational; it attacks this reality (Scotland, 2012). Reality is mutable by human action. The critical paradigm seeks to address issues of social justice and marginalism. The emancipatory function of knowledge is embraced within this paradigm (Scotland, 2012).

Scotland (2012) states:

As it is culturally derived, historically situated and influenced by political ideology, knowledge is not value free. The critical paradigm asks the axiological question: what is intrinsically worthwhile? Thus, the critical paradigm is normative; it considers how things ought to be; it judges reality. The utopian aspirations of the critical paradigm may never be realized but a more democratic society may materialize. (p. 13)

According to Scotland (2012), the critical methodology is focused on interrogating values and assumptions, exposing hegemony and injustice, challenging conventional social structures, and engaging in social action. The critical paradigm reveals how political ideology is inextricably intertwined with knowledge, but problems exist when conducting research which is informed by the critical paradigm. Scotland (2012) outlines these problems: critical research has an agenda of change; therefore, it is often not supported by existing regimes. An interchange of equals is practically impossible as power differentials between researchers and participants exist. A significant degree of obligation will be existent for students to participate; it would be difficult for a student to decline a teacher on whom they are dependent for grades and access to resources (Nolen & Putten, 2007). Hence, emancipation is not guaranteed. The transformation in the participants' lives may be negligible or non-existent (Scotland, 2012).

Scotland's (2012) critical paradigm stereotypes participants in two ways. Firstly, it often tags participants as fitting into a particular marginalized group; therefore, homogeneous notions of identity are superimposed. Secondly, the critical paradigm does not acknowledge that different participants enter the research with varying levels of conscientisation.

I will work within the critical paradigm. According to Pham (2018, p. 4), the critical paradigm provides a crucial foundation for researchers to “continuously explore and solve contemporary issues of today’s social contexts”. Taylor and Medina (2013) state that the critical paradigm is useful because it allows researchers to detect, assist, and challenge gross power imbalances in society. In my study, the imbalance related to the under-representation of scientists of non-western descent, will be addressed.

The Euro-centric curriculum in South Africa maintains the social class orders and gives one social class more privilege than the other (Le Grange, 2016). Therefore, by designing my project within the critical paradigm, “possibilities for raising teachers’ consciousness about who and what is valued in curricula, increase” (as cited in Pham, 2018, p. 5).

### **3.2.1 My position as a researcher**

I am a Life Sciences teacher and I have become aware of the colonial nature of the science curriculum by analysing textbooks and identifying the lack of representation of scientists of non-western descent and the knowledge they produce in textbooks we use to aid us to teach learners. I do not know the participants in my study on a personal level.

Bourke (2014) argues that when researchers declare their position upfront, they become cautious of their own biases and assumptions regarding the phenomenon being investigated. This declaration enables the researcher to avoid biases in the study conducted. This is supported by Cohen, et al., who states that “what counts as worthwhile knowledge, is determined by the social and positional power of the advocates of that knowledge” (Cohen, Manion & Morrison, 2007, p.7)

Therefore, declaring my position helped me be aware of my subjectivity. I would recurrently reflect on my stance to ensure that my subjectivity did not corrupt the outcomes. Subjectivity enabled me to draw from my own experience and better understand our science curriculum, using a critical lens. Realists argue that the natural and the social world exist autonomously from human action and observation.

The critical paradigm empowers individuals with the relevant knowledge, to use it to challenge the status quo and bring transformation.

In my study these individuals were the pre-service teachers who were invited to participate in this study and to challenge the colonial nature of the science curriculum. I did not know the participants but extended an invitation to them to participate, via their tutor. According to the critical paradigm, knowledge is subjective. What one sees depends on their perspective. I was not neutral in this undertaking because I was also interested in decolonising the curriculum.

### **3.3 Research approach**

An ideological critique approach was adopted in this research.

Critical theory is a critique of ideology: Ideologies are practices and modes of thought that present aspects of human existence, that are historical and changeable, as eternal and unchangeable. Ideology critique wants to remind us that everything that exists in society is created by humans in social relationships and that social relationships can be changed (Fuchs, 2016, p. 7).

The approach was suitable because the plans of pre-service teachers to decolonise the work by making it inclusive of scientists of non-Western descent was privileged. Ideological critique was central to the data generation by the participants. Using ideological critique, participants were able to discern how human subjects can be instrumental in the reproduction of domination and exploitation (Fuchs, 2016).

Critical studies that incorporate qualitative research in which there are emancipatory goals includes researchers that are committed in exposing social corruption and transforming oppressive policy. "Critical studies as qualitative research in which the researcher is committed to exposing social manipulation and changing oppressive social structures and in which he or she may have emancipatory goals." (McMillan & Schumacher, 2014, p. 2). I obtained thick, detailed descriptions through interviews about pre-service teachers' awareness about the Euro-centric dominance of knowledge producers in the school science curriculum. I also obtained descriptions of how these pre-service teachers attempted to include non-western scientists'

contributions in the planning of their lessons. This approach was appropriate for my research question, which sought opportunities for representations of scientists of non-western descent, in science textbooks. Physical Sciences and Life Sciences textbooks from grade 8 to 12 were analysed within this study.

### **3.4 Research Design**

The research design selected is a participatory method that promotes the participants as co-researchers who generate their data, rather than the researcher collecting data about other persons. However, according to Bergold and Thomas, having an outsider researcher present enables the participants to “step back cognitively from familiar routines, forms of interaction, and power relationships in order to fundamentally question and rethink established interpretations of situations and strategies” (as cited in Bertram & Christiansen, 2014, p. 48). In my study, pre-service science teachers stepped back from familiar routines of facilitating knowledge construction from contributions of scientists of western descent. They reframed what they taught by including contributions of scientists who are of non-western descent.

What makes research ‘participatory’ is not the type of research methods used, but rather the depth of involvement participants have in the whole research process (Kindon, Pain & Kesby, 2007). Inquiries about control and power, especially in the potentially exploitative relationship between the researcher and the researched has led to calls for more equitable collaboration in the research process (Kindon, Pain & Kesby, 2007). Thus, rather than purely ‘knowledge for understanding,’ participatory research also focuses on ‘knowledge for action,’ successful participation then, is achieved through partnerships between seasoned researchers and laypeople (Bagnoli & Clark, 2010). In my study, the pre-service teachers served as co-creators of knowledge about the inclusion of scientists who are of non-western descent and their contributions to the curriculum. In this way I sought to decrease the power hierarchy between myself and the participants, and address the criticism directed at critical research. I addressed the “power hierarchy” between myself and the participants by working with them rather than by instructing them.

The participatory design allowed pre-service teachers the freedom to address the Euro-centric bias in the curriculum. Participatory research is often implemented in community development. The aim was to enable people in a community to solve their community's problems, therefore, it is a change-generating style (Bertram & Christiansen, 2014, p. 47). Hence, the participatory design was implemented in the pre-service teacher community, in this study. The challenge was to decolonise a unit of work in the science curriculum by addressing the extent to which particular groups of knowledge producers are represented in the curriculum materials.

### **3.5 Sample and sampling strategy**

Participants in qualitative research are uniquely positioned to help the researcher understand what happens or what things mean. Convenience sampling (also known as Haphazard Sampling or Accidental Sampling) is a type of non-probability or non-random selection where members of the target population that meet specific practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the study (Etikan, Musa & Alkassim, 2016). The convenience sampling technique applies to qualitative and quantitative studies, although it is most frequently used in quantitative studies. (Etikan et al., 2016). According to Bertram and Christiansen (2014), convenience sampling is not driven by a particular purpose. The disadvantage of convenience sampling is that it is likely to be biased, thus, it is advised that research that uses convenience sampling should not be taken to be representative of the population under investigation (Etikan et al., 2016). Convenience sampling was useful because forming groups to develop the lesson plans with participants, was more practical in order to comply with COVID-19 protocols that the HEI had instituted.

Pre-service teachers were ideal candidates in this study because they are relatively inexperienced and have not yet developed set strategies in their teaching practice. In contrast, seasoned teachers are most often reluctant to change the way they teach and how they teach, in my experience. One of the more multifaceted processes in the teaching profession is learning how to teach (Darling-Hammond, Newton, & Wei, 2013). There was a poor response to the study due to it being conducted remotely and due to other social problems that arose from the COVID-19 pandemic. These

included pre-service teachers having to leave campus, return home and their limited internet access. They were not able to access the internet on campus, this was due to new COVID-19 protocols on campus that limited certain groups of students' entry. To overcome these challenges, social applications such as WhatsApp were used to communicate with participants and it enabled participants to collaborate with one another.

Thirty pre-service teachers who were registered to study Natural Science at Year 3 level were expected to participate in this study. They were conveniently chosen from the registered stream of students in the Natural Sciences 211 module of the first semester of the 2020 academic year. My supervisor arranged with the tutor to have access to these pre-service teachers via their lectures. I used WhatsApp messages to send out consent forms to pre-service teachers to participate in the study. The Natural Science pre-service teachers were divided into 5 groups, each comprising six members. From this cohort, 11 participants agreed to be interviewed, thus interviewees were selected based on participants availability for said interviews.

### **3.6 Data generation**

Two plans for data generation were devised: Plan A which involved social engagement and Plan B, which involved social distancing. In this study Plan B was used. Plan A was not viable due to the impact of COVID-19 and the lockdown of campus but I have included a description of Plan A in this section to highlight how COVID-19 has impacted my study. Plan A was constructed based on pre-service teachers and myself having access to the campus and being able to socialise face to face, within the pandemic regulations. The five groups of 6 participants each, were required to develop a lesson plan that incorporated a non-western scientist. Focus group interviews were planned to generate more in-depth information about why they chose a particular scientist. These interviews would be audio-recorded.

The participants would present their lesson plans to the remaining participants in a micro-teaching activity, which would be video-recorded. A semi-structured observation schedule was planned to gather information on how they incorporated the non-western scientist into the unit of work prescribed in the CAPS curriculum.

The data generation methods for Plan A were:

- Focus group interviews – audio recorded
- Micro-teaching activity – video recorded

According to Check and Schutt (2012, p. 188), focus group interviews are “A qualitative method that involves unstructured group interviews in which the focus group leader actively encourages discussion among participants on the topic of interest.” Focus group interviews would permit me to obtain deep insights from participants on their views about the non-western scientist they have selected, how they incorporate this scientist into the unit of work, and the challenges associated with this task.

Data would be collected using focus group interviews and a semi-structured observation schedule of each participant’s micro-teaching activity. The comprehensive definition of micro-teaching was given by Yusuf, who referred to micro-teaching as “a training technique that allows pre-service teachers to master the teaching skills in a controlled environment before the actual class teaching” (as cited in Majoni, 2017, p. 32). Therefore this activity would provide pre-service teachers with the opportunity to practice teaching a decolonised unit of work within the natural science curriculum. However, due to COVID-19 restrictions, Plan A was not followed.

Plan B, which was used in this study, was constructed based on remote methods of data generation, in order to adhere to COVID-19 protocols. In Plan B each group was required to develop a lesson plan with resources such as a PowerPoint Presentation, which participants sent to me via email. Thirty pre-service teachers were selected to participate. Lesson plans were subjected to document analysis. Participants were interviewed individually via telephone or a video calling app, to explore why a particular scientist was selected and how the writings of that scientist were infused into a unit of work in the science curriculum. These interviews were audio recorded.

The data generation methods used in Plan B were:

- Document analysis
- Individual interviews (telephonic or a video calling app) – which were audio recorded.

According to Bertram and Christiansen (2014), an individual interview is a useful data collection tool for finding out:

1. What knowledge and information a person attains?
2. What are the person's values and preferences?
3. What are the person's attitudes and beliefs?

Interviews are often used in qualitative studies that involve human participation (Carter et al., 2014). The advantages of conducting interviews are as follows (Bertram & Christiansen, 2014):

Easier for participants to talk to an interviewer than to write long responses in a questionnaire. The data collected is much more detailed and descriptive than through a questionnaire. The researcher can ask more questions if the participant has not given sufficient detail initially. (p.83)

According to Creswell (2012, p.223), documents provide a vital data source that helps the researcher "understand central phenomena in qualitative studies." In this study, pre-service teachers' lesson plans were analysed to gain insight into how they incorporated scientists of non-western descent into the unit of work and thereby bring an equal representation of the sources of scientific knowledge.

According to Bowen (2009), document analysis has the following advantages:

Document analysis is less time-consuming and therefore more efficient than other research methods. It requires data selection, instead of data collection. Document analysis is cost-effective. The data (contained in documents) have already been gathered, what remains are for the content and quality of the documents to be evaluated. The researcher's presence does not alter what is being studied when analysing documents. Thus documents are said to have stability. (p. 31)

### **3.7 Validity, Reliability and Trustworthiness**

Tai and Ajjawi (2016) state that when a novice researcher intends to conduct a qualitative study, the novice should consider engaging the assistance of an experienced qualitative researcher. This is to ensure that rigour is carried out throughout the study. The word 'rigour' is defined as "the quality of being extremely thorough and careful" (Tai & Ajjawi, 2016, p. 180). In this study I engaged the assistance of my supervisor and other students and academics in the postgraduate cohort, thus ensuring rigour throughout the study.

There are many different views on validity because of the various research paradigms, research designs or styles, and the worldviews held by researchers. To ensure the trustworthiness of the data, Loh (2013) states that peer validation is useful to receive confirmation from individuals who are familiar with the themes of the interview and the theory behind the interview text. This individual was my supervisor who provided corroboration with regard to the interpretation of the data.

According to Baker and Edwards (2012), there is no 'magic number' for the exact sample size, as O'Reilly and Parker (2013) state, that the justification of a sample size needs to take into account the scope of the research, the nature of the research questions, the methodology being used, and whether the amount of data collected is sufficient in answering the research question coherently and adequately.

The more variety in data sources used, the greater the richness and depth of data obtained. Different methods that produce similar patterns contribute to the findings' rigour (Creswell, 2012; Polit & Beck, 2012). In this study, two data generation methods, namely, document analysis and individual interview were used. Multiple sources of data collection ensures the credibility of the research. Document analysis and individual interviews was selected primarily to follow COVID-19 protocols, instituted by the HEI.

