Exploring how science teachers engage with the curriculum to teach socially responsive science

By

Thishen Naidoo
(210504581)

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Supervisor: Prof. Ronicka Mudaly

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DECLARATION

I, Thishen Naidoo declare that:

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

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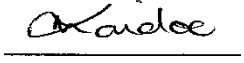
a) Their words have been re-written, but the general information attributed to them has been acknowledged; and

b) Where their exact words have been used, their writing has been placed within quotation marks, and referenced.

(v) The work described in this thesis was carried out in the School of Education, University of KwaZulu-Natal, from February 2017 to June 2020 under the supervision of Prof. R. Mudaly (Supervisor).

(vi) Ethical clearance No. HSS/1212/018M was granted prior to undertaking the fieldwork.

Signed:  Date: 24 September 2020

As the candidate's supervisor I, Prof. Ronicka Mudaly, agree to the submission of this thesis.

Signed:  Date:24 September 2020

DEDICATION

This thesis is dedicated to my parents Thamodharan Naidoo and Pathmatvathie Naidoo who have been the pillars of strength and motivation throughout my life.

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Above all acknowledgements, my humble gratitude is dedicated to the Supreme personality of Godhead, Lord Sri Krishna, for giving me the strength and ability to begin and complete this study.

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Finally, I sincerely thank my participants for making the time to be part of my study. I am grateful for all your contributions to the research.

ABSTRACT

Unbridled inequality, exploitation and poor education standards continue to encumber growth in South Africa. Here is a country of dualism, and within Africa is identified as having the second-largest economy. For this country, there exists a plethora of opportunities, nevertheless, they are obstructed by enervating encounters which include the bequest of a painful past that hinders hopes for the present, while inefficient implementation hampers progressive regulations. The lives of the affluent one percent could merely be compared to those strong population percentage living in poverty. The vastly educated contrasts with the illiterate, and well-manicured homes in deeply guarded areas are nothing but a short distance away from rickety shanties in townships.

The swift growth of the economy and the devastating effects of inflation create many challenges to South Africans, more especially to the less advantaged individuals already struggling to satisfy basic living requirements. South Africa is plagued with diverse social challenges within the environmental and economic spheres that directly affect the quality of people's daily lives. An intrinsic area of concern in South Africa is education. With a population that lacks essential education, a country will fail to progress not only in terms of economic growth but also for the reason of political development.

Additionally, numerous social challenges arise due to the lack of educational opportunities within disadvantaged communities. For the citizens, this creates further consequences which include diminished personal health which in turn leads to the inability to attend work or school. The "Bantu" education system which reigned during the apartheid years, deprived critical teacher training for the disadvantaged population. The strong influence that education has on unemployment, economic progression and social infrastructure views the necessity for education itself to be the instrument to steer the citizens towards resilience.

In response to diverse social crises, the need for a socially responsive science (SRS) is timely. What is needed then, is a science education that goes beyond the recommended theory and includes strategies which can be utilised to improve daily living conditions across the environmental and economic spheres. To deliver a socially relevant science that aids in the development of self-reliance and resilience amongst learners is an opportune direction towards responding to these challenges.

The purpose of this research was to explore how science teachers engage with the curriculum to teach socially responsive science. The emphasis of this study was to gain insight into the interpretations and practice of content and pedagogical content knowledge of these science teachers when they taught SRS related topics. Four science teachers who were teaching Natural Sciences and Life Sciences within the Senior and Further Education and Training (FET) phases of the South African school system respectively, and who were studying a postgraduate curriculum development module, were purposively selected to participate in this qualitative study.

This study was positioned in the interpretivist paradigm, and an understanding of science teachers' practice in SRS within a South African education context was sought. Qualitative data were generated using document analyses and individual interviews. Humanistic science education and theoretical constructs embedded in a social reconstruction curriculum ideology, informed the analysis of the data.

The participants who were the teachers in this research, indicated that learners attending the schools where they were teaching, experience numerous daily social challenges. These challenges were identified by conducting a needs assessment which highlighted challenges within personal and environmental health. Through the assessment, teachers identified topics and strategies to teach learners how to overcome some of these social issues. Some of the challenges experienced when teaching SRS included the limited time allocated to complete the tasks as well as having limited knowledge of teaching SRS.

The findings revealed that teachers selected topics located within knowledge strands 2 and 3 of the Life Sciences curriculum for grade 11. Lesson topics were additionally selected from within knowledge strands prescribed for terms 1 and 2 of the Natural Sciences curriculum for grades 7 and 9. These topics highlighted aspects related to personal and environmental health. Teachers taught their lessons using socio-

scientific issues (SSIs) related content to develop learners' understanding and responsibility towards societal challenges with an aim to encourage social transformation.

Teachers further utilized constructive strategies including problem-based inquiry in a learner-centered environment where collaborative efforts were encouraged. The teachers indicated that firstly these strategies developed necessary knowledge and skills learners require for addressing societal challenges. Secondly, they value learning goals and develop conscious and caring teachers and learners. Finally, the topics and activities selected, create a link between school science and the everyday living culture of the learners.

Teachers stated that SRS education should be emphasized to a greater extent in teacher training institutions so that practicing teachers in the future would be better able to deliver meaningful science education.

The findings that emerged from this research will be of significance to teachers, curriculum designers, subject advisors and teacher training institutions.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

CAPS:	Curriculum and Assessment Policy Statement
DBE:	Department of Basic Education
FAO:	Food and Agriculture Organisation
FET:	Further Education and Training
IBSE:	Inquiry-Based Science Education
IK:	Indigenous Knowledge
IKS:	Indigenous Knowledge Systems
LS:	Life Sciences
NS:	Natural Sciences
PCK:	Pedagogical Content Knowledge
SA:	South Africa
SRS:	Socially Responsive Science
SSIs:	Socio-Scientific Issues
SSI-TL:	Socio-Scientific Issues Teaching and Learning
STATS SA:	Statistics South Africa
UKZN:	University of Kwa-Zulu Natal
USA:	Unites States of America

CHAPTER 1

Orientation of the study

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CHAPTER 1
Orientation of the study

1.1 Introduction and background

> *"South Africa exhibits long-lasting effects in terms of poverty, inequality, economic growth and poor education as a result of policies of segregation and discrimination from the apartheid regime, even after its demise at the dawn of democracy. South Africa contains both extreme inequality and affluence".* (Woodlard, 2002, p.6).

Development in post-1994 South Africa continues to be hindered by uncontrolled inequality, corruption and poor education standards. An overabundance of opportunities may exist for this country that is grounded by a strong economy; however, they are impeded by replicating challenges which are brought about due to an unjust past that encumbers hopes for the present and future. The inequalities which affect living conditions are clearly evident as there is a strong juxtaposition between the affluent and poor. These comparisons reveal immense differences between the educated and the illiterate, and the high fenced homes of the rich are a few steps away from the informal settlements (squatter shacks).

In the 2002 Taylor Commission report, Woodlard (2002) confirmed that within the world, South Africa is the most unequal in terms of socio-economic conditions. The report describes South Africa as an upper-middle class nation with stark contrasts and education is identified as one of the important links to poverty in the country. Pillay (2001) states that education, among other factors, can have a positive or negative effect on unemployment, inequality and poverty, depending on the nature and direction of policy. When educational institutions become 'social institutions' they have the potential to prepare learners to respond to social challenges such as poverty, inequality and social justice. The nexus area between social ills, economy, politics and education has motivated many philosophers including Giroux to link education to democracy. A democratic society must be equipped with pedagogical practices that shape prolific citizens who possess critical and knowledgeable qualities and who are able to act in a socially responsive manner (as cited in Mudaly, 2020). South Africa faces environmental crises, such as droughts and water scarcity as well as socio-

economic challenges such as unemployment and poverty, among others. This is the reason why social responsiveness is valuable in the curriculum.

Many social dilemmas are directly linked to the discipline of science. These are often referred to as socio-scientific issues (SSIs). In my study, engaging in dialogue about these socio-scientific issues, and undertaking action to resolve these challenges, is conceptualized as socially responsive science (SRS). Science teachers have mainly focused on pure science which is embedded in disciplines such as physics, chemistry, zoology, botany and others. Further, according to Leung, Wong and Chan (2020) science learners should not only develop their scientific knowledge but also use that knowledge to be able to participate in public debates on scientific issues. In the context of South Africa, the socio-political and economic transition after the ushering in of the democratic order in 1994, saw the prevalence of many social challenges (Badat & Sayed, 2014). Several social challenges can be explored and addressed through science. Mbembe (2015) asserts that the curriculum being implemented in South Africa continues to be removed from people's context and lived experiences. However, given the demands of the science curricula which are examination driven, possibilities for engaging in a socially responsive science are few because the school science curriculum only pays attention to "undisputed" science which includes mainly theory, laws and facts, and makes almost no reference to societal contexts (Amos, Knipples & Levinson, 2020; Bencze, Halwany & Zouda, 2020). In this study, this problem is explored by examining teachers who engage in socially responsive science teaching.

Within South Africa, the need for SRS is enshrined in the curriculum. The Curriculum and Assessment Policy Statement (CAPS) for grades R-12 provides this principle: "Human rights, inclusivity, environmental and social justice: infusing the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa" (Department of Basic Education [DBE], 2011, p.5). In addition, the aim that follows, also appears in the CAPS document: "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" (DBE, 2011, p.4). A meaningful curriculum which is contingent upon people's lived experiences, which is underpinned by a social justice framework as outlined in the CAPS document,

influences my study which explores how a curriculum can be used to respond to social challenges. My view is that this can largely be achieved by leveraging the skills of innovative teachers in the classrooms as well as curriculum developers.

1.2 Purpose and focus of this study

The purpose of this study was to explore how teachers use the science curriculum to teach SRS within the South African context. It was to understand their experiences, choices and challenges, related to their incorporation of SRS into the curriculum.

The study focused on the experiences of practicing science teachers while they engaged with the curriculum to teach SRS during their study towards a post-graduate (honours) degree in the university. One module, from which this study draws, aimed at creating an understanding of the nature of the curriculum, the elements of transformation and change which shape the curriculum, and the teachers' role in decision-making and evaluation regarding the curriculum. This module was located within the Honours in Mathematics, Science and Computer Studies Education degree programme. Further, it required teachers to apply and engage critically with the aims of Mathematics, Science and Computer Studies Education in relation to a holistic approach to curriculum, with a view to contextualizing it. The content topics of this module included 'Concepts and issues related to the curriculum, Curriculum theory, Curriculum models, Curriculum analysis, Curriculum philosophy and policy, Contextualizing curriculum, Constructivism as a learning theory and Curriculum transformation' related to the Sciences and Mathematics.

The practices of ten purposively selected practicing teachers, who taught Life Sciences or Natural Sciences, and who engaged in an Honours degree as part of a professional development, were the focus of this study. The views of the practicing science teachers, generated from their perceptions and experiences, were documented portfolios of evidence. These portfolios included prepared and executed lessons on SRS related topics within the Life Sciences and Natural Sciences subjects. Their feelings along with their thoughts, challenges, methods to address these challenges, and the reasons behind what empowered them to teach SRS, are emphasised in this study.

1.2.1 Research Gap

Studies related to the use of the science curriculum and its ability to respond to social difficulties appear to be scarce. In particular, research into the science curriculum to enable learners, teachers and ultimately the society which they educate to respond to adversity such as food insecurity, affordability and consumption, water availability and quality, waste management and recycling in the South African context, is sparse. According to Evagorou and Dillon (2020) international studies have revealed that learners are engaging in socio-scientific issues (SSIs). However, studies that reflect on teachers' practices and how they support learners in SSIs are limited. Further, the challenges of addressing these issues in science classrooms are not well documented.

Despite the vast body of knowledge within the field of humanistic approaches to education, there has been very little evidence of work done which shows how the South African science curriculum can be used to respond to social challenges. This is based on my literature review, which involved search engines including Google Scholar and Worldcat. According to Santos (2008) some ideas of humanistic science education have been considered; however, a central focus on science curricula has not been explored.

In my study, I therefore address this paucity by exploring the ways in which science teachers teach to help learners respond to social issues. This research further aims to contribute to the body of knowledge to address some of the gaps within the field.

1.3 Rationale for the study

Three imperatives underpin the reasons for engaging in this study. The first relates to the Curriculum and Assessment Policy Statement (CAPS), the second, to the review of literature and third, to my personal experience as a practicing science teacher.

According to the CAPS curriculum, the purpose of studying Life Sciences is to develop an understanding of the role of science in society in taking on critical humanistic roles by valuing human rights and caring for each other in society and the environment (DBE, 2011). These values, as mentioned in the CAPS curriculum, are further emphasised by Santos and Mortimer (2002) who state that according to Paulo Freire, humanistic science education aims at making learners aware of their role in the

transformation of modern society, thus redressing education by the oppressor. Further, a general aim of the curriculum in South Africa, is to encourage social transformation to create balance (equity) among all in society (DBE, 2011, p4). The teacher plays an important role in implementing SSIs in science lessons (Nielsen, 2020; Cohen, Zafrani & Yarden, 2020). I therefore view the teacher as a critical actor in advancing humanistic science education by incorporating SSIs in SRS which I explore in my study.