In this study, the pre-service teachers were interviewed individually. The decolonised lesson plans that they developed, were analysed using document analysis. Validity in this research was obtained by engaging in individual interviews with 11 pre-service teachers, allowing for a better understanding of their experiences during the lesson planning process.

### **3.8 Ethical Considerations**

Ethics is a code of conduct that provides information to the individuals who participate in the study and allows them to see with the utmost transparency, what data is intended to be gathered from the research and how this information will be used, in the future. Ethics relates to the formulation, legislation, and dissemination of ethical issues related to the protection of knowledge (Le Grange, 2016). Ethics deals with the behaviour that is considered correct or incorrect (Resnik, 2015). Permission to embark on this study was attained from the College Ethics Committee and certain school principals. According to a 2002 study by Durrheim & Wassenaar, there are three principles regarding ethics (as cited by Bertram and Christiansen, 2014, p. 66-67) which are:

#### **3.8.1 Informed Consent and Autonomy**

Researchers are expected to obtain the consent of all participants involved in the study. All participants need to voluntarily take part and be given the freedom to withdraw from the study at any time (Bertram & Christiansen, 2014). Consent means that all participants should agree to be a part of the study, and that they should not be coerced to do so, or be included without their knowledge (Bertram & Christiansen, 2014). Participants should receive a clear explanation of the study to decide whether or not to participate in the study, without any doubt or fears. In this study, further consent was achieved by calling participants and explaining to them the aim of the study, what information was needed from them and how this information was to be used. The consent forms were given to all participants before research could begin. I indicated verbally and on the consent forms, that participants could withdraw without negative consequences and that participation was voluntary.

#### **3.8.2 Non-maleficence**

Put simply, non-maleficence means “do not harm.” This harm includes physical, social, or emotional damage. The researcher should conduct and finish his or her study leaving all participants in a neutral state or enhancing participants' lives

(Bertram & Christiansen, 2014). An example of how harm can be caused is the misuse of personal information. Therefore it is the researcher's responsibility to inform all participants of how the information will be made for the public.

Confidentiality of information is paramount here (Bertram & Christiansen, 2014). This was achieved by maintaining the pre-service teachers' anonymity that participated in the research.

### **3.8.3 Beneficence**

Any study conducted should have 'benefit' as one of its main aims. The study should benefit people, whether it is the participants, other researchers, or even society as a whole. In my research, pre-service teachers benefited by developing units of work that transcend prescribed work in the curriculum by adding decolonised elements into topics within the science curriculum. In my study pre-service teachers benefited because they were given the opportunity to think about producers of scientific knowledge differently, and to understand that education is not a neutral process.

### **3.9 Limitations of the study**

According to Simon and Goes (2013), limitations of a study are those circumstances that are not within the researcher's control. These may limit the extent to which the research can go and can drastically affect the conclusions drawn. The inclusion of only 11 pre-service teachers is one limitation of this study. It was the result of participants who had initially agreed to be a part of the study, but then rescinded their decision. This resulted in me having to solicit other willing participants. This study privileged one module in the tertiary education institution and the findings are context specific. Another limitation of my study was that most pre-service teachers are studying full time, thus making it difficult to find many pre-service teachers who would want to participate in a study with no compensation. The sample size consisting of 11 pre-service teachers was the main limitation because views from only 11 individuals make the findings non-generalisable. However, the sub-section 'Sample and sampling strategy' explains that the small sample size is less relevant in a qualitative type study.

### **3.10 Conclusion**

In this chapter, I presented the details of the methodology that informed the data generation processes of this study. I argued for using the critical paradigm, and a qualitative research approach. I described the choice of convenience sampling strategy, and justified this choice. The recruitment strategy, methods and instruments related to: data generation; validity, reliability and rigour, and ethical considerations, were also presented and argued for. In the next chapter I discuss data analysis and presentation of findings.

# CHAPTER 4: Data Analysis and Presentation of Findings

Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers.

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## 4.1 Introduction

In chapter 3, I provided the details of the methodology used to inform this chapter. I explained the suitability of document analysis and individual interviews as the methods that I used to generate data. I also provided the analytical framework that guided my analysis.

In this chapter, the analysis of the qualitative data generated through individual interviews and document analysis, is presented. To explore how pre-service teachers decolonise a unit of work in the science curriculum, responses that were related to the research questions were analysed. The literature review and associated theoretical constructs are presented in support of the emerging themes. Analysis of data in response to the following main research question of this study, is presented:

- How do pre-service teachers decolonise a unit of work in the science curriculum by incorporating scientists of non-western descent?

Five lesson plans and 11 individual interviews are analysed in order to answer these three sub-questions:

- Which scientists of non-western descent do pre-service teachers select to include in the science curriculum, and why they do so?
- How do pre-service teachers plan to include the contributions of these scientists into the science curriculum?
- What challenges do pre-service teachers encounter in working towards decolonising the curriculum by making it inclusive of non-western scientists?

In the analysis of each lesson plan (using document analysis), I described emerging themes, which relate to the research sub-questions. I also provided an analysis of how pre-service teachers planned to incorporate scientists of non-western descent, and selected content knowledge from the scientists' work to incorporate into the lesson (Table 2). The responses from the individual interviews were then categorised according to the emerging themes that were developed within each research sub-question.

Analysis of the content knowledge comprised the text (concepts being taught) and visual images (pictures of the non-western scientists, their educational and geographical background) that accompanied the lesson plans. I selected and presented images as evidence for the possibility of incorporating scientists of non-western descent into the science curriculum.

After the analysis of individual interview schedules, I also presented the discussion, by incorporating and intertwining what was said by the pre-service teachers and what has been said by other researchers, to corroborate pre-service teachers' experiences and strategies, which they used to incorporate scientists of non-western descent into the science curriculum. This discussion reveals the summary of how pre-service teachers decolonised a unit of work in the science curriculum by incorporating scientists of non-western descent.

## 4.2 Data presentation

The following codes are used to distinguish among data from different sources.

Individual Interview – II
Document Analysis Lesson Plan 1 – DALP1
Document Analysis Lesson Plan 2 –DALP2
Document Analysis Lesson Plan 3 –DALP3
Document Analysis Lesson Plan 4 –DALP4
Document Analysis Lesson Plan 5 –DALP5
Pre-service Teacher 1 –PST1
Pre-service Teacher 2 – PST2
Pre-service Teacher 3 – PST3
Pre-service Teacher 4 – PST4
Pre-service Teacher 5 – PST5
Pre-service Teacher 6 – PST6
Pre-service Teacher 7 – PST7
Pre-service Teacher 8 – PST8
Pre-service Teacher 9 – PST9
Pre-service Teacher 10 – PST10
Pre-service Teacher 11 – PST11

I used the technique deployed by Gray (2013) which is thematic analysis for identifying and examining patterns of meaning in the data. I coded data that had features related to decolonising the curriculum. The codes were then structured into themes (Maree, 2016). I used symbols to indicate the data source. For example, (II PST1) means data obtained from the individual interview of pre-service teacher 1. Data from five lesson plans was submitted and document analysis was carried out, where DALP1, for example, represents Document Analysis of Lesson Plan 1. The first and second sub-research questions and findings relate to the theme, the *who* and *how* of incorporating scientists of non-western descent into the curriculum, and how this enabled content transformation. First, pre-service teachers' were asked individually about the scientist that they had selected to include in the curriculum, and second, how they had planned (in their groups) to include the contributions of

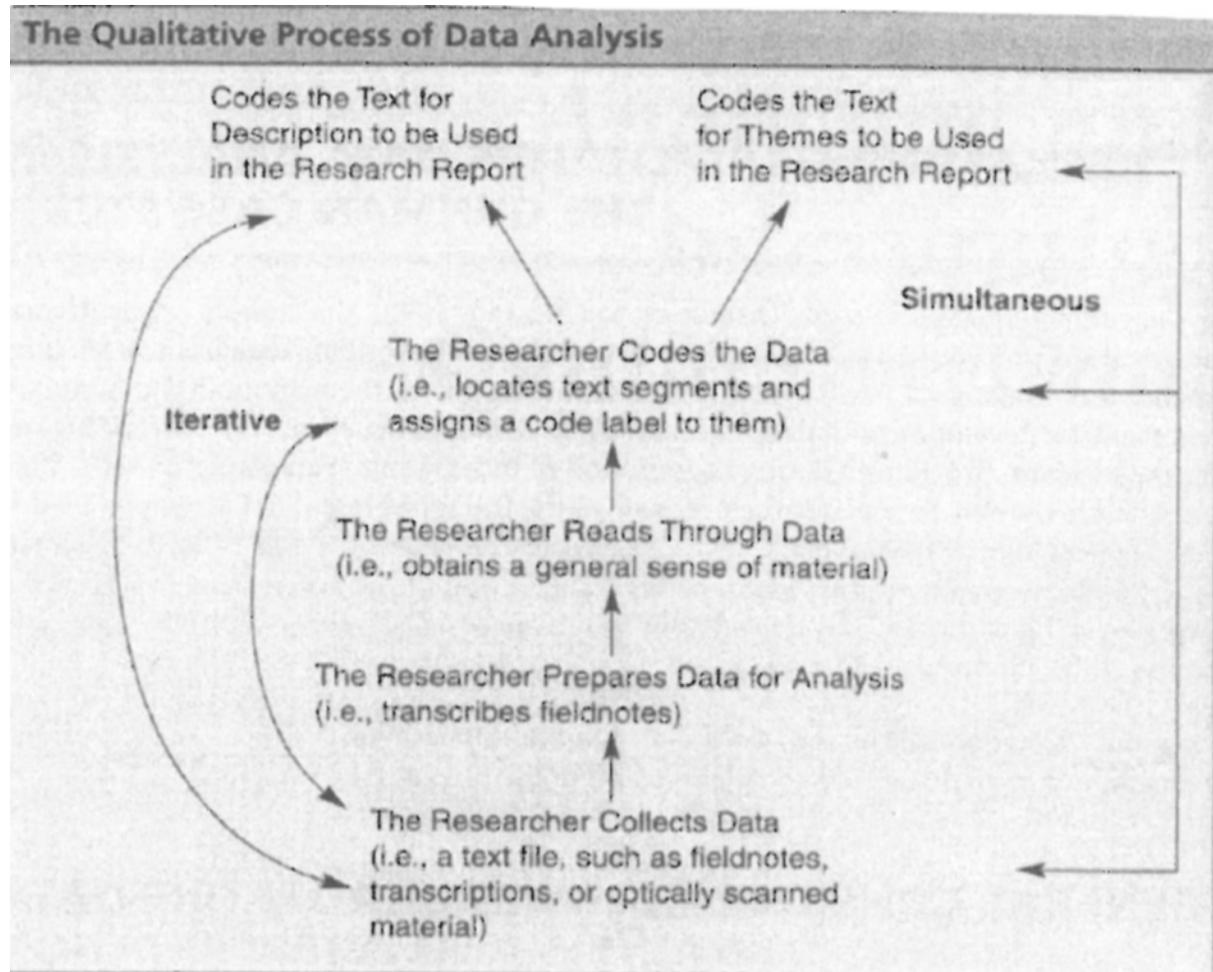
their selected scientist, to articulate with the topic that they had selected from the CAPS curriculum. I focused on identifying the pedagogy used by the pre-service teachers. The next aspect of the findings relate to what challenges the pre-service teachers faced in working toward decolonising the curriculum by making it inclusive of scientists of non-western descent. Also, I examined how this impedes the transformation towards a decolonised curriculum.

The qualitative data analysis used, is defined as being made up of three specific activities with a logical order: data reduction, data display, and conclusion drawing and verification (Corbin & Strauss, 2015). During data analysis, coding and categorising of the data was conducted. I structured the categories of data so that they would be meaningfully interpreted. Identifying topics or categories from the data and then coding these is called an Inductive Approach (Bertram & Christiansen, 2014; Carter, Bryant-Lukosius, DiCenso, Blythe & Neville, 2014). Qualitative content analysis as a method to analyse text data, was used. Zhang and Wildemuth (2009) define this type of analysis as a process of interpreting text data content. This data analysis allowed me to gain meaning from the results obtained, to understand the colonised underpinnings in the science curriculum. Analysing the lesson plans further allowed me to gain an understanding into why these specific scientists were chosen. Data from the interviews were also analysed to understand the pre-service teachers' perspectives on how they went about decolonising a unit of work in the science curriculum and what underpinned their choices in the process. The analysis also involved selecting the data and relating them to themes. I integrated the themes to generate meaning and understanding. To achieve this I used inductive reasoning which, according to Bertram and Christiansen (2014), involves beginning with raw data, detecting patterns or trends that emerge from the data, using these patterns and trends to formulate tentative hypotheses that can be explored and finally end up developing some general conclusions or theories.

Figure 1

*Qualitative Process of Data Analysis* (Creswell, 2012, p.237; Creswell, 2014, p.261)

Figure 1 further supports the method of data analysis that I used in this study.



### 4.3 Data Presentation and Analysis of findings

The first sub-question was 'Which scientists of non-western descent do pre-service teachers select, to include in the science curriculum, and why they do so?'. The scientists of non-western descent that were selected can be seen in Table 1. The themes that emerged were:

- Addressing dominance of white, male, western scientists
- Role models
- Teachers valuing inclusion of non-western scientists.
- Heightened teacher consciousness

The second sub-question was 'How do pre-service teachers plan to include the contributions of these scientists into the science curriculum?'. The lesson planning of pre-service teachers' to incorporate the scientists of non-western descent can be seen in Table 2. The themes that emerged here were:

- Self-teaching: Critical analysis of textbooks and access to knowledge from a variety of sources.
- Collaboration among pre-service teachers

The third sub-question was 'What challenges do pre-service teachers face in working towards decolonising the curriculum by making it inclusive of non-western scientists?' The themes that emerged were:

- Lack of support from school management (Heads of Department [HOD] and principals)
- Difficulty in tapping into knowledge of other experts.
- Lack of information about scientists of non-western descent from written sources.

The pre-service teachers' reflections on their experiences were captured in individual interviews which contributed significantly to the data. Themes emerged from the data through inductive analysis to provide a rich description of the views of the pre-service teachers. The views related to how pre-service teachers decolonised a topic in the science curriculum. Direct quotations from interview transcripts of the pre-service teachers, were presented in substantiation of the emerging themes. Finally, studies from the literature and associated theoretical framework, were presented in support of the emerging themes. The classification of the themes was done according to the specific research questions.

A detailed description of the findings related to the research questions follows. The themes were not mutually exclusive but several elements were found to overlap into other themes.

**4.4 Research Question One**

Which scientists of non-western descent do pre-service teachers select to include in the science curriculum and why they do so?

Table 1

*Pictures of the Scientists of Non-western Descent Pre-service Teachers Planned to Show their Students.*

LESSON PLANS	Pictures
<p><b><u>LESSON PLAN 1</u></b></p>	<p>Alice Ball</p>  <p><a href="https://scientificwomen.net/women/ball-alice-121">https://scientificwomen.net/women/ball-alice-121</a></p>
<p><b><u>LESSON PLAN 2</u></b></p>	<p>Flossie Wong Staal</p> 

	<p>Article-<a href="https://dailybruin.com/2020/08/06/biologist-flossie-wong-staal-remembered-for-pioneering-hiv-research-and-treatments">https://dailybruin.com/2020/08/06/biologist-flossie-wong-staal-remembered-for-pioneering-hiv-research-and-treatments</a></p>
<p><b><u>LESSON PLAN 3</u></b></p>	<p>Zeng Fanyi</p>  <p>Article-<a href="http://english.cas.cn/accessory/twows4th/twowsaward/201006/t20100627_55793.html">http://english.cas.cn/accessory/twows4th/twowsaward/201006/t20100627_55793.html</a></p>
<p><b><u>LESSON PLAN 4</u></b></p>	<p>Quarraisha Abdool Karim</p>



ARTICLE- <https://www.thewellproject.org/women-and-girls-south-africa-interview-quarraisha-abdool-karim>



Picture of Tongaat

**LESSON PLAN 5**

She was the first woman in East and Central Africa to receive a doctorate degree. She obtained a degree in Biological Sciences from Mount St. Scholastica College in Atchison, Kansas. She also received her Masters degree in Science from the University of Pittsburgh. She pursued doctoral studies in Germany and obtained a PhD (1971) from the University of Nairobi, where she also taught veterinary anatomy.

Wangari Maathai



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A street in the center of Nyeri, Kenya where Professor Wangari grew up.

#### 4.4.1 Theme One: Addressing dominance of white, male, western scientists

The decision making process of pre-service teachers in selecting a scientist of non-western descent to decolonise the science curriculum, is not simple because it is dependent on their access to information. It was noted that several pre-service teachers agreed that the current curriculum is colonised and that it should be decolonised to meet the needs of the type of students that teachers currently teach. The categories of race and gender motivated the selection of scientists to be included in the curriculum in most cases.

In the individual interview, pre-service teacher 3 (II PST3) set out to develop a lesson plan about the scientist, Quarraisha Abdool Karim whose life resonated with a majority of Indian students who comprised the student population in the schools in their community.

*“In the schools in my community there are mostly Indian students, therefore I did become aware that I will be teaching a class of Indian students so instead of promoting and perpetuating a white-western male as the only type of person that has the ability to produce great scientific discoveries I chose an Indian female scientist”* (II PST3)

This teacher (PST3) wanted to explicitly show Indian girls that females have the ability to become scientists. Such emphasis was to address the dominance of western-male scientists over their western and non-western female counterparts.

In the individual interview, pre-service teacher 1 (II PST1) set out to develop a lesson to suit the majority of black students in the classroom. For this reason, the pre-service teacher chose to incorporate a scientist of African descent into the lesson plan to explicitly show black pupils that individuals with African ancestry have the same ability to become scientists, and that this not exclusively the domain of white, western-men. The scientist chosen, was Alice Ball.

*“I first thought about the type of students I would have in my class, majority of the students would be black students therefore I went about surfing the internet, reading internet articles on scientists to find a scientist that would be relevant to my students and therefore cause some sort of interest and intrigue among them”* (II PST1).

*“I felt that a female non-western scientist (Quarraisha Abdool Karim) should be incorporated in the lesson plan because the contributions of male scientists are too often promoted over their female colleagues and I wanted the class to see that females can also be successful in science”* (II PST5).

*“Because student’s mindset needs to change, a common misconception is that science and mathematics is only for boys”* (II PST6). In this excerpt and others above, the pre-service teachers addressed gender dominance that makes science a masculinist discipline.

The above excerpts demonstrate pre-service teachers; commitment to disrupt the privileging of scientists who emerge from particular geographical contexts, race and gender groups.

In the following excerpts these intentions were highlighted:

*“We have very popular scientists like Albert Einstein, Louis Pasteur and Charles Darwin that are famous for many discoveries in science yet when we learn about HIV/AIDS no writer has ever thought of exposing scientists like Professor Quarraisha Abdool Karim and that has always left me thinking that white males are the only people who have a potential in science”* (II PST5).

*“Yes the study is useful. Women have for centuries been undermined and silenced by their male counterparts. I hope when I have children, they learn about scientists that are not only white males from the west. I really enjoyed researching about what women have contributed to science”* (II PST7).

#### **4.4.2 Theme Two: Role Models**

In most cases pre-service teachers reflected deeply on different aspects of their teaching practice. They examined curriculum documents and the prescribed textbook. This allowed them to uncover which scientists were privileged in the curriculum documents and textbooks. Pre-service teachers used a critical lens to determine which knowledge producers are dominant in textbooks. In the individual interview, pre-service teacher 1(II PST1) also thought deeply about the race group to which the students belonged. In this case these were black African students. In South Africa, race is intricately connected to ethnicity.

This knowledge of students allowed pre-service teacher 1 to design a lesson which was relevant to these students’ experiences, and this is evident by the following excerpt:

*“I chose Flossie because her work is relevant to the topic I intend to teach and also because Flossie is a female. My intention was to use her to be a role model for female students and encourage girls in my classroom to get into the field of STEM”* (II PST2).

In the above excerpt, the pre-service teacher purposefully chose not only a scientist of non-western descent but a female scientist of non-western descent, in order to

motivate female students to engage in fields of STEM. Female scientists, suffer triple discrimination in science, since they are marginalised based on race, gender and being located in the global south. (Gupta, Kemelgor, Fuchs, & Etzkowitz, 2005).

This purposeful choice of non-western female scientist is further substantiated by the following excerpts from other interviewees:

*“These scientists of non-western descent share a similar life background and therefore serve as role models, students can believe that science is not only for the white westerners but also for Africans, Asians and other racial or ethnicities”* (II PST1)

*“I chose her (Quarraisha Abdool Karim) because I wanted her to be a role model for the girls in the classroom, thereby empowering them and hopefully changing their mentality about science and mathematics”* (II PST4).

Again pre-service teachers’ belief that the curriculum should not favour only white males of western origin, surfaced.

#### **4.4.3 Theme Three: Teachers valuing inclusion of non-western scientists.**

The teaching capacity of pre-service teachers developed because they learnt about scientists of non-western descent. Most of the pre-service teachers relied on books from the library and surfed the internet to find information on scientists of non-western descent, who have also contributed valuable knowledge in science. They made an effort to make science relevant to their students. They accomplished this by incorporating scientists of non-western descent that shared a similar background to their students.

Pre-service teachers agreed that research into decolonising the curriculum is very useful but they also highlighted that this research needs to be implemented at tertiary levels as well as at primary and secondary school levels.

This was unanimously agreed upon, and the following excerpts support this:

*“I also wish that it does not end in research and studies but be implemented, be included in the curriculum because it is useful and very important especially for the young upcoming generation that will take their route in science”* (II PST1). Pre-service teachers found this a meaningful and worthwhile exercise, because it is a way in which teachers can motivate their students to pursue careers in science.

*“The study is useful and important as it uncovers the injustices of the past and incorporates sciences of all corners of the world and breaks stereotypes, norms and boundaries” (II PST2).* Pre-service teachers found incorporating scientists of non-western descent into the science curriculum to be a socio-political exercise as it aligned the curriculum with the democratic values we have in our constitution today.

*“Yes, tell you what when the word scientist is mentioned the image that comes to a person’s mind is a white man, old in a white coat. Why? Because that is the image we’ve been presented and set. This is why you’ll never hear about non-western scientists’ discoveries I think the whole thing originate from apartheid you will remember that during those time or simply that Africa and other are not taken serious in the science world. The only science we ever learn about throughout the school year is from a western, and western discoveries” (II PST9)*

*“I remember one time I read an article about a study that conducted on students to draw a picture of a scientist and most of them drew white looking males with lab coats and few drew females which goes to show the content isn’t recognising women and non-western scientist” (II PST3)*

*“Yes, most students would be exposed to our own milestones done by our scientist and appreciate it more, it would also bring a sense of national pride to them” (II PST3)* Pre-service teachers likened the exercise of incorporating scientists of non-western descent into the science curriculum with patriotism.

*“I hope that the curriculum in South Africa can become decolonised as soon as possible, I want the next generation to learn about scientists of non-western descent so that our country does not have to rely on west all the time” (II PST11).* Pre-service teachers envision a future in which we have a completed decolonised curriculum that truly reflects our democratic country’s aspirations for its people and future generations. The curriculum, in their view, should be inclusive of people from different contexts.

*“This study teaches students about other producers of knowledge and their importance, which I think is vital for our students to become the next generation of scientists” (II PST4)*

Pre-service teachers demonstrated the need to link the current content in the science curriculum to new faces, faces of scientists of non-western descent, thereby making

the content relevant to their students, and in the process breaking down gender-stereotypes, racial-stereotypes and geographical-stereotypes. They valued the incorporation of non-western scientists because they believed it addressed colonial and apartheid history which was the root for the marginalisation of these scientists. They realised that exposing students to non-western scientists would motivate students to pursue careers in science. They also viewed this as a valuable exercise to instil a sense of national pride, in learning about excellence in science achieved by South African scientists.

#### **4.4.4 Theme Four: Heightened teacher consciousness**

Pre-service teachers experienced a heightened consciousness of the colonised elements within the science curriculum. This was achieved- by analysing the science curriculum and reflecting on the injustices of the past in terms of white-western male scientists being privileged over their non-western male and female counterparts. This motivated pre-service teachers to learn and teach about scientists of non-western descent.

*“By taking part in this study I became aware of the colonised elements in the curriculum that suppress other sources of knowledge and put white western males on a pedestal as if they are only ones capable of producing scientific knowledge for the masses, unfortunately I couldn’t do anything about it because even our education system favours the western scientists”* (II PST1). This excerpt shows an awareness of superior status accorded to western scientists.

*“From high school I had noticed the dominance or the promotion of white, western males in the curriculum”* (II PST2). This excerpt shows an awareness of dominance of western male scientists in science curricula.

*“In all the school prescribed books I never encountered a female scientist of non-western and their findings”* (II PST2) This shows an awareness of marginalisation of women in science.

*“...To me it was something that I have never thought about. It was really surprising to see how much colonised elements are there, promotion of western males as producers of science discovery. Doing this research was eye opening for me and I*

*have learnt a lot*" (II PST6). This shows an awareness of the 'who' and 'where' of knowledge production.

Pre-service teachers realised that the colonised science curriculum is not simply privileging knowledge producers of western descent over knowledge producers of non-western descent. They were concerned about the exclusion of scientists of non-western descent and their contributions to scientific knowledge.

The following excerpts confirm this:

*"...I never noticed how colonisation of the curriculum suppresses other sources of knowledge until now in this EDNS 211 module"* (II PST4).

*"By taking part in this study and registering for this module I became aware of the suppression of other sources of knowledge as we are groomed to believe that everything has to be scientifically proven, if not it does not apply or exist"* (II PST5). This excerpt shows the awareness of exclusion, and so, the rendering of scientists of non-western descent as subaltern.

*"Yes, it makes us aware of the problems that are in the current curriculum and the mentality that most people have that only white and mostly western scientists came with scientific discoveries or research"* (II PST8).

Pre-service teachers reflected upon the decolonisation process, in their reading of research articles, in their conceptualisation of decolonising the curriculum and their own reconceptualising of previous ideas and thoughts. This new understanding informed the way they planned science lessons and the ways in which they taught.

*"I got a chance of understanding that my nationality does not matter in science, I don't have to be from the western countries to specialise in science and my gender does not have to be a boundary as Professor Quarraisha Abdool Karim is female and from a not so developed background"* (II PST5).

“I found it interesting to know that being a scientist isn't only about discovering new things but also about making contributions to make life manageable to people” (II PST10). This excerpt shows an awareness of the social value of science. This excerpt is in reference to Professor Quarraisha Abdool Karim and her discovery of CAPRISA 004: Tenofovir Gel which demonstrated effectiveness in preventing HIV and STD infections in women.

#### 4.5 Research Question Two

How do pre-service teachers plan to include the contributions of these scientists in the science curriculum?

The following table is a presentation of data from the document analysis of lesson plans.

Table 2

*The Lesson Planning of Pre-Service Teachers' to Incorporate the Scientists of Non-western Descent*

	<u>Scientist(s)</u>	<u>Link to CAPS</u>	<u>Pedagogy</u>	<u>Content</u>
<b>Lesson plan 1 (DALP1)</b>	Alice Ball	Grade 11 -Term 1 CAPS Page 39 Biodiversity •Micro-organisms: basic structure and general characteristics of the following group -Bacteria (links with Grade 9 and 10):	Pre-service teachers made use of audio-visual resources to expose students to positive role models. Interactive discussion. Student centred discussion using a movie as the prompt.  Showed students pictures of the scientists. A movie was planned to be screened for students to show them that females especially those of African descent are as capable as their white counterparts.  The movie called The Ball Method, based on real-life	Alice Ball discovered a treatment for leprosy.  At 23 years of age she had developed the technique of making 'chaulmoogra' oil injectable and absorbable by the blood stream.