Secondly, the motivation for the study is apparent by suggestions drawn from the review of literature. Research studies suggest that a humanistic approach to science education be developed, and that science education be made more meaningful and relevant to learners' lives. Evagorou and Dillon (2020) assert that there is a decline in learners' interest and motivation to choose science as a critical subject, and therefore suggest that science be made more relevant by engaging learners in SSIs. A key goal of science education, according to Davis and Bellocchi (2020), is critical thinking which can be developed by assessing evidence and arguments from a range of perspectives which include scientific, ethical and social through the valuing of SSIs. Duncan (2014) further discusses the motivation for science and its integration within resilience by using natural resources in a humanist approach. Millar and Osborne (as cited in Aikenhead, 2007) along with Freire (1970), motivate for a humanistic approach to teaching and learning science with aims to address the society's shared needs. Santos and Mortimer (2001) additionally encourage the humanistic approach to science education in the contemporary society to address environmental, social and human life issues. With the global science education landscape shifting towards incorporating SSIs in science lessons, Mudaly (2020) asserts that this signals a motion towards humanistic science education which is dynamic, democratic and socially responsive, which encourages responsible citizenship. Therefore, studying how teachers teach SRS is fundamental to ensure that delivering relevant and socially responsive science education using a humanistic approach is enabled.

The third reason for engaging in this study is based on my personal experiences of working with learners. I have identified many learners who emerge from impoverished backgrounds and encounter multiple risks in the environments in which they live, work and study. Further, the study is based on my experience of science learners' engagement with school. Learners passively absorb information that has been

transmitted to them. My view of the purpose of science education should resonate with the aims of the CAPS policy, which is that learners should participate actively in constructing knowledge and become responsible citizens who are capable of critical thinking and problem solving. These traits can be developed in learners if teachers design units of work to enhance learners' capacity for critical thinking and problem solving. Therefore, I want to understand how teachers can facilitate this process using school curricula.

1.4 Significance of the study

This study is significant because it allows teachers to acquire a deeper understanding of how to use the science curriculum to help learners respond to social dilemmas. This study will ensure an improved application of the school science curriculum in responding to needs of the society and consequently develop responsible citizenship. Further, this study will assist in-service science teachers to address SSIs within the curriculum while encouraging a CAPS approach which stimulates for humanistic and social justice ideals and consequentially transform teachers and learners' valuing of science in their lives. Additionally, the study will address silences in literature regarding social responsiveness using the science curriculum in South Africa.

The findings of this study will have a positive influence on teachers' classroom practices and will thus contribute to an enhanced value of teaching and learning within Life Sciences and Natural Sciences. Furthermore, the findings generated from this study are expected to advise teachers, subject advisors and curriculum designers of the understandings and insights of implementing a curriculum that responds to societal needs through the learning of Life Sciences and Natural Sciences.

1.5 Research aims

The aims of conducting this research were:

1. To determine how science teachers engage with the curriculum to teach socially responsive science.
    1.1. To determine which topics teachers choose to teach socially responsive science.
    1.2. To determine why they chose these topics.
    1.3. To determine how they teach socially responsive science.
        1.3.1 To determine what strategies teachers use to teach socially responsive science.
        1.3.2 To determine why teachers choose these strategies to teach socially responsive science.

1.6 Research questions

How do science teachers engage with the curriculum to teach socially responsive science?

Sub questions:

1.1. Which topics do teachers choose to teach socially responsive science?

1.2. Why was that topic chosen?

1.3. How do teachers teach socially responsive science?

1.3.1 Which strategies are used to teach socially responsive science?

1.3.2 Why do teachers choose these strategies to teach socially responsive science?

1.7 Research design

A case study design was used in this research to explore how four practicing science teachers engaged with the curriculum, to develop lessons to teach SRS. The cases under review were the practicing Life Sciences and Natural Science teachers. An interpretivist paradigm informed this research because feelings, experiences, insights and practices of teachers teaching SRS were sought. Furthermore, the study adopted a qualitative methodical approach because to acquire an understanding of behaviour and the reasons for that behaviour in detail, is a goal of qualitative researcher's (Salkind, 2012).

Two methods of data collection were adopted, namely, individual interviews and document analysis. The purpose for using two methods to collect data was to answer the research questions from different viewpoints. In that way triangulating data to enhance research rigour was possible. Validity, reliability and trustworthiness of the data obtained was enhanced through triangulation. An inductive analysis was conducted on the data that was obtained and answers to the research questions of this study emerged through the findings.

1.8 Findings

The findings of this study emerged from the data that were generated through the interviews and document analysis. The research questions that guided this study gained responses from the themes that appeared from the data. The findings included practicing teachers' views and experiences of planning and teaching lessons from the Life Sciences and Natural Sciences curriculum with a socially responsive approach. Further, the findings of the research illuminated the need for a socially responsive approach to science, because it provides a benefit to society and an enhancement of one's self-reliance.

1.9 Overview of chapters

Chapter One provides a background to the study. In this chapter, the purpose, focus, rationale and significance of the study are discussed. The aim of the research, the critical research questions, design of the research, overview of this chapter and findings are charted.

Chapter Two comprises the review of literature that relates to the study. The literature review exposes both local and international literature relating to SSIs and SRS. The concept of SSI is defined and examples within the South African context are discussed. Views around teaching SRS along with the education curriculum as it is concerned with SSIs are outlined and suggested professional development methods for an SRS are discussed. The review concludes by presenting theoretical constructs that frame this study which centres around Paulo Freire's perspectives on humanistic science education as well as a curriculum ideology namely, social reconstruction ideology.

Chapter Three focuses on the research methodology espoused in this study. An interpretative paradigm with a qualitative approach was made use of to explore the interpretations of the practicing science teachers about teaching SSIs in Life Sciences and Natural Sciences. A case study served as a design for the study and two methods of data collection were used specifically individual interviews and document analysis. Rigour of the research, ethical considerations and limitations are detailed within this chapter.

Chapter Four analyses the data and presents the findings of the study. Qualitative content analysis was used to understand the data generated from the participants. Several themes emerged from the data which were related to the research questions. The chapter closes with a discussion of findings.

Finally, Chapter Five presents a summary of the key research findings relevant to the research questions of this study. Recommendations were suggested and were grounded upon the findings that arose from exploring the views and experiences of practicing science teachers about teaching SSIs for SRS.

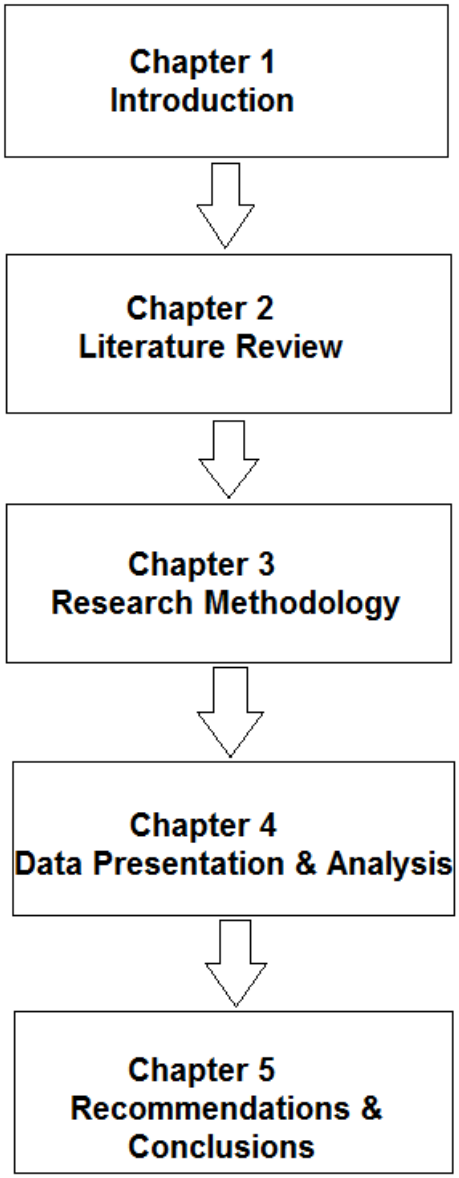

Figure 1: Order of chapters

1.10 Conclusion

This chapter presented the introduction and background of this study. The purpose and focus of the research were outlined as well as the rationale and its significance. The chapter also highlighted the aims of the research, critical questions and methodology adopted in an overview of the chapters in this thesis. The following chapter will present the reviewed literature relating to the focus of the study.

CHAPTER 2

Literature Review

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CHAPTER 2

Literature Review

2.1 Introduction

This literature review details findings from research based on socio-scientific issues (SSIs) and its relevance in promoting an SRS education. It explores the current state of the world, particularly South Africa with regard to specific social and environmental dilemmas and consequently the need for science education to be socially responsive. This review will present three main foci. Firstly, a brief definition of the concept of SSI will be discussed. Studies which reveal examples of social issues peculiar to the South African context, will then be highlighted. Secondly, teaching of an SRS will be detailed. Research related to curriculum theory, the South African education policy and its connectedness to SSIs is reviewed. Finally, the theoretical framework is presented.

2.2 Conceptualizing socio-scientific issues (SSIs) and socially responsive science (SRS) within this study

Socio-scientific issues (SSIs) refer to the issues that affect society arising primarily from social and economic spheres. Such issues include poverty, food insecurity, crime, unemployment, inequality, HIV/AIDS, pollution, housing and the lack of access to basic service delivery (Bayat, Louw & Rena, 2014). According to Cohen, Zafrani and Yarden (2020) these topics relate to science and social dimensions and are therefore understood as SSIs. SSIs are those social issues that are related to science (Topçu, Muğaloğlu & Güven, 2014). Mnguni (2017) further identifies HIV/AIDS and green economy as socio-scientific issues given their impact on society. These issues are also identified as SSIs by the European Commission (EC) (2015) within European communities. Many of these issues can be addressed using science in general and the science curriculum in particular, and therefore become socio-scientific issues. Topçu *et al*. (2014) state that social dilemmas related to science increase as advancements in science continue. These social dilemmas that involve science and society are called socio-scientific issues (Eastwood, Sadler, Zeidler, Lewis, Amiri, & Applebaum, 2012). According to Zeidler and Nicols (2009) SSIs makes use of scientific topics purposely to engage learners in discussion. Furthermore, socio-

scientific issues explore issues within science and then relate them to social issues to provide a resolution (Klosterman & Sadler, 2010; Rundgren & Rundgren, 2010). According to Leung, Wong and Chan (2020) SSIs refer to the interrelationship between science and society that is multifaceted with no distinct solution and based on delicate and contradictory evidence. Additionally, SSIs consider ethical dimensions of social issues with theoretical, methodological or technical links to science (*ibid*). Zeidler and Keefer (2003) define SSIs as social issues which are open-ended problems that relate to science. According to Sadler, Foulk and Friedrichsen (2017) the learning of SSIs has been identified as an effective approach to learning science within school contexts. SSIs are further, productive contexts for engaging learners in opportunities that merge school experiences with societal contexts. (*ibid*). Further, Nida, Rahay and Eilks (2020) identify the learning of science with SSIs as a direction towards developing active and responsible citizens that are critical and considerate towards the environment around them.

SSIs are complex societal issues that are contemporary and can be related to learners through their personal interactions and societal knowledge, observations (Sadler *et al.,* 2017) and indigenous knowledge systems. The depth of complexity of SSIs is informed by the type of non-scientific or socially scientific perspective as well as the scientific evidence and information available. The non-scientific or socially scientific perspective becomes the lens through which the scientific evidence and information are viewed and subsequently engaged. The production of knowledge and skills related to SSIs to foster social dialogue results in empowerment within science classrooms in schools (Bantwini, 2010). This fostering of dialogue and providing suitable solutions to social problems using the discipline of science are conceptualized socially responsive science within this study.

Ogude, Nel and Oosthuizen (2005) define responsiveness as a behavioral change that is motivated by a stimulus that provides a drive to survive. Further, being responsive involves being able to satisfy the wide-ranging expectations and harsh conditions within society to become aware and address issues. Social responsiveness can then be understood as being able to take action to bring about change and transformation (Freire, 1974) as well as rehabilitation of society with regard to the issues mentioned above. These actions are knowledge generation and dissemination, as affirmed by Ogude *et al*. (2005), which implies responsiveness. Holbrook and

Rannikmae mention that science should be rooted socially and culturally for it to be a human endeavor that is changeable and experimental (as cited in Mudaly, 2011, p. 29). The purpose of SRS in my study, therefore, is to equip learners with skills to deal with and address social and cultural aspects within the contexts in which they live by engaging them in activities that encourage discussions (and actions) around specific socio-scientific issues. Further, it is agreed that educational institutions where teachers are key agents in implementing SSIs in the classroom (Cohen *et al*., 2020) should be the vehicles that drive social redress through a curriculum that addresses societal issues.

The European Commission (2015) states that science education should respond to social issues so that learners develop societal responsibility and a positive attitude towards science education. According to Bencze, Halwany and Zouda (2020) the learning of SSIs allows learners to examine data which enables them to develop carefully reasoned personal positions on issues. Teachers have the responsibility to include socio-economic issues as well as ethical issues in lessons to prepare learners for active citizenship *(ibid).* Important societal goals are to respond to and reduce poverty as well as improve socio-economic contexts through the teaching of science in European communities and the rest of the world (EC, 2015).

According to Mudaly (2011) science education should be viewed as a human activity which is supported by social and political issues instead of being isolated from these issues. By incorporating and discussing social challenges within science lessons, learners will be better able to respond to these challenges. Mudaly (2011) discusses research involving how a Life Sciences teacher engaged learners in conducting a study on HIV and AIDS, which is a socio-scientific issue under the construct of gender as a focal theme. The research allowed learners to take control of their study through a dialogic process as advocated by Freire (1970) and was informed by a humanistic approach to learning. The aspect of teaching HIV and AIDS is located within the topic *human reproduction* in the Life Sciences curriculum. The findings of Mudaly's study (2011) revealed that the learners had become empowered by gaining competence in understanding the socio-scientific issues that they may encounter. As a result, through the study of science, learners become more skilled and knowledgeable to respond to socio-scientific challenges related to HIV/AIDS within their communities (Mudaly,

2011). Cohen *et al*. (2020) assert that SSIs encourage learners to engage actively and responsibly in working toward a better and safer world.

Mnguni (2017) along with Nielsen (2020) states that SSIs may include methods of learning science by guiding learners' argumentation, decision making process through critical thinking and problem solving by being alert to their surrounding and questioning situations. Further SSIs include learning about social issues that are taught as topics within the science curriculum and are identified through social dialogue, as encouraged by Freire (1970).

Socio-scientific issues in this study will refer to learning about the social issues identified within Life Sciences and Natural Sciences classrooms to foster responsible citizenship, awareness and enable the possibility of responding to challenges in society using scientific knowledge.

2.3. Examples of socio-scientific issues

In this study, I focus on two broad SSIs to which science learners at school could respond. These are personal health and environmental health. Two conditions which have been deeply embedded in socio-economic deprivation, namely, food insecurity and the vulnerability to malnutrition, will be discussed under personal health. Waste management and water insecurity, which are issues of global importance, will inform the review on environmental health. The reason for focusing on these topics is that they, among others, have direct relevance and importance within the South African context (Woodlard, 2002; STATS SA, 2017)

Table 1: Examples of SSIs within two broad categories in this study

PERSONAL HEALTH	ENVIRONMENTAL HEALTH
Food security and Malnutrition	Water availability/ quality
	Waste disposal

2.3.1. Personal Health

- Food insecurity

The Food and Agriculture Organization (FAO) (2015) report that the condition of food insecurity globally has increased. It is reported that more than 814 million people in developing countries are undernourished. South Africa (SA), which is included as part of sub-Saharan African countries accommodate approximately two hundred and four million of these undernourished people. South Africa is overcome by poverty and unemployment, irrespective of the political and economic developments recognized in the country since the inception of the democratic order. The recent global economic crisis, characterised by strident increases in prices of food and fuel, high energy tolls, unreliable energy supply, and more recently the COVID 19 pandemic further contribute to the decline of the country's economy. South Africans experience severe pressure due to these adverse conditions, especially those who are already struggling to meet their basic household requirements. This is supported by Statistics South Africa (STATS SA) (2017) which mentions that the food poverty numbers have increased since 2011. Further, STATS SA (2017) confirms the increase in poverty in a large number of households within the country. Enhancing social responsiveness in learners may help towards addressing food insecurity and poverty to some degree, through strategies such as learning how to develop food gardens to educate learners on how they could overcome these stresses.

2.3.2. Environmental health

- Waste Management

According to Hoornweg and Bhada-Tata (2012) world cities produce about 1.4 billion tons of solid waste annually. By the year 2025, this amount is projected to intensify to 2.2 billion tons. Waste generation rates in lower income countries are projected to duplicate over the next twenty years. Globally, finance required for solid waste disposal will increase drastically by 2025. Cost increases will be most stark in low income countries such as Zimbabwe, Uganda, Nepal and many others as well as lower-middle income countries such as Thailand, India, and China. Upper-middle income countries which include South Africa, as well as high income countries, will also be affected. The impacts of solid waste show rapid growth on a global scale. A major source of methane which is an influential greenhouse gas (GHG) is solid waste

and has a particularly short-term impact (Alam & Ahmade, 2013). The recycling sector is now a global concern. Locally, uncollected solid waste is a large contributor to flooding, air pollution, and public health. This causes negative impacts such as diarrhea, respiratory disorders and dengue fever as confirmed by Alam and Ahmade (2013), whose research was conducted in India. These health issues are also confirmed by the Department of Environmental Affairs of South Africa (2014). With the influx of these diseases and the solid waste levels taking up our land, strategies to overcome and deal with these issues should be developed. The way in which this can be done in schools is by enhancing a socially responsive attitude in learners within the science classrooms. This could help start a chain of resilient attitudes such as recycling products for income, reducing and reusing products thereby reducing waste produced amongst family members and ultimately the community in which they live.

- Water availability and quality

According to Bigas (2012) water security is the basis for food and energy, and for long-term development economically and socially. Water supports health, nutrition, equity, well-being and economic progress, more specifically in developing countries. But water quality and availability are threatening life even in the most developed countries of the world. In the USA, for instance, water availability has already been recognized as a national concern, which is affecting the country's ability to meet the water, food and energy needs *(ibid).* Many places, especially in sub-Saharan Africa, West Asia and North Africa, are already experiencing serious water shortages. This is evident in the recent effects of drought in South Africa. Apart from the water shortage, Fobosi (2013) asserts that South Africa is plagued with poverty and consequently many rural areas do not have access to secure (clean) running water and therefore use communal taps which pose additional problems. Gupta (2010) states that poor quality of water has detrimental health effects which include diarrhea, cholera and gastroenteritis. Socially responsive learning within science classrooms could initiate actions to be taken to purify water and sustain water resources to eliminate the water crises and the consequent negative impacts on human health and bio-physical environment in the country.

2.4. Teaching socially responsive science

This study seeks to understand the application of teaching the science curriculum to achieve the ends which result in a socially responsive undertaking by the (active) consumers (learners) of the curriculum, as mediated by the facilitator (teacher). The aim is to determine what strategies can be employed by the teacher to engage learners in socially responsive activities and thinking.

According to Gay (2010), culturally responsive science as utilising past experiences, cultural information, frames of reference, and performance styles of ethnologically diverse learners render learning more applicable to and effective for learners. Additionally, Ladson-Billings (2009) asserts that culturally responsive teaching is a pedagogy that socially empowers learners, emotionally, intellectually and politically because cultural references are used to inform knowledge, skills, and attitudes. Social responsiveness according to Ogude *et al*. (2005), equips learners with skills to deal with social and cultural aspects that are closely linked. It is evident that education can play a vital role in developing and restoring a culture within society. According to Bassey (2016) culturally responsive education can be seen as using culture to improve academic and social achievement and additionally develop learners who become agents of social change and ultimately achieve social justice.

To successfully execute a socially and culturally responsive curriculum, teachers need to tap into the culture and societal settings of their learners. They further need to identify challenges and discomforts that will serve as aspects to which lessons will be designed to promote some change using knowledge of science (Bassey, 2016). This is agreed upon by Hernandez, Morales and Shroyer (2013) who state that lessons should be taught considering the background of the learners. Further, it is mentioned that prior knowledge is to be assessed, and to do this, Freire (1972) proposes a process of dialogue between teachers and learners. This prior knowledge gives the teacher an indication of how much is known and in which direction the lesson should be driven. Prior knowledge and culture within a specific social context raise concerns over indigenous knowledge systems (IKS). Specific Aim 3 in the CAPS curriculum directs teachers to adopt IKS to teach education that is inclusive of culture, and history and to provide a link with societal issues so that learners gain an understanding of the relevance of school science in everyday life (DBE, 2011, p.10).

This research will identify the ways in which teachers link content and pedagogy to enhance learning. Pedagogical content knowledge (PCK) is defined by Shulman (as cited in Chapoo, Thathong & Halim, 2014, p.465) as “the merging of content and pedagogy into knowledge of how specific topics, problems, or issues are put together, represented, and implemented to the diverse interests and abilities of learning, and presented for teaching”. Chapoo *et al*. (2014) mention that PCK is helpful in teachers’ understanding of what is known, what should be known and how it can be developed. Having a background of PCK is beneficial to the learners as learning becomes organized and smooth. Additionally, Chapoo *et al*. (2014) state that this may develop an inquiry-based mindset in the learners because they will become equipped to address issues outside the classroom. This research will therefore gain insight into PCK that informs teachers’ decisions in the classroom in terms of what to teach and how to teach it when enhancing learners’ responsiveness to social dilemmas that they may face, with the aid of the science curriculum.

According to Freire (1970) teaching of science should be an active process. Rokos (2015) asserts that to eliminate high distraction and lower interests in science, teaching should be redirected in a way where methods that allow learners to be more active in learning are used. Inquiry-Based Science Education (IBSE) learning is suggested for this to happen. Shamsudan, Abdullah and Yaamat (2013) define inquiry as seeking information through investigation on particular phenomena where the process is a hands-on action that involves engaging in science experiments to understand the characteristics of science. Amos *et al*. (2020) encourage the learning of SSIs via IBSE for active citizenship. Through IBSE, Shamsudan *et al*. (2013) explain that learners learn best through active roles when they practice what they have learned. Additionally, Wang and Wen (2010) suggest that an inquiry-based approach to learning provides learners with better understanding of subject content and an ability to think more creatively and critically. These are some skills involved in the learning of a socially responsive science as posited by Schiro (2008).

Inquiry-based learning in SRS is used to tackle learning that involves problem solving where learners engage actively through inquiry to investigate and provide solutions to a given problem. This type of learning is identified as an example within the learning theory of constructivism. Singh and Yaduvanshi (2015) describe constructivism as an approach that allows learners to construct meaning through their own experiences and

illustrates that this approach to learning is an active and collaborative process. Constructivism in learning science is suggested in contemporary classrooms as it opposes the conventional methods of teaching which promotes direct instruction and memorization (*ibid*). Constructivism, through inquiry, is claimed to spark interest in learners, enhancing critical thinking and development of scientific process skills that are beneficial in causing significant transformation through learning science with a view to responding to social challenges.

Socio-scientific issues (SSIs) in this study relate to those social issues which are linked to science and present themselves as challenges in society. Socially responsive science goes beyond an awareness of SSIs, because in my view it involves dialogue, deeper understanding of SSIs, plans to address social challenges using knowledge and skills of science and implementing those plans.

2.5. Teachers who teach socio-scientific issues

As addressed earlier, socio-scientific issues relate to societal issues that involves the role of science (Bossér, 2018). Teachers are expected to deliver science education in a meaningful manner that promotes the development of responsible citizens to take up active roles in society (Department of Basic Education [DBE], 2011; Nida *et al*., 2020). Additionally, Bossér (2018) states that teaching science by dealing with SSIs, can prepare and empower learners for active and responsible involvement in an intricate and democratic society. The teaching of SSIs is viewed as productive frameworks in teaching and learning (Zeidler, 2014). Hancock, Friedrichsen, Kinslow and Sadler (2019) however states that teachers are given limited guidance to selecting key issues for SSI-related teaching and learning.

Hancock *et al.* (2019) provide insight into a USA based midwestern state study that involved secondary science teachers redesigning the science curricula according to the New Generation Science Standards (NGSS). This formed part of a professional development activity and the new curriculum design involved an SSI based approach to teaching science. Hancock *et al.* (2019) state that teachers worked collaboratively when designing SSI based curricula and became more informed and intrigued by delivering such an approach. It was further mentioned that teachers became creative designers and agents of contextualized curricula which embodied a shift from being purveyors of information. Some of the strategies that the teachers adopted included

group work and hands on investigations. Almost all activities that were conducted enabled learners to work with minimal assistance from the teacher. Teaching SSIs challenges learners during the lesson and in the future, that is by encouraging critical problem solving (*ibid*).

Although many of the teachers held the view that SSIs are useful in learning science, others indicated that numerous challenges exist (Nida *et al.,* 2020). The challenges that they experience are viewed to be enough to abort the application of SSIs. Some of these challenges included absent SSI based teacher training (Anagün & Özden, 2010; Nida *et al*., 2020), limited time to plan and execute the lessons (Nida *et al*., 2020), the lack of SSI-related resources (Tidemand & Nielsen, 2017) and limited support from administrators (Hancock *et al*., 2019; Saunders & Rennie, 2013). Further, Bossér, Lundin,Lindahl and Linder (2015) suggest that successful SSI based teaching should not be enacted alone. It should also view the "integration of SSIs as a beneficial way of stimulating the transformation of classroom practices" (p. 174).