		(Include leprosy and Alice Balls contributions to science in treating this condition effectively.	events of Ball's life, in which she developed a method called the Ball Method to effectively treat leprosy.	
<b>Lesson plan 2 (DALP2)</b>	Flossie-Wong Staal	Grade 11 -Term 1 CAPS Page 39 Biodiversity •Microorganisms: basic structure and general characteristics of the following groups (links with Grade 9 and 10): - viruses (HIV, include the contributions of Flossie here)	Show students pictures of Flossie a scientist of non-western descent.	Flossie Wong-Staal was a Chinese-American virologist and molecular biologist who cloned the human immunodeficiency virus (HIV) for the first time. By cloning and analysing the virus, Wong-Staal discovered how HIV reproduced and changed the body's cells, and was able to develop anti-retroviral drug therapies, — which help manage viruses.

				<p>She discovered how its genes work, a significant stride in our understanding and management of HIV/AIDS.</p> <p>She was among the first to identify HIV as the cause of AIDS.</p>
<p><b>Lesson plan 3 (DALP3)</b></p>	Zeng Fanyi	<p>Grade 12</p> <p>-Term 2</p> <p>CAPS Page 57</p> <p>Mutations</p> <p>-Genetic engineering: Stem cell research, genetically modified organisms, biotechnology and cloning.</p>	<p>The pre-service teachers planned to show students pictures of Zeng Fanyi a scientist of non-western descent. They made use of visual resources to teach about the scientist and her background- This would be done by a teacher-student discussion. And then followed up by a student centred discussion based on a YouTube video.</p> <p>They also planned to use a YouTube video showing the cloning of Dolly the sheep- <a href="https://youtu.be/q0B9Bn1WW_4">https://youtu.be/q0B9Bn1WW_4</a></p>	<p>Professor Zeng developed a method that made possible the molecular analysis of embryos at a very early stage.</p> <p>This allowed profiling more than 30,000 genes at major developmental stages and explaining key mechanisms of gene regulation, as well as signal pathways critical to mammalian</p>

				embryo development
<b>Lesson plan 4 (DALP4)</b>	<u>Quarraisha Abdool-Karim</u>	Grade 11 -Term 1 CAPS Page 39  The effect and management of one disease from each of the four groups:  Selected group was viruses-  HIV/AIDS	The pre-service teachers planned to show students a picture of Professor Karim and also a picture of Tongaat, which is a small town in KwaZulu-Natal, where Professor Quarraisha Abdool Karim grew up.  This made the scientist more relatable to students by highlighting that these scientists come from similar geographic locations as them. Pre-service teachers planned to have a discussion with students about the scientist and her background using the resources mentioned above.	She developed the CAPRISA 004: Tenofovir Gel which demonstrated effectiveness in preventing HIV and STD infections in women.  It is a gel that women apply to the vagina before and after having sex.
<b>Lesson plan 5 (DALP5)</b>	Wangari-Muta Maathai	Grade 10 -Term 1 CAPS Page 23  The need for fertilisers in over-utilised soils, e.g., where crops are grown and	Pre-service teachers planned to show learners a picture of Wangari-Muta Maathai and a street that is located in Nyeri, Kenya where Professor Wangari grew up.  Photo-elicitation- showing students a picture of the scientist to construct knowledge about scientist.	She presented the idea of community-based tree planting. She continued to develop this idea into a broad-based, grassroots organisation, the Green Belt Movement

		<p>regularly harvested, fertilisers are washed away into rivers, and eutrophication can take place.</p> <p>Eutrophication is one detrimental effect to the environment when there is mismanagement or inadequate farming practices.</p>	<p>Video to stimulate student-centred discussion on recognition of the scientist and her work in sustaining/conserving the environment.</p> <p>Practical, hands-on approach- students establish sustainable gardens to raise awareness of the value of plants.</p> <p>They also planned to show students a Youtube clip (<a href="https://youtu.be/dZap_QlwlKw">https://youtu.be/dZap_QlwlKw</a>) of her receiving the Nobel Peace Prize for her contributions to science and the geo-political landscape of her country.</p> <p>Pre-service teachers planned to provide students with an opportunity to grow plants which was the fundamental contribution of Professor Wangari's work.</p> <p><b><u>Assignment Task</u></b></p> <p>Students are to form groups of 5. The group must locate an area of 1m x 1m on the school grounds and select one type of plant to harvest. Each member in the group must plant their own seed and be responsible in watering his/her own plant on a</p>	<p>(GBM), whose main goal includes poverty reduction and environmental conservation through tree planting.</p>
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			<p>regular basis. For each plant that is grown and harvested the group will get 5 marks. The total marks for this task is therefore 25 marks.</p> <p>N.B As a group you need to prepare the soil before you plant your seeds.</p>	
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The strategies used by the pre-service teachers to decolonise the science curriculum within this study were shared by several participants.

**4.5.1 Theme One: Critical analysis of textbooks and access to knowledge from a variety of sources.**

Analysing the curriculum includes analyses of textbooks. Pre-service teachers choose textbooks that were commonly used or recommended by the Department of Basic Education. Analysing the textbooks enabled pre-service teachers to identify the scientists of western origin that were privileged. They also identified the topics within the science curriculum that could have been linked to the scientific contributions of the non-western scientists that they had selected.

*I briefly went through several textbooks to see if I could find a non-western scientist that was mentioned but I could not find any. I then relied heavily on the internet, website articles and also YouTube videos in finding information on our scientist of non-western descent and her contributions which could be aligned with a topic in the current science curriculum (II PST2).*

Pre-service teachers found the scarcity of scientists of non-western descent in literature that they reviewed disquieting and challenging.

Pre-service teachers used their access to ICT resources and access to other material resources to search for more content based on the CAPS science curriculum. They searched for scientists who had contributed to knowledge in the topic they had

selected, topics such as micro-organisms, mutations, effect and management of diseases and soil fertilisation. They found that the internet made it easy to find information.

In the following excerpts, this experience is evident:

*I accessed information easily from the internet (II PST2).*

*I then searched using my laptop, a scientist that took part or at least discovered something related to what is taught in schools, I then found out that Alice Ball are great scientist to feature in our lesson plan and above all, they are female and of African descent (II PST1).*

*I have my own laptop and internet access, and I also visited the library which has a lot of books on science. (II PST5).*

*I went about surfing the internet, reading internet articles on scientists to find a scientist that would be relevant to my students and therefore cause some sort of interest and intrigue among them (II PST1).*

*...then providing students access to the internet in order to find information on these non-western scientists themselves and discussing their scientific contributions to their classmates (II PST1).*

Pre-service teachers searched for more content based on the CAPS science curriculum. And they searched for scientists who had contributed to knowledge in that particular topic. They used YouTube videos to introduce and incorporate the contributions of these scientists of non-western descent.

This action is supported by the following excerpts:

*Pictures of scientists and YouTube video about animal cloning was used as visual resources. YouTube video will consolidate the work that the non-western scientists have contributed to cell research (II PST6).*

*.....YouTube videos about cloning helps to highlight the work these non-western scientists have contributed (II PST7).*

Pre-service teachers also used YouTube as a resource to introduce the scientists of non-western descent and teach the content knowledge that was developed by those scientists. Use of this strategy is confirmed by the following excerpts:

*There was also a YouTube video to show Professor Wangari Maathai receiving the Nobel Prize for her contributions in science (II PST8).*

*YouTube videos was a fast and easy way of learning about these other scientists and the work they have contributed and finding YouTube videos was also good because I could play them to the class as a conclusion or introduction to the lesson using my own projector (II PST9).*

*The use of YouTube videos on Micro-organisms, harmful micro-organisms and use of textbook activities (II PST11).*

The use of YouTube videos to initiate discussion and stimulate student interest formed the pedagogical strategy which was intended to maximise student interaction.

The preceding data represents sources that teachers accessed in order to learn, and this is evidence of - self teaching, taking responsibility for one's own learning. In the document analysis of the lesson plans it has been highlighted that pre-service teachers planned student-centred lessons, which included student-teacher and student-student discussions. Pre-service teachers planned the use of audio-visual aids such as images of the chosen scientist of non-western descent and images of the locations in which the chosen scientists of non-western descent had grown up. These pedagogical strategies further informed their planning.

#### **4.5.2 Theme Two: Collaboration among pre-service teachers.**

The significance and importance of collaborative efforts were overwhelmingly acknowledged by the pre-service teachers. The process of decolonising a selected topic within the science curriculum aided the pre-service teachers to investigate criteria and to do group work. To achieve this set goal a collective effort was required. The social and intellectual experiences of collaborating as investigators are evident in the following excerpts:

*As a group, we looked through recommended science textbooks to find topics in the science curriculum that would link to the work of our selected scientists of non-western descent (II PST1).*

*Instead of centralising the lesson around a scientist of western descent, we planned to incorporate pictures of our non-western scientist and elaborate on her background (II PST1).*

*I was surprised to see how as a group, we brainstormed ideas to develop this lesson plan. This whole process of decolonising the curriculum has made me become aware that the effects of colonialism is still present in society today (II PST8). Our science curriculum is colonial in nature because it does not promote the knowledge of people of colour (II PST8).*

*I feel that by working with others it helped me better understand what we were actually doing and by working as a team it made it easy to achieve our goals because we had many discussions over WhatsApp groups and WhatsApp calls (II PST9).*

*Working with others on the lesson plan helped me understand the decolonial nature of the curriculum and also kept us from going in the wrong direction in terms of achieving the goal of our task (II PST10).* This excerpt highlights the importance of a team effort and collaborating with others to navigate teaching and learning towards a goal.

*I've gained a lot of experience on researching and in working with other people. It has made me more aware of the Eurocentric and white-male dominated nature of the CAPS science curriculum (II PST11).*

*At the beginning, we were not very productive because we did not know how to start this project. However, as we moved along sharing ideas, I was enlightened, and I believed that we can accomplish this goal of decolonising the chosen unit of work (II PST6).*

Participants valued the strategy of teamwork. They used WhatsApp and other forums to discuss and brainstorm, as they analysed the curriculum, then planned to address inequality related to representation of scientists in the curriculum.

## 4.6 Research Question Three

What challenges do pre-service teachers encounter in working toward decolonising the curriculum by making it inclusive of non-western scientists?

### 4.6.1 Theme One: Lack of support from school management

Pre-service teachers reflected upon their experiences during teaching-practice. They identified managerial and administration challenges that hindered the process of working toward decolonising the curriculum by making it inclusive of non-western scientists.

The following excerpts elaborate on these challenges:

*Thinking back to my experiences in teaching practice I don't think I would be given the time and support to incorporate a non-western scientist into my lesson plans because the principal did not encourage creative and new ways of teaching and learning, he is old school and still believes in chalk and board and textbook as the only way to teach (II PST2).*

In the above excerpt the following insights are revealed: Obstacles such as time constraints, lack of support from staff, school leadership confined to traditional methods of teaching and possibly subscribing unknowingly to Euro-western ideologies. The management team was unsupportive of new thinking and new ideologies.

*I called and emailed teachers from the schools in my area to ask for help, the staff members in the science department are not really interested in the task that I had to conduct, everyone at schools are only focussed on completing syllabus and uploading marks (II PST3).*

The preceding excerpt provides insight into the experiences which characterise school life: Teachers are too busy and they do not have the time to invest in new teachers who have different ideas. Some teachers have neither the time nor the inclination to support creative new ways of thinking and teaching school science

*I am not sure if this a challenge for this study but I feel that when young new teachers enter the schools, the senior teachers especially the HODs like to stamp their authority*

*in terms of how to teach. I have had bad experiences in that I was not able to teach the way I had planned to teach during teaching practice by introducing videos and giving students a chance to discuss with each other in the lesson (II PST4).*

*From my experience in teaching practice, to actually spend time conducting a lesson like this is very difficult. Some HOD's are very strict and narrow minded in that they like to have things done one way and no other way can be accepted, therefore I don't think I'll have the freedom to adapt and change my teaching methods when I do become a professional teacher (II PST11).*

The preceding view provides a glimpse into some school management approaches: The authoritarian style in school management limits what new teachers can do. The restrictions imposed by school managers is possibly rooted in parochial thinking.

#### **4.6.2 Theme Two: Difficulty in tapping into knowledge of other experts**

Networking, forging links with more knowledgeable others in any field is invaluable to the process of learning. By drawing from the past strategies of seasoned teachers it allows us to better understand the purpose of the curriculum.

It should be noted that pre-service teachers made efforts to collaborate not only among one another, but they tried to gain insight from seasoned teachers and lecturers in the field of science education. Very few pre-service teachers were successful in obtaining assistance from the more seasoned teachers.

The following excerpts draws upon their attempts:

*I also tried asking my science teacher from high school to help me with incorporating the non-western science into the unit of work, but she did not understand that the science curriculum is colonised (II PST1).* This reveals that some senior teachers normalised the exclusion of scientists of non-western descent in the curriculum.

*I tried emailing teachers from my high school for help and I also emailed lecturers for help but I think because of the coronavirus I did not get a response (II PST2).*

*I called and emailed teachers from the schools in my area to ask for help, they could not help as they did not have the time and they did not know that the science curriculum is colonised (II PST3).*

#### **4.6.3 Theme Three: Lack of information about scientists of non-western descent from written sources**

Pre-service teachers found it difficult to find information about the lives of scientists of non-western descent. Information about scientists of non-western descent is very scarce, and this further amplifies the suppression of their contributions to scientific knowledge, as noted below:

*And their work is not published in books and very limited on the internet (II PST4).*

*It was very challenging to find non-western scientist, we couldn't find them on NS textbooks, they were not mentioned (II PST11).*

*The main challenge that I encountered was that it was extremely hard finding information about non-western scientists, even if we do get an information it was limited (II PST6).*

*The one most specific challenge was because there are very few recognised non-western scientists. And their work is not published in books and very limited on the internet. So, finding them and also trying to incorporate their work in the lesson was very challenging (II PST4).*

The work of scientists of non –western descent is not published especially in school science textbooks that are promoted to students, they are not recognised here. There is sparse information on them, thus a vicious circle of subtle colonialism persists. To disrupt the reproduction of this pattern, opportunities should be created for teachers to engage in exercises that focuses on previously excluded knowledge producers.