A study conducted by Altan, Ozturk and Yenilmez (2018) in Turkey, highlights teachers' designs of Science, Technology, Engineering and Maths (STEM) lessons around focal SSIs that they identified. According to Altan *et al*. (2018) STEM education enables learners to interact with problematic situations in the form of SSIs and which are further connected to their prior experiences. This is also well-matched with the social and cultural environment in which they live and work (*ibid*). Teaching STEM education by involving SSIs contributes to more than the awareness of different disciplines within the SSIs which includes raising individuals' awareness of social issues (Zouda, Halwany, Milanovic & Bencze, 2017). The learners worked collaboratively with each other through investigations related to agriculture, power sources and fuel. Learners designed and presented plans and proposals for solving related problems.

Altan *et al.* (2018) state that the lessons and activities executed by the teachers were suitable for teaching SSIs through STEM education. The lessons were identified as being structured around socio-cultural contexts of the learners. The teachers indicated that the activities could develop various skills which include decision making, critical thinking, argumentation and problem solving (Atlan *et al.,* 2018; Nida *et al*., 2020).

Further, SSI activities were related to everyday life which made it interesting (Anagün & Özden, 2010), motivating and enabled learners to develop solutions to the problematic situations in the context of their society (Altan *et al*., 2018).

Bossér (2018) asserts that there is an increase in the interest of teachers with regard to the linking of school science curricula to real life societal contexts. According to Bossér (2018), some studies reveal that teachers encourage and welcome SSIs in science education as they familiarize themselves with the advantages of SSI learning based curricula. Further, the teachers indicate that they believe it is important to include social issues when teaching science. However, many teachers provide few opportunities for learners to consider it. Additionally, Bossér (2018) states that some teachers are inclined to direct attention more on the content of science that is related to social issues rather than giving attention to social and ethical considerations.

Another study revealed by Bossér (2018), was on secondary science teachers' perceptions on learner-centered activities as important in dealing with social issues. Some of these activities included group discussions, debates and role-play. Bossér (2018) encourages a dialogic approach when engaging with SSIs and reflects on teachers that teach science using this approach. Further, the teaching of SSIs in the classroom provides opportunities for science lessons that are dialogic. This does not only involve respect to the inclusion of learners' ideas but also considers diverse knowledge, values, and thoughts emerging from numerous individuals, groups, or disciplines.

Anagün and Özden (2010) reveal through a Turkish study, that teachers may not necessarily understand SSI concepts and consequently are unable to teach it correctly. Further, SSIs have been incorporated within science and technology lessons addressing social and environmental topics that were current and visible through the local news reports. Teachers indicated that when successfully implementing science through SSI approaches, learners are able to identify science, technology, society and environmental relations (Anagün & Özden, 2010). SSIs are mentioned in assisting learners to connect science and technology to social living spaces and the environment and in so doing improve their decision making and inquiry skills.

According to Nida *et al*. (2020) despite the growth of SSI integration in science classrooms over the years, many teachers experience numerous challenges with successfully implementing the approach. On the other hand, while understanding the advantages of the SSI based approach, many teachers do not actually enact it. Teachers still tend to place their focus on science as a subject to deliver facts and theories instead of making learning relevant and meaningful to contextual realities. Nida *et al.* (2020) further elicits responses from practicing science teachers on their application of SSIs in science lessons. Teachers indicated that SSIs develop necessary scientific skills in learners along with considerations towards societal issues. Additionally, teacher competencies that could be developed were identified using SSIs. These include professional pedagogical skills, such as developing contextualized learning, employing and designing varied learning materials, forming reliable assessments, and motivating students.

2.6. Curriculum Theory

Curriculum theory as defined by Glatthorn (2005) is “a set of related educational ideas that provides a methodical and illuminating perspective of curricular phenomena” (p.74). Curriculum theory has the ability to provide teachers with a critical understanding on the society and its schools so that reasoned choices are made when guiding practice. Glatthorn (2005) states that curriculum theory plays an important role in developing a curriculum. Eisner and Vallance (as cited in Glatthorn, 2005) identify social reconstruction-relevance as a classification of curriculum theory. This theory emphasizes societal needs rather than individual needs. Learners can therefore learn through a curriculum that will enable them to solve issues within society. Society centered curricula within content-oriented theories identify the radicals as those who see society as flawed and educate learners to address these flaws. Evident here is Paulo Freire’s goal of education where the masses are enlightened about inequalities in sociocultural realities through conscientization. Using curriculum theory, one has to understand that curriculum development should be guided by ideas that may create positive effects within a society which is facing challenges. The aim then, is to develop a curriculum that is socially responsive.

2.7. The science curriculum (CAPS)

2.7.1. Using the science curriculum to teach socially responsive education

This study focuses on how the science curriculum can be used to identify social challenges and respond to them. The CAPS document stipulates that schools are expected to work towards a social justice ideal which is expected to be achieved by addressing community challenges through the curriculum (DBE, 2011). This is evident in the aims and objectives of the curriculum policy, some of which are worthy of repetition from chapter 1.

- Specific Aims/ Objectives of Science Education

A general aim of the curriculum, as mentioned in the CAPS document, is to help learners "acquire and apply necessary knowledge and skills that is meaningful to their own lives and contexts" (DBE, 2011, p.4). The social context focused on in this study relates to personal and environmental health. Science education can be a tool for helping learners develop skills to deal with these challenges (DBE, 2011).

The DBE (2011) further mentions in the CAPS curriculum that using the science curriculum, learners will be equipped to participate meaningfully in society which is what is needed for social responsiveness to be developed. Additionally, through the learning of Life Sciences, "learners will make connections between the role of science for society, on the one hand, and the environment, on the other" (DBE, 2011, p.12). This relates to Specific Aim 3 which is especially relevant in my study.

"Appreciating and understanding the history, importance and applications of Life Sciences in society".

Within this aim, learners should understand:

> *a. The history and relevance of some scientific discoveries*
>
> *b. The relationship between indigenous knowledge and Life Sciences*
>
> *c. The value and application of Life Sciences knowledge in the industry in respect of career opportunities and in everyday life*
>
> (DBE, 2011, p.17).

Similarly, within the Natural Sciences CAPS Curriculum document, Specific Aim 3 indicates that science learnt at school should be entirely relevant to everyday life. The understanding of history, scientific discoveries as well as indigenous knowledge enriches understanding between science and society.

Ogude *et al.* (2005) mention that becoming responsive to context-based issues develops responsible citizens who occupy responsible roles in society. In developing responsive learners within the South African context, the effects of apartheid cannot be overlooked which initiates rehabilitation of South Africans in terms of psychology, cultural affirmation and fostering of intellectual independence (*ibid*).

Onwu and Kyle (2011) state that the role and effect of education in general and science education in particular, is to be altered to address global environmental challenges. It is contended by Lemke (2001) that "the restructuring of the science curriculum towards social relevance should be driven by the challenges and issues faced by citizens at the current point in time" (as cited in Mudaly, Pithouse-Morgan, van Laren, Singh & Mitchell, 2015, p.3). Ogude *et al*. (2005) suggest that the curriculum be made context specific through Africanisation. Mudaly (2020) affirms that the exclusion of indigenous knowledge systems (IKS) and the advancement of education guided by Euro-Western instruction pervade arguments in Africanising education. Further, Dowling and Seepe (2009) state that educational institutions must endeavor to meet the needs of social and economic goals of African people by submerging themselves within a culture and value system specific to Africans to ensure an ultimate African experience of the curriculum. Creating African experiences in the classroom means understanding and implementing IKS as envisioned by the DBE (2011) in the CAPS curriculum document. These arguments are in favour of enhancing learners' awareness of socially responsive science and are informed by a humanistic approach to science education although the CAPS curriculum document does not overtly declare this.

2.8. Relevance of IKS in the curriculum in responding to social issues

Indigenous knowledge (IK) is defined by Manzini (2000) as a type of “contextual knowledge that has been historically originated in a particular area and has been inherited by people from previous generations” (p.20). In a thesis, Ismail (2013) reports that the vast teachings and practice of indigenous knowledge (IK) have been ignored since the dawn of colonialism in South Africa. With the fall of apartheid and the rise of democracy in the country, colonial curricula had to be reformed so that “school science is delivered within the context of societal and cultural knowledge” specific to the learners (DBE, 2002, p.10). Specific Aim 3 in the CAPS curriculum document for Life Sciences, instructs teachers to make use of indigenous knowledge systems (IKS) to teach education that is “inclusive of culture, history and provide a link with societal issues so that learners gain understanding of the relevance of school science in everyday life” (DBE, 2011, p.10) and become equipped to respond to contextual challenges. Incorporating IKS in science classrooms makes school science relevant to learners’ lives and, in this way, they become equipped and better able to respond to socio-scientific issues.

This study therefore delves into understanding how teachers use these curriculum aims in their lessons and assessments as well as understanding their relevance in promoting the development of socially responsive learners. Through the CAPS curriculum, the DBE (2011) advocates that learners who study Life Sciences and Natural Sciences should become humanistic and critical thinkers. This can lead to the improvement of society by addressing socio-scientific issues with the aid of values and skills acquired through the science curriculum. In agreement with this, Santos and Mortimer (2002) state that the science education curriculum through the use of SSIs in lesson designs (Furman, Taylor, Luzuriaga & Podestá, 2020) should prepare learners for decision-making and develop critical thinkers in order to make valuable and democratic choices in society.

2.9. Attaining social responsiveness through resilience

2.9.1. What is resilience?

A key international volunteer-based humanitarian network known as The International Federation of Red Cross and Red Crescent Societies (IFRC) (2014) define resilience as the ability of people, communities, organizations or countries to anticipate and prepare for the effects of shock. They also become able to reduce the effects of these stresses and recuperate from adversity (IFRC, 2014). According to Chandra, Acosta, Stern, Uscher-Pines, Williams, Yeung, Garnett, and Meredit (2011), resilience is the ability to tolerate and convalesce from harsh conditions which may include economic stress, health issues, natural or human-made disasters. Similarly, Luthar (as cited in Ferreira & Ebersöhn, 2012) describes resilience as the constructive ability to adapt to significant life difficulty. Ferreira and Ebersöhn (2012) additionally view resilience as an ecological phenomenon where there is a dynamic interaction of resource systems.

Van Donk and Gaidien (2014) mention that the amount of change or shock that a system can absorb is emphasised within the ecological arena in terms of resilience and the level of stability to maintain the status quo. This is reached through reorganisation of a system. The ideas of adaptation, transformability, learning, innovation and self-organisation have become quite persuasive in resilience thinking, despite being positioned within the ecological setting. This is principally with regard to social or community resilience (McAslan, 2011). In my view teaching SRS could enhance resilient behaviours and attitudes in learners by equipping learners with skills, values and ways of thinking. I further believe that resilient practices and knowledge could be applied to SRS when mediating through social challenges.

2.9.2. Social vulnerability and resilience

When understanding resilience, it is important, to consider the idea of social vulnerability (Van Donk & Gaidien, 2014) which Berkes (2007) identifies as a ‘flip-side’ to resilience. In addition, McAslan (2011) suggests that issues and characteristics that reduce vulnerability should be focused on. Pasteur (2011) defines vulnerability as the scope to which a system or population is tending to and unable to address and manage stress. This vulnerability then requires resilient thinking to recover from these stressful situations. Pasteur (2011) discusses that stresses and hazards are more prone toward individuals that live in rural or impoverished areas. This is due to the lack of resources

to assist, handle and recover from these hazards. Pasteur (2011) further mentions that people may have declined availability to, and effect over, the systems and policies that administer their resource access. This means that they are then limited in terms of what they can do to address the principal sources of their vulnerability and to become resilient. However, this research identifies how learners can be taught to become resilient stakeholders, at least to some degree, in school, at home and ultimately in society using the science curriculum. A variety of factors influence social vulnerability (Singh, Eghdami & Singh, 2014). One of the major causes of social vulnerability is social class (Burton & Cuter 2008). This includes employment (stability and type), savings, income, as well as stages of education, and each of these is significant in South Africa, where unemployment is high. This is motivated by STATS SA (2019), which revealed that the unemployment rate in South Africa has increased. This undesired increase has a strong effect on the youth of the country as it was revealed that a large percentage of unemployment was due to achieving education levels below matric. Hence, this study explores the reduction of social vulnerability through education for resilience within Life Sciences and Natural Sciences classrooms.

2.9.3. The need for resilience toward social responsiveness

The Food and Agricultural Organization (FAO) is a United Nations (UN) agency that is concerned with the international food and agriculture. The 2004 FAO admits that, South Africans are not able to recover from adversities encountered within a deteriorating economy and overwhelming environmental uproar as they are placed under pressure, with convalescing difficulties (Labadarios, Mchiza, Steyn, Gericke, Maunder, Davids & Parker, 2011). Theorizing “resilience” is central, in addition to considering why it is essential. The USA based National Health Security Strategy (NHSS) (2015), specifies that resilience is critical to national health. This means that measures to acclaim the nations’ readiness, and response ability to incidents that have possible negative health consequences are endorsed. The availability of resources become reduced as a result of sudden crises. Individuals as a result, may then have to support themselves before any help is attained directly after an incident. This therefore views the need to develop resilience prior to an emergency as crucial. Further, NHSS views resilience as perilous to individual capability after an emergency, to reduce elongated periods of recovery, which can otherwise impose an extensive duration of suffering and resources at the national, and local stages.