It is possible that decolonised elements introduced into a unit of work (for example, introducing images of scientists of non-western descent) would reflect a modification in curriculum. This modification could lead to transformed views about the notion of valuable knowledge and legitimate knowledge producers, within the science classroom. Transformation according to Gramsci (1997) means a modification. Gramsci (1997, p. 161) emphasises that “the working class could gain equality by possession of the apparatus of production, exchange and state power”. That apparatus, in this study, is equivalent to education.

*Not enough information was the biggest challenge, so we had to fill in the gaps a bit using our own understanding (II PST3).*

The biggest challenge was the lack of information about the work that the non-western scientists have contributed, therefore it was challenging to incorporate their work into the curriculum (II PST1).

#### **4.7 Discussion**

This discussion begins with certain perceptions about gender and science, as these relate to scientists who were selected by pre-service teachers. It then focuses on each specific theme, drawing on literature to discuss the findings from the individual interviews and the lesson plans that were developed by pre-service teachers. In this section the disruption of the normalisation of colonial elements in the science curriculum is discussed.

The first research question focussed on pre-service teachers' choices of non-western scientists and their rationale for this. Pre-service teachers selected the following non-western scientists: Alice Ball for her work in microbiology, Quarraisha Abdool-Karim for her work in virology, Flossie Wong Staal for her work in molecular biology, Zeng Fanyi for her work in embryology and Wangari-Muta Maathai who is valorised for her- contributions to conservation and community-based tree planting.

The reason pre-service teachers' selected specific scientists were based on the race, gender and geographical backgrounds of their students. These criteria were used in order for the students to identify with the scientist of non-western descent. All pre-service teachers in this study selected female scientists. According to Schmader (2010), if teachers, curriculum designers, and textbook developers can create more female-favourable gender representations, young female students might more easily envision a future for themselves in science. The importance of providing good role models cannot be over-emphasised. The finding here was that pre-service teachers produced positive role models, to disrupt the prevailing gender order in the representation of scientists.

Pre-service teachers considered the gender of their students, when they focussed on bringing about a change in the perception of women becoming scientists and women within the field of STEM. This formed an integral part of their lesson planning and

addressed the 'why' for their selection of female scientists of non-western descent. People in many countries associate science with men more than with women (Smyth & Nosek, 2015). The social scientist David Chambers had requested 4,807 elementary-school children between 1966 and 1977, mostly from Canada and the United States, to draw a scientist (Yong, 2021). Their illustrations regularly featured white coats, eyeglasses, lab equipment, and books. Often, the depicted scientists were seen to exclaim things like "I made a discovery!" or simply "Wow!". According to Yong (2021), upon further inspection of Chambers's original data, published in 1983 by other researchers such as David Miller from Northwestern University, one trend leaped out. Of the almost 5,000 drawings produced within the study, only 28 depicted female scientists, and all of those were drawn by girls. Not a single boy drew a female scientist (Yong, 2021).

Stereotypes can play a central role in constraining children's beliefs of what they can and cannot do (Schmader, 2010). This is why pre-service teachers selected the scientists of non-western descent based not only on their geographical location but their gender too, which is evident in the data collected from the individual interviews.

Gender stereotypes of scientists not only shape adolescent girls' and boys' perceptions of who is a scientist, but also influence their perceptions of who *can be* a scientist (Steinke, 2017). This suggests an influence on whether female students perceive a place for themselves in science, and whether they look to scientific careers at all. This might also influence how male students perceive their female classmates, or network with them in professional environments later on in life. Many female scientists suffer triple discrimination in science, therefore they are marginalised based not only on gender but also race and being located in the global south.

Therefore, decolonising the science curriculum is imperative in high schools so that male and female students do not leave the school system and enter the world of work with biases that continuously reproduce gender, racial and geographical stereotypes in science.

Evidence from various standardised assessments has led to the acknowledgement that social class inequalities legislated by race under apartheid, have persisted in South Africa, and that a highly stratified system of education in terms of social class has become entrenched (Roberts, 2017). Therefore, a decolonised science

curriculum that is not relevant further serves to exclude black and poor, and, more commonly, female, citizens from higher education and work opportunities. That divergence between legislative vision and lived realities affects South Africa's teachers, parents, and children considerably and hinders our attempts to modify the science education landscape.

Pre-service teachers' awareness about the scientists who were dominant in curriculum and textbooks influenced their choices of scientists. According to Greer (2019), teacher education is defined by patterns of how current educational institutions alienate non-dominant knowledge. Therefore, a crucial component for teacher preparation in these environments, is the element of critical consciousness (Gay & Kirkland, 2003), multicultural awareness (Cochran-Smith, 2003), and commitment to social change (Zeichner, 2009). A growing body of literature is directing attention towards the social justice-oriented capacities of teacher candidates (Conklin & Hughes, 2015). The finding here was that pre-service teachers disrupt reproduction of a biased gender order in school, based on a heightened awareness of inequality.

The pre-service teachers also reflected carefully on the race and ethnicity of their students in order to make learning more relevant to them. According to McGrath and Rogers (2019) bringing the real world into the classroom, can have a positive effect on academic achievement because it is strongly associated with the development of new skills and an increased motivation within students. Teaching is not a neutral activity, and the source of knowledge, as well as the people for whom it is intended, should be critically examined, as part of the process of decolonising the curriculum (Ruddock, 2021). The finding here is that pre-service teachers wanted students to identify with scientists by selecting those who were similar to them in terms of either race or gender or having emerged from a global south area.

Mudaly (2018) describes the how, what and why of teaching:

I think that how one teaches, what one teaches, and why one teaches depends on the intended student, among other things. In an autocratic political order, the student is expected to passively accept received dogma. In a more liberal setting, it is expected that the student will be sceptical and more critical. (p. 52)

According to Buckley, Farrell, & Tyndall (2021) negative stereotypes about female intellectual abilities occur in students as young as 6-years old, and can mould a child's educational pathway and career choice, particularly in relation to Science, Technology, Engineering and Math (STEM). In their study they found that exposure to stories about females in science can assist in counteracting the negative stereotypes concerning female intellectual ability. A key implication of this study is that young female students who learn about members of their own gender, who accomplished success in STEM fields, and who adopts them as role models, may be significantly inclined to think of STEM careers as a possibility for themselves in future (Buckley et al., 2021). According to O'Brien, Hitti, Shaffer, Camp, Henry and Gilbert (2017) there is evidence that exposure to women in STEM, as role models, can increase middle school girls (age 11-13) sense of fit in science. Certainly, exposing female students, aged 12 to 16, to real-life female role models that currently hold a successful professional occupation in STEM fields, significantly increases female students' enjoyment of and belief in the importance of mathematics, along with enhanced expectations of their own success in mathematics (González-Pérez, Mateos de Cabo, & Sáinz, 2020). Furthermore, González-Pérez et al. reported a reduction in effects of negative gender stereotypes. Therefore, influencing beliefs around female intellectual ability remains crucial to potentially aiding the impact that successful female role models can have in STEM.

The second research question explored how pre-service teachers planned to include the contributions of these scientists into the science curriculum. Pre-service teachers engaged in a deconstruction exercise by analysing textbooks critically, and found that western scientists were exclusively represented. This they viewed as coloniality in education. The finding here was that through critical analysis they were able to deconstruct a unit of work in the science curriculum.

In the study by Weiner (2016) colonised elements within textbooks specifically history textbooks have been studied in depth. "A Eurocentric neo-colonial master narrative homogenises and essentialises Africa as a poor, primitive, and violent continent; discursively denies Dutch historical responsibility for African underdevelopment; excludes African nationalist efforts; and depicts the Dutch engaging in benevolent aid efforts toward African nations and peoples unable to help themselves" (Weiner, 2016, p. 450). Based on Weiner's insights, pre-service teachers' analysis of textbooks, was

crucial in unearthing the power and knowledge relations suggested by the privileging of particular scientists in textbooks. Weiner's findings can be extended to this study, where the exclusion of African scientists could imply that Africa is intellectually poor.

Multiple ICT resources, including the Internet, YouTube videos' and access to material resources, such as laptops and library books were used by pre-service teachers to advance their own content knowledge and to develop pedagogical knowledge to plan their lessons. This theme is associated with the self-development of teacher knowledge. Most pre-service teachers used different sources to build their knowledge base about other scientists who contributed to knowledge in the topics they were planning to teach. The findings here are consistent with development of content knowledge by accessing multiple resources and the development of pedagogical knowledge to teach about non-western scientists.

According to Olsher and Kantor (2012) the value of self-studying can be located in its defining and refining ideas about what constitutes knowledge of teaching. LaBoskey (2004) stated that self-study also aims to improve one's practice and stimulate professional growth and to: "provide evidence to us . . . that we are learning from what we are discovering; that we are reframing our thinking and transforming our practice in defensible ways" (as cited in Olsher & Kantor, 2012, p. 158). This is supported by Attard (2017) who stated that teachers do not learn solely by engaging in formal educational processes, rather, they need to develop the necessary tools necessary to take charge of their own continuous professional development. This is precisely what the pre-service teachers had done in this study. They examined and analysed the spaces to decolonise the science curriculum and actually engaged in doing it, by self-reflection and self-study.

According to Goh, Yusuf, and Wong (2017) the first three years of teaching for a novice teacher has a great impact on their career. In this study it was evident that the use of technology (conventional and ICT resources) by all pre-service teachers to decolonise the unit of work they had selected was essential. This phenomenon could be a result of developing countries now focusing on greater access to digital technology (du Plessis & Webb, 2012). This suggests that pre-service and novice teachers enter into the teaching profession with a lot more technological or ICT skills than more experienced teachers who entered the profession years ago, because pre-service

teachers are taught to use and access essential ICT resources and materials. It is highly possible that pre-service teachers are not digital strangers, and therefore use digital tools for their independent learning.

Greener and Wakefield (2015) state that educational technologies are used by teachers not only to develop students' understanding but also to support in lesson preparation and for aiding in refreshing their memory of concepts. They promote strong conceptual understanding amongst teachers and thereby boost confidence prior to being in the classroom. In this study it was evident that all pre-service teachers channelled technology as a basis to find information and use this information to develop lesson plans that represent the dismantling of the Eurocentric-dominant curriculum. In the individual interview, pre-service teacher 5 (II PST5) said that *"I have my own laptop and internet access, and I also visited the library which has a lot of books on science."* In the individual interview, pre-service teacher 9 (II PST9) said that, *"YouTube videos was a fast and easy way of learning about these other scientists and the work they have contributed and Finding YouTube videos was also good because I could play them to the class as a conclusion or introduction to the lesson using my own projector"*.

In the individual interview pre-service teacher 6 (II PST6) said *"Pictures of scientists and YouTube video about animal cloning were used as a resource. Pictures of scientists helped students recognise non-western scientists. YouTube videos would consolidate the work that the non-western scientists have contributed to cell research"*.

In the individual interview pre-service teacher 7 (II PST7) asserted *"The use of visual resources such pictures of the scientists and YouTube videos about cloning helps to highlight the work these non-western scientists have contributed."* In the individual interview pre-service teacher 11 (II PST11) stated *"The use of YouTube videos on micro-organisms, harmful micro-organisms, was important"*. Most of the pre-service teacher's accessed technology to better understand colonised and decolonised elements within the science curriculum. According to Zinger, Tate, and Warschauer (2017) it is the national priority of many countries whether developed or developing to prepare a workforce for the information and communication technologies (ICT) used daily in almost all fields. This suggests that ICT resources were key to enabling pre-service teachers to learn about non-western scientists and their contributions. Zinger,

Tate, and Warschauer (2017, p. 580) further state “exemplary teachers do not need to be experts in all – or even many – modes of technology, but they are expert at leveraging relevant, useful technologies that they have sufficient expertise in to engage in student-centered, meaningful learning”. The pre-service teachers used technology to develop their lesson plans by downloading and viewing videos, and by expert advice from lecturers at campus on how to decolonise a unit of work within the science curriculum. They communicated with teachers in their communities and also lecturers who have actual experience decolonising units of work. According to Hur, Shen and Cho (2020) the rapid transformation of classroom environments has resulted from the development of advanced technology and an increasing number of diverse students that require pre-service teachers to develop proficiency in technology integration, as well as competence in supporting students from different ethnic groups.

The findings here were that pre-service teachers undertook a self-teaching process, they accessed content knowledge from multiple sources and developed suitable pedagogy to teach about non-western scientists.

The second theme was ‘Collaboration among pre-service teachers’. Although pre-service teachers tapped into the knowledge of experts, not all of them were successful in obtaining assistance. For this reason a collaborative effort among pre-service teachers became increasingly significant in developing lesson plans that incorporated the work of scientists of non-western descent. According to Chen (2012) seasoned teachers are in as much need of team efforts as pre-service teachers. Instead of only engaging in isolated self-study, collaborative professional development is advocated, as it can deepen and refresh in-service content knowledge and advance pedagogical practices, which in turn benefits students. This suggests that when pre-service teachers collaborate they advance their content knowledge and pedagogical practices, before they become in-service teachers, can benefit their students on a larger scale.

According to DuFour and Eaker (as cited in Hoaglund, Birkenfeld & Box, 2014), the 21st century school environment is one that requires of its students, faculty, and staff a highly specialised set of collaborative skills. If new teachers are to be prepared for this environment, pre-service teachers must be given the skills needed to succeed. Moving toward an environment of meaningful collaboration may be the single most

important factor for sustaining successful school improvement (Hoaglund, Birkenfeld & Box, 2014). Vanassche and Kelchtermans (2015, p.1) have stated that “self-study refers to teachers intentionally and systematically investigating their practices in order to improve them, based on a deepened understanding of these practices, as well as the contexts in which these practices evolve”. This is the type of activity that pre-service teachers underwent, reflecting upon their own practices in order to improve them, enhance their content knowledge and thereafter, decolonise a unit of work in the science curriculum to make the content relevant and meaningful to their students.