Allenn and Alther (2015) state that resilience is relevant to human development and humanitarian action. This includes resilience that is used to understand lived experiences that affect the sensitivity of people and communities and further, their recovery from calamities. Humanitarianism is related to resilience in this way. My study will therefore focus on teaching with the use of the science curriculum that favours the development of resilient learners in humanistic ways in which resilience to a variety of factors can be enhanced among learners in doing Life Sciences and Natural Sciences.

Resources that are encouraging towards resilience ensue within systems of individuals, families and broader societies in relation to children. In my view, schools are examples of these systems that play a role in helping learners become resilient thinkers in order to enhance their living conditions as well as those of others through various lesson topics and activities as proposed by the national curriculum are discussed. According to Ungar (2008), the way in which people behave depicts a function of their environment. If one changes the environment, then strategies for improving one's life can be changed. These changes can be dealt with through resilience and therefore a need for resilience is seen. Structural supports like schools can provide an opportunity for learners to improve their life situations (*ibid*). Science teachers who use the science curriculum to improve learners' life situations are investigated within this study.

2.10. Silences/ gap in the literature reviewed

Studies related to the use of the science curriculum to respond to social difficulties appear to be scarce. Research into the science curriculum that prescribes socially responsive teaching procedures that promote resilience from adversities is not evident within the South African context. The challenges of addressing these issues in science classrooms are not well documented. Although there is a vast body of knowledge within the field of humanistic approaches to education, there is very little evidence of work done which describes how the science curriculum that is used in South African schools can foster response to social challenges. Santos (2008) agrees that ideas of humanistic science education have been considered but have not been given central focus within science curricula. Further, Evagorou and Dillon (2020) state that while there has been evidence of learners engaging with SSIs, documentation about

teachers' practices, understanding and support toward learners are sparse. Despite the growing literature on applying SSIs in science education, the available implementational strategies of this approach are limited. This study therefore aims to address this paucity by exploring how teachers deliver science education to promote social responsiveness.

2.11. Theoretical constructs framing the study

This study is informed by theoretical constructs from humanistic approaches to science education. Further, this study is grounded in a curriculum ideology namely, the social reconstruction ideology.

2.11.1. Humanistic science education

This study is framed by Paulo Freire's perspective on humanistic science education. Although Freire does not provide a distinct process that could drive this study, his proposal for a humanistic science education is what serves as a framework to support this research. Santos (2008) mentions that learners are not given answers, but rather allowed to evaluate contexts and determine their own solutions within their setting for transformation, when a humanistic approach is adopted. Freire (1974) further mentions that individuals are to reflect by themselves and be responsible for their role in new situations to enter educational contexts critically to create social transformation. Santos (2008) states that Freire's view of knowledge is different from the capitalist view, because knowledge is to liberate, emancipate and transform society. This view supersedes the view of accumulating and exchanging knowledge in the place of work within the aim of only doing one's job and uplifting the economy.

According to Santos and Mortimer (2002) humanistic science education is a way of changing the context of society through educational processes. Its main position is to make learners aware of their role in society and make the necessary decisions to change societal contexts. They state that Freire's educational proposal is one that is essentially a humanist pedagogy related to real contexts of human settings. In addition, Aikenhead (2006) identifies a humanistic perspective to education as that which encourages practical utility, humanistic values and learner orientation which prioritizes a learner-centered point of view in their daily lives. A humanistic process characterizes education to transmit, reproduce and create values (Freire, 1970). Here

it is seen that humanistic educational pedagogy is an approach that considers the real context of human conditions. This approach anticipates transforming these human conditions and improving the quality of human life by changing the view of science learners. Learners perception of science should be transformed from studying science in order to become a scientist, to studying science to become socially responsive citizens.

According to Santos (2008) humanistic science education means to teach to create awareness of social human conditions in order to act instead of teaching to generate income in the field of work as characterized by the capitalist ideal of education. A Freirean humanistic perspective includes one where “environmental issues that threaten life are discussed in a dialogic process within science classrooms” (Santos, 2008, p.379). Freire’s idea of education is to direct a path away from the mere oppressive act of depositing knowledge to one where emancipation is created through understanding human reality in order to “enact change in teaching and learning to transform the human world” (Santos & Mortimer, 2002, p.3). The humanistic perspective, according to Santos and Mortimer (2002), is to take note of societal contexts and human values so that learners are prepared to not just live in their societies but to also transform them. Ungar (2008) asserts that social ecologies that an individual interacts with, plays an important role in realising resilience. These social ecologies include schools, amongst others.

It is very important, according to Aikenhead (2006) that humanistic science education includes SSIs. With reference to Zeidler and Nicols (2009) SSIs involve using scientific topics deliberately that necessitate learners to participate in dialogue, discussion and debate related activities. SSIs explore the arguments surrounding an issue that is informed by science and then integrate social aspects (moral, ethical, economic, etc.) to develop a solution (Klosterman & Sadler, 2010). Santos (2008) affirms Freire’s educational view of moving away from the oppressive nature in curriculum, to one where people are able to reflect on and transform society. Freire (1973) explains that education has come from serving the capitalist economy where only the elite benefit. This renders the non-elite the oppressed, using education as a vehicle to perpetuate social class hierarchy. In addition, he mentions that this oppressive curriculum dehumanizes people and therefore proposes humanistic values within science learning so that it is beneficial to all individuals. Additionally, a humanistic approach to

science education is valuable because it creates transformation in oppressed societal contexts so that people are empowered through self-sufficiency and self-reliance.

The capitalist curriculum of the elite, in Freire's opinion, "objectified people and took away their creativity to act upon the world" (Santos, 2008, p.364). This is well demonstrated by the ways in which indigenous knowledge systems were isolated from the world of learning due to the introduction of the oppressive curriculum by the Europeans in Southern Africa. Humanistic science education aims to work within the context of the learner and make use of traditional or indigenous knowledge that is specific to their environments to respond to social issues peculiar to them. According to Santos (2008) a science education project called the Guinea Bissau project sought to appreciate local community knowledge. These understandings were known to contemplate social issues existing within that community. Traditional African knowledge was replaced by technology of the oppressor which showed that Africans were oppressed by the Europeans (*Ibid*).

Freire (1970) proposes dialogue as a basic principle of his pedagogy. The communication and active participation are what drives transformation and learning. For Freire (1970) dialogue helps learners develop critical understanding (through consciousness raising) of their social realities so that they are able to transform it. Freire (1972) asserts that education for critical consciousness is impossible if the dialectic process that comprises dialogue is absent. Santos and Mortimer (2002) state that humanistic science education must be carried out through a dialogic process where learners participate directly in discussions on social issues so that they can become committed to social change. Freire strongly recommends that teachers drive lessons that allow discussions around humanistic values that contribute towards the act of teaching learners about responsiveness to social issues.

Freire's educational approach is broken up into 3 phases as illustrated by Santos (2008):

1. Identifying socially relevant themes within context for discussion
2. Dialogic process by discussion to identify learner's existential situation
3. Engagement of learners in discussing and adopting socio-political actions

A Freirean perspective of education advocates that learners engage practically in field work to solve issues and transform societal conditions, which is what this study aims to determine by focusing on specific socio-economic issues that learners face.

Santos (2008) states that the purpose of education should be humanistic to address the oppressive state of modern society. Humanistic education is more than just learning to read and write (Santos, 2008), since it involves human values, a transcendence beyond the teaching of content, making use of cultural knowledge to enact transformation. Aikenhead (2007) states that humanistic education is an alternative to the traditional science curriculum that aims to equip citizens to assess science and technology critically and rationally. According to Magil and Rodriguez (2014) humanism favors practical knowledge for the creation of a more democratic social action through the empowerment of individuals. They further mention that humanism offers human agency as a solution to deal with human suffering.

Humanistic education along with science has a central role in building a world which is more socially just. This is confirmed by Barton and Tobin (2001) who have worked within this field to understand how to create inclusive and empowering science. Their results indicate a political commitment towards the struggle for liberation and the protection of human rights. The social justice ideal of education is also what is advocated by the South African curriculum (DBE, CAPS, 2011).

The importance of humanistic education is thus evident, as the CAPS curriculum seems to echo ideals and expectations of the theorists whose work is embedded in social justice ideology.

A single general aim of the curriculum, which is repeated here, is “to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives” (DBE, 2011, p.4). This meaningful living involves taking action and transforming current problematic conditions (Santos, 2008). This is also clearly visible within the CAPS curriculum, where it is emphasized that learners are to be prepared to assume meaningful roles in society (DBE, 2011). These roles allow them to become agents of change and democracy. The CAPS curriculum envisages learners being critical and active in learning rather than uncritical of rote learning (DBE, 2011). The South African curriculum advocates what Freire proposes in his perspective of humanistic education as being active in the learning process. The CAPS curriculum further highlights the humanistic approach to education (as proposed by Freire) and for science education to “infuse principles of human rights and encourage social justice” (DBE, 2011, p. 5).

2.11.2. Curriculum Ideology - Social Reconstruction

According to Schiro (2008) a curriculum is regarded as a social perception. Society is assumed to be unhealthy and its survival is endangered. A curriculum ideology includes the ideas of the content knowledge, along with skills as well as the learning outcomes that define the purpose of teaching and learning. Four ideologies have been identified by Schiro (2008) namely: scholar academic ideology, social efficiency ideology, student centered ideology and social reconstruction ideology. This study emphasizes social reconstruction ideology which aims to provide practical knowledge and skills to learners about social issues that have negative impacts to effect change by reconstruction (Mnguni, 2017; Mudaly, 2018). Further, the social reconstruction ideology states that education is a means to solve society’s problems and keep it from destroying itself.

Schiro (2008) states that the influence on education that the ideology has, formally commenced in 1932 which is when the learner-centered ideology was ridiculed for not addressing society’s difficulties and the inequalities that it caused to its members. It further mentions that education is a social action. This provides social reconstructionists with a view that learners would be prepared to deal with only crises of the past and not the future if the learner’s mind is filled with an assortment of facts and perceptions. Children should be prepared to challenge, analyse, understand,

respond to and correct social challenges that may surface in the future, by constructing an explicit social attitude and perspective which includes social values and skills such as problem-solving. Schiro (2008) primarily views children as not just children, but as societal products, social participants and possible contributors of society who will be able to aid its reconstruction. This view of children who are the science learners, should be taught in a socially relevant manner to take up socio-political roles in addressing socially contextual issues. Schiro (2008) further states that the role of the teacher is to equip learners with necessary knowledge and skills to analyse and understand social problems that they encounter, so that they are able to provide solutions to these problems.

This ideology makes use of SSIs to develop skills to initiate change and empowerment within society. The model by Zeidler, Sadler, Simmons and Howes (2005) illustrates a framework on how SSIs within social reconstruction ideology should be integrated within the Life Sciences curriculum. The framework in Figure two shows how learning SSIs in Life Sciences lessons lead to the development of various skills related to SSIs and the curriculum.

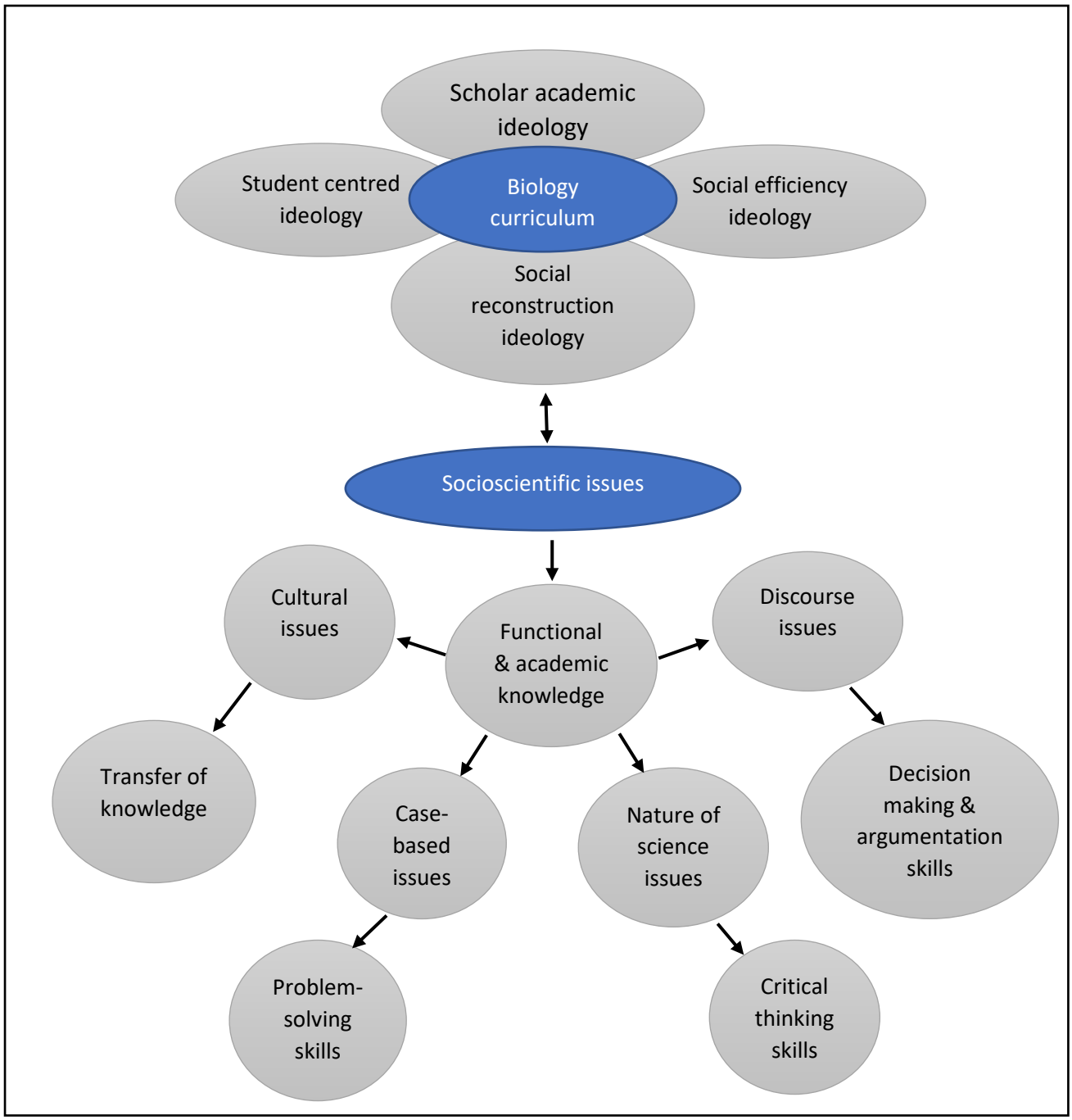

Figure 2: The theoretical framework for integrating SSIs in Life Sciences (Adapted from Schiro, 2008 and Zeidler et al., 2005).

As a result of the various socio-economic and socio-scientific challenges that South Africa faces, the application of a social reconstruction ideology is proposed which comprises teaching SSIs within the framework posited by Zeidler *et al*. (2005). With reference to Zeidler *et al*. (2005), science classrooms should include cultural and case-based matters in order for the content to mirror and challenge the society in which

learners reside. If lessons include these issues, then their respect to differing world views are encouraged (*ibid*). Discourse on growing SSIs must also be incorporated because it provides an opportunity for learners to efficiently contribute to social dialogue by making use of scientific knowledge and skills in the context of lived experiences. This is to be achieved by introducing the nature of science to learners which encourages critical thinking about scientific knowledge when dealing with SSIs. Zeidler *et al.* (2005) further state that academic and functional knowledge must be taught so that science becomes related and pertinent to daily lives so that the society can be empowered. Through the above framework, an SSI-based social reconstruction curriculum is required to ensure that learners learn concepts and knowledge of Life Sciences along with their consequence on society as SSIs.

2.12. Link between the theoretical framework and the study

Mosweunyane (2013) argues that education at school level was largely imported from a western setting and was advocated by the oppressor to benefit the oppressive class. Le Grange (2004) states that western science is generally identified as superior or universal, and as not having cultural references. Additionally, western science does not include cultural and social perspectives of non-western learners. Freire (1970) proposes an approach to science education through dialogue, where teachers seek background contexts of learners to drive the lesson. Further, his view of humanistic science education is to depart from the tradition of merely depositing knowledge into the learner (defined by Freire as the banking concept of education) to one where creativity and active, democratic involvement is displayed (Mahbubul, 2013). In this way learners begin to understand their roles in society, gain skills to improve their living conditions and be part of an education system that is directed toward social justice.

The study aims to identify processes of delivering meaningful science lessons in which Zeidler *et al.* (2005) suggest the addition of SSIs in teaching through a social reconstruction curriculum ideology. Additionally, Schiro (2008) states that teaching under the constructs of this ideology will foster the development of critical problem solvers in addressing socially contextual issues. These theories are applicable to my study because they call for a socially responsive approach to learning Life Sciences

(which is using science knowledge to respond to social issues) by incorporating SSIs (which are context specific social issues that are to be addressed in teaching SRS).

2.13. Conclusion

The literature reveals that South Africa experiences on-going environmental crises, including, among others water scarcity. Further, there is an ever-growing concern regarding socio-economic factors that challenges South Africans, with poverty being one of the most crucial ones that threaten the comfort and the lives of its citizens. Determined efforts are required from the government, curriculum developers and teachers to mitigate these issues as suggested in the literature. Scholars emphasize the need to address these issues within Life Sciences and Natural Sciences as SSIs so as to deliver a science that is able to develop necessary skills in learners that will enable them to respond to the social dilemmas they may encounter. Learning science constructively through inquiry-based activities allows for active participation and development of critical thinking and other science process skills that are helpful in providing solutions to a problem.

According to the literature, teachers should enquire through dialogue with learners about their backgrounds and social contexts to identify challenges they could be experiencing, which can then be addressed in the science lesson. This is important because it allows learners to relate more easily to concepts with which they are familiar. It is the function of educational institutions to drive social redress through the science curriculum. Through the learning of science, learners can become skilful at addressing socio-scientific challenges.

This review revealed research studies which value a humanistic approach to teaching and learning science by incorporating SSIs, an approach that creates awareness of socio-political inequalities within society. The method of teaching science using this approach aims at developing learners' capacity to critically solve problems using scientific knowledge to create and produce a society that is more liberal and just. The CAPS curriculum advocates for a curriculum that promotes social justice ideals, preparing learners to take up responsible roles in society. It is clear through this review that the CAPS curriculum is underpinned by a humanist approach. However, this does not necessarily translate to an enacted curriculum which assists teachers to implement

humanist ideals. The aim is to make the curriculum more context specific and responsive to issues peculiar to South Africa.

Further, science education should transcend the mere understanding of content to succeed within an examination-driven curriculum context. It has a more lasting aim, and that is to provide solutions to society's challenges. The literature reveals a paucity of documented research relating to how science teachers can address societal challenges using the science curriculum.

This review of literature and theories provides an insight into the study and has informed the research design, analysis, findings and recommendations. The next chapter will discuss the research design and methodology which was adopted for the study.

CHAPTER 3

Research Methodology

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3.1 Introduction

Walliman (2011) states that research methods are key in conducting research. They are viewed as tools and techniques that are adopted to conduct research. Similarly, McMillan and Schumacher (2014) view methods of research as a set of processes required to collect and analyse data from research. This chapter highlights the research methodology that guided this study. A qualitative approach was adopted, and the study was embedded in an interpretivist paradigm. A case study design facilitated an in-depth study of practicing teachers' use of the science curriculum to teach socially responsive science. Reasons underpinning the choice of data collection methods and instruments as well as issues of trustworthiness are explained. This chapter concludes by discussing ethical considerations and limitations of the study.

3.2 Context of the study

This research was conducted at Jagannath University (this is a pseudonym used to anonymise the institution) within the School of Education that trains students to become teachers and offers postgraduate programmes for practicing teachers. The university encompasses a diverse student population in terms of culture, race, age and ethnicity. The university offers a four-year undergraduate degree programme with optional post graduate degree qualifications in the field of education. The unit of analysis for this study comprises in-service Life Sciences and Natural Sciences teachers who engaged in a curriculum development module as part of the requirements in completing their post graduate qualification towards an Honours in Science and Mathematics Education degree.

This module had been taught during the first semester and according to the module template, the aim of the module is "to understand the nature of the curriculum, the determinants of transformation and change and the role of the teacher in curriculum decision-making and evaluation" with precise reference to science education (University, Module Template). The module content includes the following topics: concepts and issues related to the curriculum, curriculum theory, curriculum models,

curriculum analysis, curriculum philosophy and policy, contextualizing curriculum, constructivism as a learning theory and curriculum transformation, as they relate to science education.

Participants in this study were made up of practicing science teachers who were required to plan, prepare and deliver lessons within Life Sciences or Natural Sciences using the CAPS curriculum. These teachers taught at public schools that were located in suburban geographical areas that experience high unemployment rates, poor health care, pollution, as well as water and food insecurity. Further, these schools serve lower socio-economic groups in politically unstable areas. The lessons that the teachers taught, had to be designed to empower learners and communities to become self-sufficient, improve the quality of life, address contemporary challenges and transform thinking towards resilience and self-reliance. The data generation methods chosen for the study helped in exploring how teachers interrogated the science curriculum to teach a science that is socially responsive.

3.3 Paradigm

A paradigm, according to Huitt (2011) is an arrangement of interrelationships accompanied by their parts and further how these parts function (a specific context and the behaviour within them). According to Creswell (2009) paradigm means a worldview.

This work was informed by the interpretivist paradigm. According to Edirisingha (2014) an interpretivist researcher is one who has an aim to recognize and understand the implications in how humans behave. According to Cohen, Manion and Morrison (2011), the interpretive paradigm anticipates understanding of the independent sphere of human experiences. An interpretive researcher then, seeks to gain an understanding of people's experiences and behaviour. Schutt (2012) further describes interpretivism "as the belief that reality is socially constructed and that the goal of social scientists is to understand what meanings people give to that reality" (p.15). The interpretive paradigm is then suitable for this study because it enables construction of meaning and identification of social challenges and how these challenges can be overcome. Cohen, Manion and Morrison (2007) additionally state that the interpretivist paradigm concentrates "on the individual in order to understand the phenomena that

is being investigated from within the individual" (p.21). The phenomenon being explored in this study is of how teachers use the science curriculum to teach SRS.

3.4 Approach

A qualitative methodological approach was employed in this study. Corbin and Strauss (2015) state that qualitative researchers have a goal and that is to explore detailed descriptions of internal experiences that the participants have and how they form meaning. Creswell (2009) describes qualitative research as a technique for understanding a persons or group's insight of a social or human issue. The nature of qualitative research is inductive and involves the researcher to generally explore meanings and insights in a specified situation (Mohajan, 2018). Detailed and thick descriptions are necessary, according to Drew, Hardman and Hosp (2008) to "concentrate an accurate and clear image of the nature of each culture that form the basis of anthropological studies" (p.185).

According to Mohajan (2018), qualitative research aims to collect and work with non-numerical data. Meaning is interpreted from these data and it helps researchers to understand social life by studying targeted populations or places. In addition, Mertler and Charles (2008) state that for a research to be qualitative, it must possess the following characteristics:

- The research should take place in a natural setting.
- Data should be collected from that setting.
- There must be descriptive representations as opposed to numerical.

Furthermore, qualitative studies do not merely focus on the outcomes, but afford attention to the reasoning of phenomena. During research, events take place naturally and on their own terms and the thinking of the participant is motivated and emphasized (Mertler & Charles, 2008). In this study, participants' views and habits were focused on, with the understanding of the reasons behind them being crucial.

Flick (2018) states that qualitative research has gained more importance over quantitative studies in terms of its relevance towards the postmodernism concept of world views. In this sense, views of the world hold a variety of interpretations and are not uniform which Elaati (2016) describes explanation of phenomena in postmodernism as being abstract. People create their own view about the world based

on personal interactions, history and culture. Mohajan (2018) alludes to this by stating that qualitative research investigates local knowledge, personal experiences, relationships, meanings and social progressions along with contextual factors that relegate a group of people. Teachers and learners' views that are exposed in this study are personal and contextual toward the concept under review.

In this study thick, detailed descriptions about teachers' practices and behaviours concerning the engagement with the science curriculum within the South African schooling system, to deliver a socially responsive science, was sought. I aimed to understand the motivation and perceptions that inspire and influence the teachers' practice. De Vos and Fouché (2000) identify interviewing as an "example of data collection methods utilised within a qualitative study" (p.80). In this study I interviewed participants and analysed teacher portfolios, curriculum documents as well as module guidelines.

The study focused on a curriculum development module for post graduate students who were also practicing science teachers. Most of the data that was generated emerged from the activities conducted within this module. The data was captured in interview transcripts and portfolios of evidence, to afford a rich description of the behaviours and practices of the participants in the study.

This research does not seek to identify figures and quantity through experimentation and manipulation which Drew, Hardman and Hosp (2008) identify as features of quantitative research. Therefore, this research does not incorporate a quantitative methodological paradigm.

3.5 Design

A case study methodology was chosen to inform this research. According to Yin (2013) research with a case study design, permits the researcher to focus on a "case" to gain understanding into intricate social phenomena. This design enabled me to study the main focus of the research in detail, which was exploring how teachers engaged with the science curriculum to teach SRS. Yin (2009) further asserts that "a case study is an empirical inquiry that examines a contemporary phenomenon in-depth and within its real-life context" (p.18). This resonates well with Opie (2004) who states that the emphasis of a case study is placed on real life encounters that occur within

environments with which the researcher is familiar. Starman (2013) states that case studies are used to provide comprehensive descriptions and analyses in detail, of each individual person or people in groups. The cases may also include individual institutions or a problem, process, phenomenon or incident in a specific society. These ideas of a case study design resonate very well with the qualitative approach as discussed earlier and is confirmed by the following excerpt: “The interpretative paradigm, as a paradigmatic basis of qualitative research is closely linked to the definition and characteristics of case studies” (Starman, 2013, p.30).