Pre-service teachers who participated in this study collaborated to find unique ways of making science relevant to the students. The pre-service teachers ensured that they met regularly to collate information that they had obtained about the chosen scientist of non-western descent, and to brainstorm ideas on how to incorporate the scientist’s contribution to science within the chosen topic from the science curriculum. The collaborative efforts of the pre-service teachers were possible by them leveraging the affordances of technological devices such as cell phones with internet connectivity, and the use of applications such as ‘WhatsApp’ to ensure efficient communication during the hard-lockdown that was implemented by the South African Government due to COVID-19. WhatsApp is an application within most cell phones that have an internet connection thus allowing for users to text message, chat and securely share, through end to end encryption voice and video messages with individuals or groups (Montag et al., 2015). The use of these communication devices and social applications allowed the pre-service teachers to interact efficiently so that their goals could be met. This resonates with studies by Falk (2012), Pickering, Bast Jr, and Keyomarsi (2015) and Espey (2018) who established that communication is crucial to a team being successful. In addition, through collaborative efforts, a group can make a more desirable determination as compared to an individual’s perspective because there is the deliberation of a diversity of perspectives (Bialik, Fadel, Trilling, Nilsson, & Groff, 2015). The finding here was that digital platforms played an integral part in the collaborative endeavours.

Tuckman and Monetti (2011) claimed that functioning cohesively and learning from one another, in this case among the pre-service teachers, leads to the acquisition of

knowledge and the development of skills, instead of just being told what to do by an instructor. In this study, collective learning paved the way for pre-service teachers' to become conscious of the colonial nature of the science curriculum. This unavoidably involves rethinking the object of decolonisation (of curriculum) in terms of the institution where it lives, in this case secondary schools and the people who shape how life is lived within it, viz teaching staff and school management (Lee Moncrieffe & Norman, 2021). Suhaiymah Manzoor-Khan (as cited in Lee Moncrieffe & Norman, 2021) highlights that decolonisation cannot be restricted to what is on the blackboard. It involves considerations of who is invited, to do what? as what? for whom? and for what? This helps us to reflect on whether we are just working together to decolonise the curriculum just to 'unwhiten' syllabi, or is it aimed at encouraging anti-racist teaching.

This shift in pre-service teachers' mind-sets enabled them to develop the skills to decolonise the science curriculum thus disrupting the normalisation of privileging western scientists in science textbooks. It is essential for pre-service teachers to have teamwork abilities as these will enhance healthy professional interactions with their colleagues, students, and parents when they become in-service teachers in the future (Ammentorp & Madden, 2018). The Ontario Ministry of Training Colleges and Universities (2009) stated that collaboration among colleagues is one of the essential employability skills that graduates of tertiary education should have. The Ontario education organisation articulated that any graduate leaving the higher education institution should be able to (1) show respect for the diverse opinions, values, belief systems, and contributions of others, (2) interact with others in groups or teams in ways that contribute to effective working relationships and the achievement of goals. In view of the foregoing, the pre-service teachers who participated in this study of decolonising the science curriculum by incorporating the work of a scientist of non-western descent into the selected topic, demonstrated collaboration which is one of the employability skills vital for successful workplace life. This suggests that a decolonised curriculum does not only have a positive impact on the lives and careers of students but it also has a positive impact on those individuals that are actively decolonising the curriculum for the students.

Insights into challenges which pre-service teachers experienced when attempting to include non-western scientists into the curriculum were revealed in response to research question three. Pre-service teachers experienced multiple challenges, including lack of support from school management, the inability to tap into the knowledge of other experts, such as lecturers, senior teachers etc, and the scarcity of information about scientists of non-western descent.

Unsupportive school management members who were narrow in their thinking hindered the development of new, creative ideas. Prohibiting young energetic teachers new to the profession can lead to a detrimental impact on our school system. This could suggest why coloniality persists in contemporary South African curricula. According to a study by Smith and Ingersoll (2004) novice teachers who were supported by mentors, were less likely to move to other schools and less likely to leave the teaching profession after their first year of teaching practice (as cited in Jin et al., 2019). In this study, those findings were supported by the responses received from II PST2, II PST3, II PST4 and II PST11. In the individual interview pre-service teacher 11 (II PST11) complained that the actual implementation of the selected topic, using a decolonised lens, would be difficult within the school context. He elaborated upon his experiences from teaching practice: *“Some HOD’s are very strict and narrow minded in that they like to have things done one way and no other way can be accepted, therefore I don’t think I’ll have the freedom to adapt and change my teaching when I do become a professional teacher.”* Individual interview pre-service teacher 2 (II PST2) also drew from her experiences during teaching practice. Teaching practice is when pre-service teachers are given an opportunity to be in a public or private school for a certain amount of time within the semester, and gain experience by developing lesson plans, teaching students and observing seasoned teachers. *“Thinking back to my experiences in teaching practice, I don’t think I would be given the time and support to incorporate a non-western scientist into my lesson plans because this would be a waste of time. The principal did not encourage creative and new ways of teaching and learning, he is old school and still believes in chalk and board and textbook as the only way to teach”*. Individual interviewee 3 (II PST3) also added, *“I called and emailed teachers from the schools in my area to ask for help, the staff members in the science department are not really interested in the task that I had to conduct, everyone at*

*schools are only focussed on completing syllabus and uploading marks.*" These are powerful statements because it means that teachers are kept very busy with day to day demands of the curriculum and school. They do not have the time or space to consider oppressive ideologies which marginalise scientists of non-western descent.

Similar experiences were echoed by PST4 in the individual interview: *"I am not sure if this is a challenge for this study but I feel that when young new teachers enter the schools, the senior teachers especially the HODs like to stamp their authority in terms of how to teach. I have had bad experiences in that I was not able to teach the way I had planned to teach during teaching practise by introducing videos and giving students a chance to discuss with each other in the lesson."*

Pre-service teachers' found that senior teachers were inundated with administrative work and were mainly focussed on completing syllabi. They were indifferent to the colonial nature of the science curriculum and therefore did not provide help to the pre-service science teachers. Information was sought from other senior teachers and lecturers, about scientists of non-western descent who produced scientific knowledge on the topics they were teaching. The pre-service teachers found it difficult to decolonise the selected topic because there was little to no support from seasoned-teachers. Inexperienced-expert teacher interaction plays an important role in teacher professional development (Jin et al., 2019). The finding here was that schools' main focus was to complete syllabi, thus there is a blinding effect towards colonial elements in the science curriculum.

International research shows that expert-teachers' support is associated with the improvement of inexperienced teacher teaching. (Jin et al., 2019). Support from expert teachers is an important external source for inexperienced teachers. Expert-teachers' support not only provides feedback and suggestions for alternative teaching methods, but also encourages and maintains inexperienced teachers' learning (Jin et al., 2019). My study revealed that expert teachers did not play a pivotal role in helping the participants towards decolonising the curriculum.

This suggests that the colonial ideology is so pervasive and convincing, that the dominance of particular scientists in textbooks has not been questioned by expert teachers. The normalisation of colonial privilege, as it relates to representation of

knowledge producers in science, was far reaching. There are sparse human resources to serve as repository of knowledge about non-western scientists, so material and human resources to include non-western scientists are almost absent. This fuels under-representation or total exclusion of scientists of non-western descent from the science curriculum. These challenges play a role on the race and gender of scientists selected to be included in the science curriculum.

Individual interviewee 2 (II PST2) stated: *I felt very angry and back then I did not have access to the internet or a library so I could not do research about these female non-western scientists.* This means that when pre-service teachers do not have access to ICT resources they are impeded in their quest to change the colonial nature of the science curriculum. The use of ICT resources is important to decolonise the science curriculum so that more meaningful and relevant teaching can occur within South African schools and schools globally.

The lack of information on scientists of non-western descent was widely experienced by all participants. According to Hudson (2016) there is a global information inequality and as a result, this causes the reproduction of racialised discourses. The construction of inequality at such a macro-level, is a sign of marginalisation and thus a venue for perpetuating racialised knowledge to the people (Hudson, 2016). In Hall's (2012) words, "the library and information science field has seemingly slapped itself with a gag order" (as cited in Hudson, 2016, p. 63). This gag order could be why expert teachers do not know or are unaware of the colonial nature of the science curriculum. He further states, "while the discussion of diversity in libraries has proliferated over the past few decades, meaningful dialogue around race has been eviscerated or altogether evaded" (as cited in Hudson, 2016, p. 63). It is possibly the reason why all pre-service teachers in this study found it difficult to acquire information about the non-white, non-western or female scientists that they portrayed to decolonise the unit of work. My study revealed that pre-service teachers discovered a scarcity of publications of scientists of non-western descent. This buttresses the dominance of western, white, male scientists in the school science curriculum.

A deeper theoretical analysis reveals with reference to Chilisa's (2012) five phases of decolonisation (cited in Mudaly, 2018), the participants within my study mourned the sinister ways in which the science curriculum, as part of the high school curriculum,

had perpetuated epistemic violence by excluding scientists of non-western descent as contributors of scientific knowledge. This is supported by interviewee 7 who stated *“Women have for centuries been undermined and silenced by their male counterparts. I hope when I have children, they learn about scientists that are not only white males from the west. This interviewee stated that “Definitely, it is useful. Simply because this helps us as teachers to realise that we as non-western people have contributed to science and also this helps us to evoke love for science in our students”.* This suggests that the pre-service teachers and I entered the dreaming, commitment, and action phases by under-taking activities that incorporated scientists of non-western descent into selected topics within the science curriculum, thus disrupting the normalisation of only white western scientists as the sole producers of scientific knowledge. This allowed for transformation and cognitive justice in its encouraging of pre-service teachers to engage in the first of these phases—rediscovering and recovering the scientists of non-western descent, who are so much a part of their culture and relatable to the students that they will teach when they become in-service teachers.

#### **4.8 Conclusion**

Kruger and Fataar (2017) advocated for a human-centric orientation to knowledge. In this study, pre-service teachers selected scientists of non-western descent, to make science knowledge relevant and relatable to non-western, South African students. By tapping into local and international non-western producers of scientific knowledge, pre-service teachers disrupted the dominant discourse about the identities of legitimate scientists. By interweaving these other personalities and their contributions to science into the CAPS science curriculum, they blurred the lines between decolonial and colonial and non-western and western knowledge, and decentred dominance of scientists of Euro-western descent. The use of diverse figures and their contributions to science created a platform for the school curriculum to be more inclusive of previously marginalised scientists, and served to decolonise the curriculum to some extent.

Kincheloe (2008) described the digression from the monocultural perspectives of who is the legitimate knower, what is legitimate knowledge, and how it is produced in higher education as “crawling through a new curriculum wormhole” (p. 8). In this

study, I have highlighted a new science curriculum wormhole by drawing on pre-service teachers' inclusion of previously marginalised scientists of non-western descent and their contributions to the body of scientific knowledge. I have also highlighted their ability to re-imagine *how* they can teach and *what* they can teach. The status quo was disrupted by pre-service teachers who incorporated alternative pedagogical strategies that did not emulate the so-called normal learning spaces in the school science curriculum. In addition, this led to the pre-service teachers' understanding of how the science curriculum can be more relevant to South African students and, that working in science fields is attainable by all, regardless of geographic, gender, or racial backgrounds.

Further, this disruption of the epistemological status quo has the potential to shape their teacher identity in ways that enable them to develop their curricula and pedagogy by drawing from and contributing to a home-grown epistemology (Mudaly, 2018). Greater awareness of non-western scientists needs to be shared, and their contributions to knowledge cited. According to Lee Moncrieffe and Norman (2021) more names need to be added to the list of Stuart Hall, Sonia Boyce, Lubaina Himid, Nelarine Cornelius, Harry Goulbourne and Avtar Brah. In this study, I have added to this list by presenting scientists of non-western descent that pre-service teachers had researched. These scientists are Alice Ball, Flossie Wong Staal, Zeng Fanyi, Quarraisha Abdool Karim and Wangari Maathai.

## **CHAPTER 5: Summary of the Findings, Limitations and Recommendations**

Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-western descent in the science curriculum, by pre-service teachers.

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### **5.1. Introduction**

In the previous chapter, I provided the results of data generation and analysis for this study. I analysed five lesson plans that formed the sample for this study and 11 individual interviews, which were conducted to generate in depth qualitative data. In chapter three I argued for the suitability of the critical paradigm and the research approach which informed the framework that guided the analysis, as well as themes that emerged from the individual interviews. This qualitative study aimed to explore pre-service teachers' experiences of decolonising a unit of work to teach science by making it more inclusive of scientists of non-western descent. In doing so, an attempt was made to disrupt the perpetual exclusion of scientists of non-western descent from colonial elements used to teach science. This chapter serves to recapitulate the main findings that emerged inductively from the data. These findings contribute toward answering the three critical questions which guided this study. First, a summary of the key research findings addressing each research question, is presented. Second, a discussion of the recommendations directed to teacher training institutions, university educators and school curriculum designers, brings this chapter to a conclusion.

### **5.2. Summary of key research findings**

This chapter captures the responses of pre-service teachers to the three critical questions that framed my study, namely:

**Research Question One:** Which scientists of non-western descent do pre-service teachers select to include in the science curriculum, and why they do so?

For research question one, three themes emerged, namely:

**Theme One-** Addressing the dominance of white, male, western scientists

Pre-service teachers selected several scientists for inclusion into the current science curriculum (refer to Table 1). The findings revealed that pre-service teachers awakened to the colonial nature of the school science curriculum, thereafter actively addressing the dominant status of white, male, western scientists over their counterparts of non-western descent. Pre-service teachers were of the view that there is a lack of representation of female scientists of non-western descent in the school science curriculum. Pre-service teachers agreed that this lack of representation needed to be addressed so that they could become gender and race inclusive teachers. They experienced this lacuna, borne of the exclusion of important scientific knowledge by scientists of non-western descent from the school science curriculum as regrettable and worthy of being mourned (Chilisa, 2012). Pre-service teachers believed that more attention should be given to the integration of scientists of non-western descent in the school science curriculum. A significant outcome was that pre-service teachers developed decolonised lesson plans to address this biased representation of the *who* of knowledge production, found in teaching materials for school science.