Opie (2004) states that in case study research designs, the number of participants is meaningless. Case studies in research could therefore comprise an individual person, a group of people within a setting and a whole class of learners at a school. Two practicing Life Sciences teachers and two practicing Natural Science teachers who participated in the study formed the case under review in my study.

3.6. Sample and sampling strategy

According to Gay, Mills and Airasian (2009) in a qualitative study, sampling is recognised as the technique which involves a small number of individuals that is selected as key informants and who to contribute to the researcher’s perceptions of a particular phenomenon under review. Etikant, Musa and Alkassim (2016) describes a sample as things or cases that form the subject of research. Convenience and purposive sampling were used. Cohen, Manion, and Morrison (2011) state that convenience sampling is one that allows the researcher to choose participants that are easily accessible. Similarly, Etikant *et al*. (2016) asserts that in order to compile an ideal participant population, they should satisfy particular practical criteria, which includes easy accessibility, close geographical proximity, availability, or the willingness to participate in the study. I chose to work with participants at the university because I had easy access to them.

Etikant *et al*. (2016) describe the rationale for convenience sampling through their view that using a whole population is superlative in every research. However, such a method is almost impossible to consider all subjects due to the population being finite. Additionally, Setia (2016) states that convenience sampling is one of the easiest methods of sampling and is therefore most commonly used in qualitative research.

Furthermore, the participants who were sought through convenience sampling do not represent the entire population and therefore cannot be generalised (*ibid*).

The researchers within purposive sampling, “hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought” (Cohen, Manion & Morrison, 2009, p.156). Etikant *et al.* (2016) additionally posit that purposive sampling involves the deliberate selection of participants based on the qualities they possess. Similarly, Setia (2016) asserts that purposive sampling involves researchers selecting their participants purposively, to answer specific research questions. Dolores and Tongco (2007) assert that purposive sampling is a non-random method and does not require foundation theories or a predicted number of informants. With purposive sampling strategies, researchers decide what they require and then go out to find worthy participants that they believe would be best at providing key information (*ibid*). Etikant *et al*. (2016) further state that purposive sampling is typically adopted within qualitative studies to “identify and select the information-rich cases for the most proper utilization of available resources” (p. 2).

Purposive sampling was used, since it included ten purposely chosen practicing teachers at secondary schools, teaching Life Sciences or Natural Sciences, who are qualified and who have engaged in professional development programmes as part of a postgraduate qualification. The sample was recruited by addressing these ten teachers who are engaged in professional development by studying an Honours module. A full class of teachers, who studied the Curriculum Development in Science and Mathematics Education module, was addressed and the first ten that volunteered to participate became participants. There was attrition of six of the ten teachers in the initial sample. The final sample comprised four participants, who completed the portfolios of evidence and participated in the interviews. Successful recruitment and retention of participants is fundamental to obtaining meaningful results from studies According to Guillot (2019) a major challenge in research is recruiting and retaining participants. Far (2018) states that researchers should focus on participants’ motivations and consider the contributing factors in recruiting students and other members as research participants, before developing a recruitment strategy. This is imperative to ensure possible participant retention (*ibid*). The final sample after attrition in this study maintained their motivation to engage in the study, because it delved into their own teaching practices and it was something with which they were familiar.

These participants had to research, plan and prepare lessons regarding the needs of learners that they taught which was part of a module towards the Honours degree. The module outline offered guidelines under the following sections, and responses to these were captured in a portfolio of evidence over a period of three months:

1. Awareness of the school and learners

    - Describe your school in terms of its population of learners, number of learners studying the subject you teach, background of learners (socio-economic, political stability).

    - Conduct a needs assessment to understand the social challenges. You could use interviews or surveys or equivalent methods.

2. Develop your content knowledge

    - Select a key concept which relates to the social issue you intend addressing, from the CAPS curriculum. Find at least two resources (example, textbooks, Internet, field guides, journal, newspaper, periodical) to extend your knowledge about this socio-scientific issue. (Think about how you could guide your learners to respond to the issue, using their knowledge of science).

3. Develop your teaching and assessment practices

    - Plan lessons to address the specific concept you have worked with and researched.

    - Ensure that you select methods in relation to the concepts, skills and values that are included in CAPS that are relevant to both the curriculum and the lives of learners.

    - Include an assessment activity in your plan.

    - Implement your lesson plans. Take photographs which capture how social responsiveness/resilience/empowerment was being fostered in each lesson.

- Provide an explanation/description of the teaching/learning interactions for each photograph. Include in the description risk factors, protective factors, challenges (external and internal), agency, and so on.
- Reflect on the planning and preparing to teach, and the teaching and assessment, using an SRS approach.

Four participants were purposively chosen as interviewees because they completed their portfolios. The contents of their portfolios contributed to the phenomenon under interest because it included contextual SSI based science instruction and further indicated their ideas towards developing resilient and self-reliant learners. I selected these four individuals to participate in individual interviews because I wanted to extend the data obtained through the analysis of the portfolios.

Table 2 that follows, illustrates a summary of the participants and the knowledge strand of topics selected (the latter was based on a needs assessment conducted at their school).

Table 2: Summary of participants and the knowledge strand of topics selected to teach socially responsive science are represented in the table below

PARTICIPANT NUMBER	RACE GROUP		GENDER	GRADE WHICH WAS TAUGHT	LEARNING AREA	KNOWLEDGE STRAND
	AFRICAN	INDIAN				
1		X	Female	7	Natural Sciences	Matter & materials
2	X		Female	11	Life Sciences	Life processes in plants & animals
3	X		Female	9	Natural Sciences	Life & living
4		X	Female	11	Life Sciences	Environmental studies

In this study, four participants comprised the sample and all were female. In terms of racial demographics, there were two of Indian origin and two of African origin. They focused on Life Sciences and Natural Sciences topics which are presented in the CAPS curriculum document (DBE, CAPS, 2011).

Participant one (P1) is an Indian female who teaches grade 7 Natural Sciences. The participant had been teaching science for a period of six years and has worked towards completing her Honours Degree in the process. Participant 1 displayed enthusiasm in engaging with the study because she was able to relate to it. Participant 1 further, focused on waste management investigation as an SSI in her school and results of this focus were presented in her portfolio of evidence which I analysed. Participant 1 indicated that she taught at a high school that accommodated one grade 7 class to which she taught Natural Sciences. Further, the high school caters for approximately 1000 learners of which 38 belong to grade 7 and whose grade average in Natural Sciences is approximately 65 percent. Participant 1 viewed the school as the 'community' and addressed a contextual social challenge experienced by the

surrounding community. The school is situated along side an informal settlement and a dump site, which creates not only a health hazard but also a ground for increased pollution. There have been no signs of recycling or proper waste disposal measures at the school and therefore this social challenge was addressed. Participant 1 engaged with the issue under the topic of *waste management* that is prescribed in the CAPS curriculum document for grade 7 Natural Sciences.

Participant two (P2) is an African female who teaches one class of grade 11 Life Sciences learners. This participant had been teaching at this school for four years and during her second year of being employed at school, she engaged in her postgraduate study. The school where P2 teaches, is located within a township which is approximately 24km in-land from the city of Durban. The school consists of an estimated learner population of 1400 with diverse socio-economic backgrounds. The academic performance in Life Sciences of this grade 11 class is reflective of the performance nationally. This is a no fee-paying institution which means that all contributions and donations are made by the government and external sponsors. In addition, the school is aided by the national feeding scheme which provides meals to learners. However, many of the learners choose not to receive the food due to various reasons and therefore purchase unhealthy meals and snacks from the tuck shop at the school. Participant 2 saw this as an opportunity to teach learners about healthy eating, healthy lifestyles and nutritional disorders that many learners and community members experience along with physical activity as one measure to curb the effects of unhealthy eating. This social challenge was addressed under the topic of *Animal nutrition* that is prescribed for grade 11 learners in Life Sciences according to the CAPS curriculum.

Participant three (P3) represents an African female who teaches four grade 9 Natural Sciences classes. Participant 3 engaged in her postgraduate honours degree to broaden her knowledge and pedagogical approaches in science education. The school where she teaches is situated in a densely populated area that is recognised and noted (by P3) as a rural area comprised of numerous human settlements. The community is poverty stricken. The school is a no fee-paying institution and receives meal support from a nutritional programme. The school comprises 712 enrolled learners and accommodates fifteen classes for grades 8 and 9 and one class for grade 10. With 300 learners registered for grade 9, P3 teaches four classes which makes up

172 learners. Participant 3 describes the learners' academic performance in Life Sciences as "very poor" with average ranges between 35 to 45 percent. Most of the learners reside with their grandparents whose only mode of financial income are social grants from the government. Participant 3 indicated that she had experienced learners fainting due to not having eaten. After recognising the financial constraints of the school and learners, P3 decided to initiate the development of food gardens as a solution to food insecurity which is also identified as an SSI. Further, the community members were identified to have been suffering from diseases and nutritional disorders and P3 suggested that the community could also be assisted through the food gardening project. Thus, P3 addressed the topic of *food insecurity* and *benefits of healthy foods* as a social challenge which is prescribed by the CAPS curriculum for grade 9 Natural Sciences.

Participant four (P4), who is a female of Indian origin, makes up the final informant in this study. Participant 4 has been teaching Life Sciences for approximately 4 years and completed her honours degree within that period. Participant 4 teaches Life Sciences to grade 11 learners who attend this school that is located within a middle-class suburb and that is located near an informal settlement. Many of the learners walk to school from informal dwellings (where they live) which are around 10-15 minutes' walk away. The school comprises approximately 900 learners and 35 staff members. There are 12 classes that comprise 331 Life Sciences learners ranging from grades 10 to 12. Participant 4 indicates that the academic performance of the learners in Life Sciences vary from excellent to very weak. Participant 4 chose to conduct her work towards her postgraduate degree with one grade 11 Life Sciences class. Most learners that attend this school experience various social challenges daily. These challenges include food insecurity, crime, access to proper water and sanitation, threats to health due to excessive pollution and limited waste management all of which are a result of poverty. Participant 4 addressed these social challenges by teaching them as SSIs in her Life Sciences lessons. These SSIs were incorporated within the topics of *food insecurity*, *water availability and quality* as well as *waste management*. Further, these topics are prescribed by the CAPS curriculum for grade 11 Life Sciences.

3.7. Data generation

The comparison of research outcomes is found to be enhanced using several data sources in a case study research (Creswell & Poth, 2018; McMillan & Schumacher, 2014; Yin, 2014). Several data generation approaches were made use of to ensure trustworthiness. Creswell (2012) defines this as triangulation and specifies that "qualitative researchers triangulate among different data sources to enhance the accuracy of a study" (p.259). Engaging data collection methods in triangulation enhances trustworthiness and justification of findings in the research (Maree, 2009; Creswell & Poth, 2018). According to Litchman (2011) triangulation may involve data collection using documents, interviews and reflective journals. Cohen *et al.* (2011) state that documents and interviews are two of six methods of generating data in case studies. Individual interviews and document analysis of reflective participant portfolios were used as methods to obtain data in this research.

3.7.1. Data generation methods:

3.7.1.1. Document analysis

Qualitative Document Analysis (QDA) provides a systematic, sequential and rigorous method for eliciting meaning from the contents of written documents (Wood, Sebar & Vecchio, 2020). Similarly, Bowen (2017) describes document analysis as a methodical process for reviewing or evaluating documents. Document analysis further allows for gaining understanding and constructing empirical knowledge through data that is examined and interpreted (*ibid*). Creswell (2012) views documents as a valued data source which supports the researcher to "understand central phenomena in qualitative studies" (p.223). Additionally, Wood *et al*. (2020) emphasize that document analysis in qualitative studies are commonly used together with interviews and observations in case study research.

Participants in this study were required to develop portfolios of evidence which included lesson plans based on lessons taught for socially responsive science. These portfolios were analysed using content analysis. In addition, the CAPS curriculum document was also analysed to link lessons taught to the prescribed curriculum. The analysis of student portfolios allowed me to gain insight into their understanding and

how they teach to equip learners to respond to social issues. The analysis was done using an analysis template or rubric. Some of the aspects included in the document analysis schedule were: (See appendix 5)

- *The topic of the lesson*
- *Reason for the choice of the topic*
- *Methods and strategies used to teach the topic*
- *Reasons for the choice of these methods and strategies*
- *Reflections on the portfolio*

According to Bowen (2009) document analysis has both advantages and limitations.

Some advantages of document analysis are as follows:

- "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".
- "Document analysis is less time-consuming and therefore more efficient than other research methods. It requires data selection, instead of data collection".
- "The researcher's presence does not alter what is being studied when analysing documents. Thus, documents are said to have stability".