**Theme Two-** Role models

To address the *who* of knowledge production, pre-service teachers selected scientists that shared similar geographical backgrounds as the students they had interacted with and taught during teaching practice. Pre-service teachers believed that providing apposite role models to students would ignite greater interest in science among students who would identify with these role models, and be more likely to pursue the study of science after they graduated from secondary school. This would dismantle the idea of science being only for white, western and male individuals especially in black, economically poor communities.

**Theme Three-** Teachers' valuing inclusion of non-western scientists.

Pre-service teachers' valued the incorporation of non-western scientists because they believed it addressed marginalisation of these scientists which was rooted in

colonial and apartheid history. They agreed that exposing their students to non-western scientists would motivate students to pursue careers in science.

#### **Theme Four-** Heightened teacher consciousness

By analysing the science curriculum and reflecting on the injustices of the past in terms of white-western male scientists being privileged over their non-western male and female counterparts, pre-service teachers' awakened their consciousness to the disparity. Pre-service teachers realised that the colonised science curriculum is not simply privileging knowledge producers of western descent over knowledge producers of non-western descent. They were concerned about the exclusion of scientists of non-western descent and their contributions to scientific knowledge.

The findings revealed the following for research question one, which focussed on participants' selection of scientists of non-western descent, and reasons for this

Pre-service teachers' attempted to disrupt the dominance of the representation of scientists from the global north.

The pre-service teachers also reflected carefully on the race and ethnicity of their students in order to make learning more relevant for them. According to McGrath and Rogers (2019) bringing the real world into the classroom can have a positive effect on academic achievement because it is strongly associated with the development of new skills and the enhancement of motivation within students.

Pre-service teachers disrupted the reproduction of gender order in school, based on a heightened awareness of inequality.

Pre-service teachers' awareness of the marginalisation of non-western scientists increased, and they took action to address this reproduction of the status quo by demonstrating how scientists of non-western descent, who are females and non-white, can be included. Teachers, curriculum designers, and textbook developers can create more female-favourable gender representations, and young female students might more easily envision a future for themselves in science (Schmader, 2010)

Pre-service teachers wanted students to identify with scientists by selecting scientists who were similar to them (learners) in terms of either race or gender or having emerged from a global south context.

According to Schmader (2010) stereotypes can play an integral role in limiting children's beliefs of what they can and cannot do. This is why pre-service teachers selected the scientists of non-western descent based not only on their geographical location but also on their gender. Steinke (2017) contends that gender stereotypes of scientists influence young boys' and girls' perceptions of who can be a scientist.

**Research Question Two:** How do pre-service teachers plan to include the contributions of these scientists into the science curriculum?

For research question two, there were two themes that emerged, namely:

**Theme One-** Self-teaching: Critical analysis of textbooks and access to knowledge from a variety of sources.

Pre-service teachers used resources that they had access to, and deconstructed the section on the topic of TB in the textbooks to reflect on hidden messages which were perpetuated in school science lessons. These messages are part of the 'hidden curriculum'. This activity of reflection provided them with an opportunity to increase their awareness about the colonial elements within the curriculum and provided them with a platform to deconstruct a unit of work and then reconstruct it, while being respectful about representation of scientists.

**Theme Two-** Collaboration among pre-service teachers

Pre-service teachers were of the view that working in groups and making use of one another's ideas through brainstorming, critically assisted them in learning to plan a science lesson that incorporated a scientist of non-western descent. The findings from this study further revealed that although pre-service teachers were already challenged, they were still able to find opportunities that helped them in their planning to decolonise a unit of work in the curriculum.

For research question two which focussed on how pre-service teachers planned to include the contributions of scientists of non-western descent, the following findings are crucial.

Through critical analysis they deconstructed a unit of work in the science curriculum.

Pre-service teachers' analysis of textbooks was crucial in unearthing the power and knowledge relations suggested by the privileging of particular scientists in textbooks (Weiner, 2016). In this study pre-service teachers' deconstructed a unit of work by unearthing the knowledge produced by scientists of non-western descent and then critically modified the unit of work by incorporating this knowledge, and the scientist of non-western descent who produced it. In order to do this pre-service teachers' engaged in:

The development of content knowledge by accessing multiple resources and the development of pedagogical knowledge through collaboration to enhance teaching of non-western scientists.

A self-teaching process, and then they worked collaboratively, to access content knowledge from multiple sources and developed suitable pedagogy to teach about non-western scientists.

Multiple ICT resources, including the internet, YouTube videos' and material resources, such as laptops and library books were used by pre-service teachers to advance their own content knowledge and to develop pedagogical knowledge to plan their lessons. Digital platforms played an integral part in the collaboration endeavour.

It was evident that the use of technology ICT resources by all pre-service teachers to decolonise the unit of work they had selected was essential. According to Chen (2012) instead of only engaging in isolated self-study, collaborative professional development is advocated, as it can deepen and refresh in-service content knowledge and advance pedagogical practices, which in turn benefits students. The use of communication devices and social applications allowed the pre-service teachers to interact efficiently so that their goals could be met.

**Research Question Three:** What challenges do pre-service teachers encounter in working toward decolonising the curriculum by making it inclusive of non-western scientists?

For research question three, there were three main emerging themes, namely:

**Theme One-** Lack of support from school management

**Theme Two-** Difficulty in tapping into knowledge of other experts

There was consensus among pre-service teachers about a lack of support from school management. Pre-service teachers were not supported in their quest to decolonise a unit of work. In-service teachers did not have sufficient time because they had to meet deadlines with regard to syllabus coverage and other administrative tasks. Principals and HOD's were not keen on modifying the curriculum in anyway. They were probably confined to thinking about the curriculum as prescribed and inflexible. This reluctance suggests that the ideologies which prize euro-western knowledge holders, still persists today thereby making it challenging for experienced teachers to adopt new perspectives in teaching science.

**Theme Three-** Lack of information about scientists of non-western descent from written sources.

Pre-service teachers' search revealed a scarcity of literature in the area of scientists of non-western descent. This study contributes to the discourse of decolonising science education by tapping into the work of scientists of non-western descent. Studies which specifically explore how pre-service teachers incorporate scientists of non-western descent in science lessons are needed.

Key findings related to research question three which explored the challenges pre-service teachers encountered in working toward decolonising the curriculum by making it inclusive of non-western scientists included:

The scarcity of publications of scientists of non-western descent which further supports the dominance of western, white, male scientists in the school science curriculum.

Lack of input from expert teachers.

Main focus was to complete syllabus thus there is a blinding effect towards colonial elements in the science curriculum.

According to Hudson (2016) there is a global information inequality and as a result this causes the reproduction of racialised discourses. This is possibly the reason why all pre-service teachers in this study found it difficult to acquire information about the non-white, non-western or female scientists that they researched, to decolonise the unit of work.

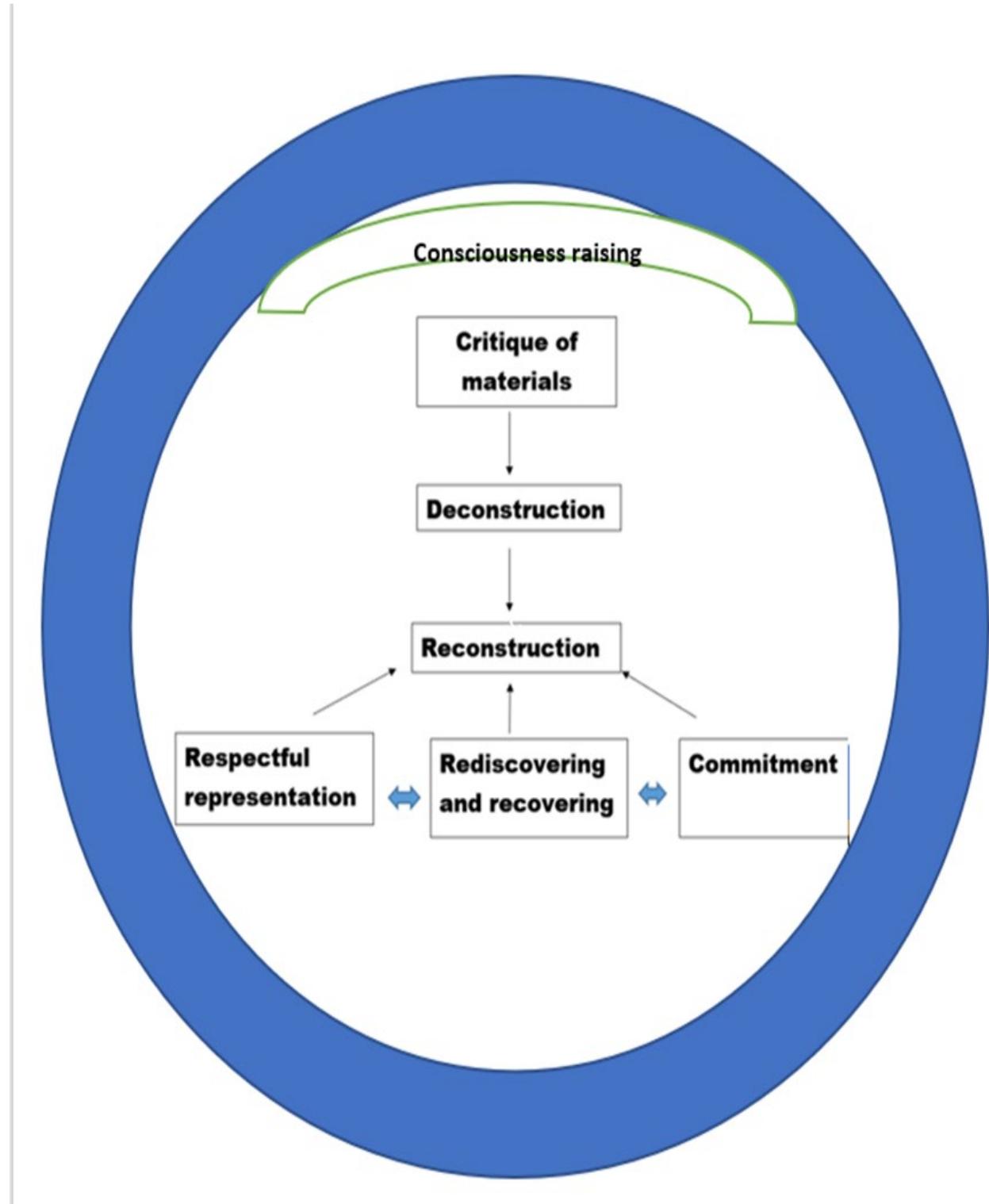
Inexperienced-expert teacher interaction plays an important role in teacher professional development (Jin et al., 2019). It was unfortunate that pre-service teachers' found that senior teachers were inundated with administrative work and were focussed on completing syllabus. In addition, pre-service teachers concluded that experienced teachers were unaware of the colonial nature of the science curriculum and therefore were not able to provide further insights to the pre-service science teachers.

Based on anecdotal evidence, in my experience as a practising teacher, I agree with the above finding. School management is consumed with issues related to syllabus coverage and the matric examinations hence modification of the curriculum is not allowed or would be discouraged based on time constraints, and a refusal to critique the current curriculum.

The model in Figure 2 illustrates the nonlinear processes which unfolded, as participants engaged in this project towards decolonising the curriculum project.

Figure 2

*Processes in Working Towards Decolonising the Curriculum.*



In this study, the constructs in figure 2 applied to decolonisation in the following ways: Consciousness-raising was the awakening of pre-service teachers to the colonial elements located in the science curriculum. This re-awakening occurred through examining the available written material used to support the teaching of science, using a critical lens. This heightened awareness enabled them to deconstruct what they already knew and formulate a better understanding of what they should be teaching their students. According to Shih (2018), Paulo Freire's main concern was how to teach people to unshackle themselves from the chains of silence and to respond to the needs of humanity, to develop a more just society. This emancipatory educational method is conscientious, and can be used to stimulate individuals' critical consciousness, which can result in a more critical view of social reality to obtain liberation (Shih, 2018).

According to Shor and Freire (as cited in Shih, 2018, p.65) it is for this reason that, "Freire's liberation through education can change people's perception of their external reality and make individuals more critical and more autonomous". Katz (2014, p.18) asserts that "the more appropriate role for teachers is to awaken students' minds..."

In my study, the path from deconstruction to reconstruction was enabled by pre-service teachers modifying their mental scaffolding, to build new knowledge on the foundation of their existing knowledge. According to Shor (2014), we do not start with a clean account free from history, society, or cultural conflict related to gender, race, and class, when we endeavour to reconstruct power relations. Berlin (as cited in Shor, 2014) states that critical pedagogy is "social-epistemic" which acknowledges the existing political hurdles to critical thought, it teaches about and against the power relations opposing the revolution of imbalanced power. Shor (2014) reminds us of Lev Vygotsky's discussion of the "Law of Awareness", which suggests that a break in a routine or an impediment to an automatic activity, raises awareness of the activity and routine. In my study, this would mean that when pre-service teachers attempted to decolonise a unit of work in the school science curriculum, they then had a chance to; notice the colonial elements therein (dominance of male, white, western scientists), to question this representation and to consider alternatives (inclusion of scientists of non-western descent). Liasidou (2012) states that such initiatives (decolonising the curriculum) must be ushered in by attempts to mobilise

cultural and symbolic changes in current schooling with a view to questioning and deconstructing disabling pedagogies. These pedagogies disempower certain groups of students perpetuating disproportions of power and oppressive institutional and ideological governments.

The path from rediscovery and recovery to reconstruction, is the modification of the curriculum which stops the perpetual epistemic violence, evident by exclusion of non-western knowledge producers. Pre-service teachers were respectful in their representation in that they did not erase all contributions that western scientists had made. They incorporated non-western scientists, but the content knowledge continued to be aligned with the curriculum and assessment policy statements. I borrowed the term “respectful representation” from le Grange (2016) but gave it another moral undertone- respectful of knowledge and knowledge producers of non-western descent as well by acknowledging their value and including it in the curriculum. Pre-service teachers’ commitment enabled them to think differently, to rediscover and recover the work of non-western scientists. This happened as a result of self-learning, collaborative engagements, and by tapping into affordances of digital and analogue resources, as well as those of written, hard copies of textbooks.

Rediscovering scientists of non-western descent who had produced valuable knowledge but were overlooked, possibly because of gender, racial and geographical prejudice, was affirming to pre-service teachers. This prejudice is elaborated upon by Ndlovu-Gatsheni (2013), where he explains the human space as divided into two zones: ‘Zone of Being’ and ‘Zone of Non-Being.’ People of the South like Africans, Asians, Indians and others who experienced colonialism, were re-constituted by technologies of power and colonial matrices of power into an incomprehensible state of being, which is called the Zone of Non-Being. Prejudice was practiced because the possibility of co-presence or peaceful co-existence of those in the ‘zone of being’ with those in the ‘zone of non-being’, was rendered impossible (Ndlovu-Gatsheni, 2013).

Recovering the contributions of scientific knowledge of non-western scientists, which had been overlooked, in order to promote the scientific enterprise as a purely western one, was a valuable experience for pre-service teachers. Pre-service teachers used these constructs to decolonise the school science curriculum by

providing an alternative way of thinking and teaching. “There are no simple answers to the decolonisation of the curriculum, and therefore the process should be embarked upon thoughtfully but also be open to experimentation from which much could be learned” (Le Grange, 2016, p. 6).

Chilisa (2012) outlined five phases in the process of decolonisation: rediscovery and recovery; mourning; dreaming; commitment and action. Pre-service teachers’ mourned the exclusion of scientists of non-western descent from the curriculum. They demonstrated commitment to address this exclusion by working individually and collectively, to rediscover and recover contributions of non-western scientists. They engaged in action to build knowledge about scientists of non-western descent and to insert this seamlessly into the existing CAPS curriculum. Their action of revising lesson plans also arose out of this commitment. In these ways, pre-service teachers’ actions were aligned to Chilisa’s (2012) phases of the process of decolonisation.

Smith (1999) identified the following elements of decolonisation: deconstruction and reconstruction. Deconstruction and reconstruction concerns discarding what has been wrongly written, and “interrogating distortions of people’s life experiences, negative labelling, deficit theorizing, genetically deficient or culturally deficient models that pathologized the colonised . . . and retelling the stories of the past and envisioning the future” (Chilisa, 2012, p. 17). The deficiency in the curriculum was the process of rendering scientists of non-western descent as subaltern, and this was explicit by their exclusion from curriculum materials. By researching works of non-western scientists and including this in the curriculum, new stories about scientists from the global south can be told, through reconstruction.

### **5.3. Recommendations**

Pre-service teachers in this study experienced challenges and learnt valuable skills whilst working towards decolonising a unit of work within the science curriculum. In addition, pre-service teachers became more sensitive to coloniality through the curriculum. Recommendations for further study are suggested:

The first recommendation is to provide opportunities for pre-service teachers to critique the curriculum, using a decolonial lens, because most pre-service teachers

come to university without this knowledge, thus they normalise marginalisation of non-western scientists. University modules, especially Natural Sciences, should be aligned with the university policy which promotes and values all gender and racial backgrounds. Teacher training institutions should include figures of non-western descent in all modules. Pre-service teachers should be explicitly exposed to decolonised content knowledge as well as implementation strategies in Natural Sciences content and improved pedagogic content knowledge modules. This could be applied to other modules as well.

The university should aim to develop a resource centre and conduct workshops to assist pre-service teachers with the implementation of an inclusive science curriculum. Mignolo (2017) asserts that decolonisation advocates are failing to break the dominance of Euro-Western ideologies in tertiary institutes. In an effort to breathe life into decolonial conversations, Mignolo (2017) calls on universities to embrace their role as agents of social change by creating spaces where indigenous peoples can fully participate.

The second recommendation is to conduct a study to identify what underpins rigid, managerial styles and how these can be addressed. Tertiary educators at teacher training institutions need to be aware of the colonial elements within the curriculum. They need to be mindful of the multicultural student populations that pre-service Natural Sciences teachers will be interacting with when they enter the world of teaching. By doing this, tertiary educators can convey to pre-service teachers the need to be aware of colonial elements in the science classroom. Tertiary educators need to incorporate the various teaching styles and strategies required to implement an inclusive science that incorporates non-western figures. This study has demonstrated how pre-service teachers can be stimulated by an activity designed to enable them to go beyond current intellectual boundaries and obtain higher levels of knowledge, by engaging with a multitude of resources within and outside of the university. The growth of university students as independent thinkers who are responsible for their own learning can be facilitated if university educators develop their modules carefully.

The third recommendation is to develop a systematic review of published materials of scientists of non-western descent.

University and school curriculum designers need to provide assistance to teachers (practicing and pre-service), to implement a science curriculum that decentres colonial ideology. They need to design the school policy documents for all science subjects in a way that makes it possible to implement decolonial strategies of teaching. Scientists of non-western descent and the scientific knowledge that they have produced should be included in textbooks together with examples of how this knowledge can be integrated into school science concepts.

To decolonise the curriculum, pedagogy should be decolonised (Atkinson et al., 2018). Therefore, the rigid structures of authority entrenched within the educational institutions should be dismantled and the knowledge that is generated should be engaged intensely by teachers (Atkinson et al., 2018). This is because whiteness simultaneously perpetuates a disguise of fairness, impartiality, and sympathy and maintains the status quo. So, purposeful, conscious, and reflective actions should be adopted by schools' management, curriculum designers and teachers, to implement change. To ensure effective change, schools should recognise that there is a problem, and work to solve it (Lee Moncrieffe & Norman, 2021). Schools in South Africa should address the beliefs, hearts, and minds of their teachers or the issues of racial inequality and racism will continue to be perpetuated through the education system. School leaders should demonstrate courage to deconstruct the debilitating structures they have maintained. All educators should recognise their pivotal roles and start the necessary steps towards dismantling racism and white supremacy.

In this study pre-service teachers focussed on school sciences such as Natural Sciences and Life Sciences, and the main reason for this was that selection of pre-service teachers was from a natural science module. However, these insights can be extended to other modules.

The following are outlined strategies by which secondary school teachers could tackle the whiteness of the subject. These strategies were:

Analysing case studies by adopting a critical approach to geographical knowledge e.g. examining the impacts of colonialism and apartheid on contemporary racial inequalities in South Africa. (Lee Moncrieffe & Norman, 2021).

At the classroom level, drawing on students' knowledge and experiences to diversify the knowledge production process.

Adopting an enquiry-based approach to enable students to develop critical awareness, necessary for tackling issues of misrepresentation. (Milner, 2020)

#### **5.4. Limitations**

This study was restricted due to COVID-19 regulations, therefore there was no face to face communication with participants. This study drew on participants who worked in particular contexts, therefore results cannot be generalised. This study was dependent on the information supplied by participants. It is suggested that further research be conducted involving the decolonisation of units of work from other subject curricula.

#### **5.5. Conclusion**

In order to answer the three research questions within this study, pre-service teachers used several strategies, for example, they reflected on the racial diversity of their students. This was one of the factors which informed their selection of non-western scientists. Pre-service teachers accessed ICT resources to learn how to cater for the diverse student population by ensuring relevant and meaningful learning through the decolonisation of a eurocentric-dominant curriculum. This suggests that a social justice ideology underpinned the work of these pre-service teachers who sought racial and gender equality by teaching a topic that incorporated the contributions of scientists of non-western descent. According to Lee Moncrieffe and Norman (2021), it is not sufficient to make black people visible (in my study scientists of non-western descent academic contributions to knowledge visible) we also need to engage in a transformation of the academic and social structures, by reflecting on how behaviour reinforces colonial mentalities in academia and the world today.

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# Appendices

## Appendix A: Ethical Clearance



18 August 2020

Mr Riaan Kazan Khan (214510006)  
School Of Education  
Edgewood Campus

Dear Mr Khan,

Protocol reference number: HSSREC/00001731/2020

Project title: Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-Western descent in the science curriculum by pre-service teachers.

Degree: Masters

### Approval Notification – Expedited Application

This letter serves to notify you that your application received on 30 July 2020 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. **PLEASE NOTE:** Research data should be securely stored in the discipline/department for a period of 5 years.

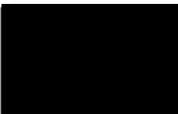
This approval is valid until 18 August 2021.

To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

**All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.**

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,



Professor Dipane Hlalele (Chair)

/dd

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Humanities & Social Sciences Research Ethics Committee  
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building  
Postal Address: Private Bag X54001, Durban 4000  
Tel: +27 31 260 8350 / 4557 / 3587  
Website: <http://research.ukzn.ac.za/Research-Ethics/>

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**INSPIRING GREATNESS**

## Appendix B: Document Analysis Template

Plan B (no direct interaction: **Social Distancing**)

Decolonised lesson: Template for analysis

Subject: Natural Sciences

Grade:

Topic:

1. Topic Breakdown:

2. What topic is selected?

3. Which scientist is selected?

4. Pre-service teachers activities

5. Student/ Learners activities

6. What resources will be used?

7. Description of how the resources will be used?

8. Analysis of lesson

## **Appendix C: Individual Interview Schedule conducted telephonically or via a video calling application**

- 1) What was the name of the non-Western scientist that you incorporated into your lesson plan? Give a reason for your selection?
- 2) Please tell me about the background of the scientist country of birth, where the scientist studied, socio-economic status when the scientist was young?
- 3) What knowledge did the scientist contribute to science?
- 4) Which unit of work did you select?
- 5) How did you attempt to incorporate the non-Western scientist into a unit of work from the Science CAPS? (What content did you use? What strategies did you plan to teach?)
- 6) Tell me more about your experiences of learning to develop a unit of work which includes a non-Western scientist.
- 7) What were some of the specific challenges that you encountered when attempting to incorporate a non-Western scientist into your lesson plan?
- 8) What opportunities arose when attempting to incorporate a non-Western scientist in your lesson plan?
- 9) Before taking part in this study and registering for this module, did you have any idea that the current science CAPS are filled with colonized elements which suppress other sources of knowledge and promote white Western males are the producers of scientific discovery? Please elaborate
- 10) Do you think a study of this nature is useful? Please elaborate

## Appendix D: Consent Form (with Social Distancing)



Science and Technology Cluster,  
School of Education,  
College of Humanities,  
University of KwaZulu-Natal,  
Edgewood Campus, KwaZulu Natal  
09-03-2020.

Dear Teacher,

### **INFORMED CONSENT LETTER Natural Science pre-service teachers**

My name is Mr. Khan. I am a Masters of Education student from the Science and Technology Cluster, College of Humanities, University of KwaZulu-Natal. I am conducting research titled 'Towards decolonising a unit of work in the curriculum: Exploring the inclusion of scientists of non-Western descent in the science curriculum by pre-service teachers.

The purpose of this study is to find out which scientists of non-Western descent pre-service teachers can select to include into the science curriculum. The contributions of these scientists will also be examined. The broader purpose is to examine how the school science curriculum can be decolonised by including the work of scientists of non-Western descent. In this study decolonisation of the curriculum focuses on those individuals or cultures which are privileged, with a view to suggesting a more equitable representation of knowledges. It also focusses on engaging pre-service teachers in the decolonisation of the curriculum by re-focusing on the "who" of knowledge production.

The objectives of the research are as follows:

- To explore which scientists of non-Western descent pre-service teachers select to include in the science curriculum
- To explore how pre-service teachers plan to include the contributions of these scientists into the science curriculum.
- To explore the challenges that pre-service teachers face in working towards decolonising the curriculum by making it more inclusive of non-Western scientists.

**Data generation will be done to observe Covid-19 regulations as follows:**

I will also ask you some questions during an individual interview, of 25-30 minutes duration conducted telephonically or via a video calling app (WhatsApp, Skype, Zoom or Google Duo) this will follow the protocol of social distancing. In addition, I will collect your lesson plans via email for document analysis, avoiding the transfer of hard copy materials from person to person will prevent the chance of COVID-19 infection.

Please note that:

- You are requested to please participate in the study. To gather the information, I am requesting your participation in this project by reflecting critically on the non-Western scientists that you select to include in a lesson plan
- Your participation is voluntary. If you do not participate you will not be penalized in any way.
- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- The individual interview will last for about 25-30 minutes. This will be audio-recorded.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be in the form of interview transcripts, completed lesson plans, and document analysis of your lesson plan. All data will be stored in secure storage.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

Thank you  
Yours faithfully

Mr. Khan R.K

My contact details are as follows:

Email: 214510006@stu.ukzn.ac.za

WhatsApp Number: 071 871 8972

My supervisor is Professor Ronicka Mudaly. She is an Associate Professor at the Science and Technological Education Cluster, College of Humanities, Edgewood Campus, University of KwaZulu-Natal

Contact details:

Email: mudalyr@ukzn.ac.za

Phone number: 0312603643

You may also contact the Research Office at:

**University of KwaZulu-Natal**

**Humanities and Social Sciences Research Ethics**

**Govan Mbeki Centre**

**Tel +27312604557**

**Fax +27312604609**

Thank you for your contribution to this research.

#### DECLARATION

I ..... (Full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

(Please indicate whether or not you are willing to allow recording by the following equipment)

Indicate your response with a tick	Willing	Not willing
Digital audio recording of Interviews		
Document Analysis of your lesson plan		

**I understand that:**

- **I will participate voluntarily and am at liberty to withdraw from the project at any time, should I so desire, with no negative consequences.**
- **I voluntarily give permission for the study's activities to be digitally recorded.**
- **I give permission for my lesson plans and interview responses to be used as sources of data.**
- **My identity will not be disclosed.**

.....

**Name of Participant**

.....

**Signature of Participant**

.....

**Date**

## Appendix E: Turnitin Report

Towards decolonising a unit of work in the curriculum:  
Exploring the inclusion of scientists of non-western descent in  
the science curriculum, by pre-service teachers

### ORIGINALITY REPORT

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