(Bowen, 2009, p.31)

Limitations of document analysis are that:

"Documents usually do not provide sufficient detail to answer research questions; this is seen as a disadvantage" (Bowen, 2009, p.32)

Bowen (2009), further mentions that inadequate detail is seen as a potential flaw and not a key limitation. However, O'Leary (2014) states that documents provide additional research data which makes them highly useful and beneficial in research studies. Document analysis clearly provides advantages that surpass the limitations, considering its competence and cost-effectiveness. Documents were not used in isolation to answer the research questions in this study. Individual interviews were also conducted to recompense for where the shortfall may have been identified, so that sufficient and detailed information could be attained to successfully provide answers to each research question.

3.7.1.2. Individual interviews

According to Alsaawi (2014) qualitative interviews are used to obtain experiences of participants as well as their beliefs and identities. These interviews are conducted with an individual or in groups. Galletta (2013) further states that semi-structured interviews are designed to address specific issues of the research and also allow the participants to suggest new set of meanings to the topic that is being studied. The interviews conducted in this study were semi-structured which allowed for deep and unrestricted responses. (See appendix 6 for schedule of questions).

“Face-to-face interviews allow the interviewer insight into the non-verbal as well as the verbal responses of the participants. It additionally gives the interviewer the chance to motivate the participants” (McMillian & Schumacher, 2010, p.205). Face-to-face semi-structured individual interviews were conducted with each participant. The interviews took place after relevant documents (student portfolios and module outline) were analysed to enhance data obtained from these documents. According to McMillian and Schumacher (2010) individual interviews allow the interviewer to probe questions based on verbal responses from the interviewee. Similarly, Hart (2005) mentions that individual interviews offer an opportunity for issues to be probed and further leads to a comprehensive discussion around matters relating to the given study.

In this study, the interviews allowed me to probe responses to understand teachers’ perspectives about their practice. It further allowed me to gain deeper understandings and knowledge and addressed areas of ambiguity to provide a clearer picture into their understanding to teach socially responsive science. Interview schedules and transcribed responses are included as appendices in this thesis report. (See appendix 7 for interview transcripts).

3.8. Triangulation

Cohen *et al*. (2007) define triangulation as finding a single answer for a single purpose, by employing two or more data collection methods in a study. Triangulation from several data collection methods enhances rigour (Bowen, 2017). Neuman (2006) describes triangulation as a system of confirming authenticity by viewing something from differing viewpoints. Heale and Forbes (2013) state that the combined findings from two or more rigorous methods provide a more complete illustration of the results as compared to either method being used alone. It is for this reason that two methods to collect data have been used in this study. Information retrieved at diverse angles converge and build a text. Furthermore, “triangulation is seen as a procedure of validity where researchers search for convergence among several and different sources of information to form themes or categories in a study” (Creswell & Miller, 2000, p.126).

Heale and Forbes (2013) assert that methodological triangulation is a largely preferred type of triangulation. Studies that make use of methodological triangulation may comprise two or more data collection sets within the same methodology, such as those from sources of qualitative data. Further, triangulation is commonly considered to encourage a more comprehensive understanding of the phenomenon under review and to enhance the rigour of the study (*ibid*). This research made use of two methods of data collection to triangulate the data collected thereby increasing the validity and reliability of the study.

3.9. Data generation methods fit for purpose

A summarised presentation of the data generation methods is illustrated in Table three that follows. It also presents arguments for the methods that were selection, based on the insights from qualitative researchers. The purpose of the data collection method, as it relates to each critical question, is also descripted.

Table 3: Summary of the methods used to generate data and justification for the methods

Data collection method	Purpose	Research Question	Justification for method
Document analysis	Teachers' portfolios were analysed to attain insight on how they make use of the science curriculum policy to design and present lessons to teach SRS.	RQ 1.1 RQ 1.2 RQ 1.3	Document analysis is an emergent process that focuses on searching for foundational meanings, themes and patterns, rather than a firm set of measures with tight parameters (Wood *et al.,* 2020).
Individual interviews	Individual face to face interviews were conducted with four teachers after portfolios were analysed. Teachers were asked about their lessons, planning, and the importance of SRS. The interview allowed me to gain information that was not necessarily visible in the portfolios.	RQ 1.1 RQ 1.2 RQ 1.3	One-on-one interviews are ideal for interviewing participants that are articulate and comfortable to speak out, to close any logical gaps in the data. (Creswell, 2014)

3.10 Data analysis

Cohen *et al*. (2011) state that qualitative data analysis is about explaining, organizing, and accounting for the data that is obtained. The data that were produced in this study was analysed. The analysis involved careful obtaining, organization, coding, theme derivation and recognising patterns that arose from the collection of data.

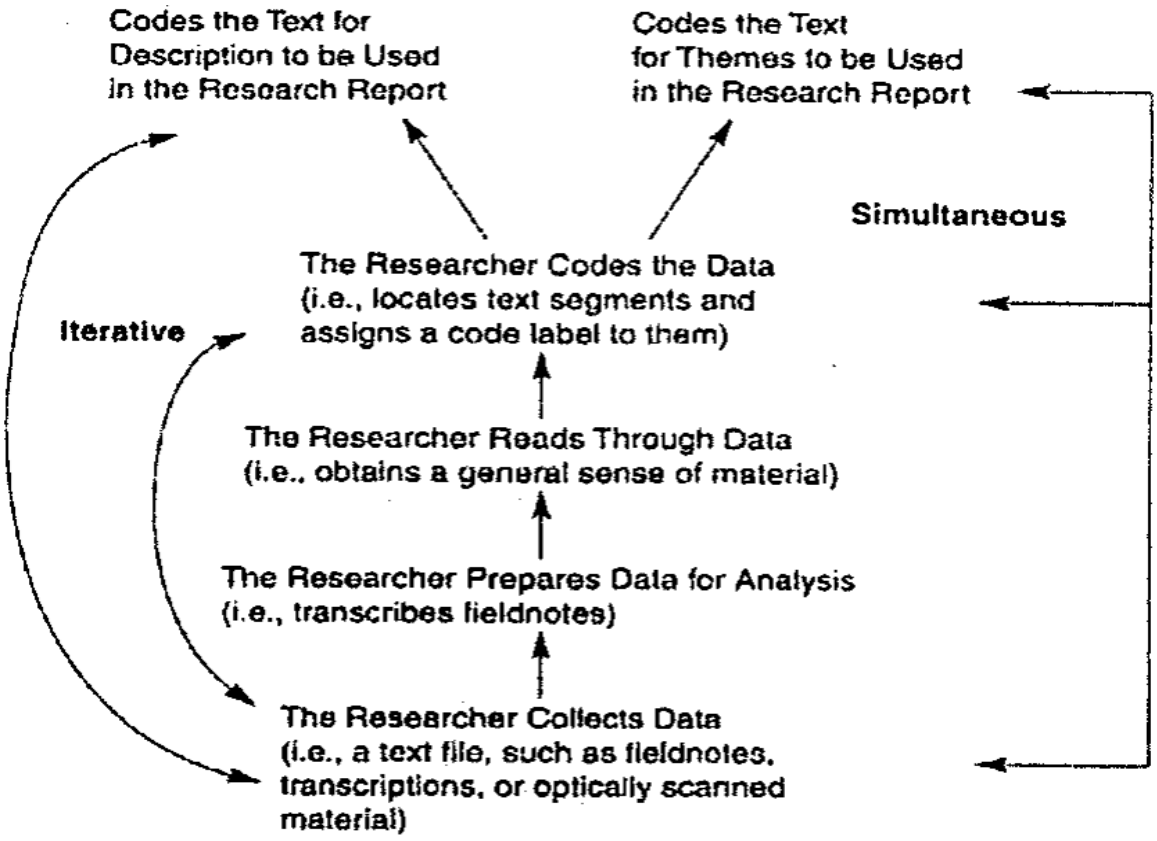

Figure 3: Diagrammatic representation of data analysis

Adapted from Creswell (2012, p. 237)

Figure three confirms that the process of analysing data is not direct or a one-way event, rather it is a process that allows one to move backward and forward to attain the subsequent outcome that is trustworthy. Creswell (2012) illustrates the procedure of data analysis as “iterative”, “inductive”, “eclectic” and “interpretive” (p.238). Data analysis involves working from precise groups of data to create overall codes and patterns.

An example of how these steps (in Figure 3) were applied in response to question 1.2 which was “Why was that topic chosen?” follows. I collected the data from portfolios of evidence and by conducting interviews. I prepared data for analysis by transcribing the interviews. This was followed by a careful and thorough reading of all the data. In order to code the data, I identified the key messages that emerged in response to this question (“Why was that topic chosen?”). Responses included: relates to how (they) learners live, make it (the lesson) practically beneficial to learners, learners experience this in everyday life. The unifying theme was “The topic is relevant to learners’ lives”.

Data were obtained using document analysis and individual interviews. The teacher portfolios that included lesson plans and reflections were read multiple times to make sense of the content presented by the text data. Individual interviews were audio recorded which allowed me to listen and re-listen as well as capture all elements including the pauses between sentences by the participants (Kvale & Brinkmann, 2009). The interviews were transcribed verbatim and transcripts were generated for each interview. I repeatedly read the transcripts at different intervals with breaks in-between to understand the participants’ insights in relation to providing answers to the research questions of the study.

Adler and Clark (2008) define coding as a method of relating remarks made in the transcripts and then grouping them together. Open coding was used and according to Nieuwenhuis (2012), this is done by assigning a word or phrase to a text to describe its meaning. Each statement was assessed and the participants’ experiences and practices of teaching SRS in relation to the research questions were categorized and coded. Drawing from Creswell (2012) themes will surface when similar pieces or codes are fused together. The process of coding allowed me to develop themes to summarise and understand data obtained which were then organised according to the research questions of the study.

3.10.1 Content analysis

Qualitative content analysis as a method to analyse text data was used in this study. According to Zhang and Wildemuth (2009), this is a type of analysis is a process of interpreting the contents of scripted data. The results obtained, provided meaning to this research and further gained understanding of the reality of the actions in enhancing resilience through SRS. Cohen *et al*. (2011) describe content analysis as

the process whereby text data are summarised up and presented. This further encompasses “coding, categorizing, comparing and concluding” after “themes” combined using practical languages from the data transcripts which eventually draws theoretical conclusions from the script (Cohen *et al*., 2007).

Cohen *et al.* (2007) suggests that the researcher can use content analysis with any scripted material, such as interview transcriptions. Document analysis and individual interviews generated data that were transcribed into text form. This enabled participants to essentially verify the data, thus allowing replication and re-analysis. Re-analysis is possible due to content analysis this method of analysis is relevant in this study due to its flexibility.

3.11 Rigour of the research

According to Ryan (2005), rigour refers to “research which is both transparent and explicit, researchers need to be able to describe to their colleagues and their audiences about what they did in simple language” (p.5). Ghafouri and Ofoghi (2016) further identify rigour along with trustworthiness, as essential in every qualitative study. Trustworthiness is important to consider throughout the research process as it increases the reliability, inclusiveness and quality of a study (Amankwaa, 2016). Validity, reliability, credibility and transferability are all related to trustworthiness and rigor of research. Two constructs validity and reliability served to evaluate and judge the quality of this research in ensuring trustworthiness.

3.11.1 Validity

McMillan and Schumacher (2010) define validity as the level of accuracy in relating the elucidations of the phenomenon that is being studied and the veracities of the world. Furthermore, validity refers to the degree in which the results of the study expose collective meanings that exist between researchers and participants (*ibid*). According to Creswell (2012), the validation of research findings requires “triangulation and member checking” to be conducted by the researcher to confirm the “accuracy or credibility” of the data obtained (p.259). Validity is imperative for a respectable study because the entire research would be meaningless if a part of it is improper (Cohen *et al*., 2011).

The research is valid because member checks was encouraged where the participants were allowed read the descriptions of the findings. The member checks provided an opportunity for the participants to validate the accuracy of the data that was grounded on their experiences (Pitney, 2004). Descriptions of the research process, context and participant descriptions were provided along with detailed records of my positionality, ensured transferability in this research. More than one data collection tool was used for triangulation which were reviewed by the participants and my supervisor to ensure that they have captured information for which they were designed.

3.11.2 Reliability

Cohen *et al*. (2011) state that a research is reliable if the instruments used can generate the same findings using different participants and researchers over time. Therefore, Neuman (2006) states that reliability is how dependable and consistent research is. Obtaining data is collaborative between participants and researchers and therefore various methods of collecting data should be utilised. (*ibid*)

Kvale and Brinkmann (2009) state that for research to be reliable all questions asked must be unambiguous. This research was conducted using questions that were unambiguous as the interview schedule was analysed and revised before being used. The research is reliable because several data generation collection tools were utilised to ensure triangulation. Credibility is closely linked to reliability (Welman, Kruger & Mitchell, 2005). Credibility is enhanced by providing thick descriptions of teachers experiences and practices (Morrow, 2005). The findings of this study were credible because anonymous interview transcripts are included in the research as proof to data obtained. (See appendix 7).

3.12. Ethical issues

Resnik (2015) states that the code of ethics in a research is imperative because it affords valuable information to the participants. This information includes details of the research goals and the intentions of the researcher regarding the findings that emerged. The code of ethics further highlights the promise of the researcher to respect and treat the participants and the information that is provided with honesty.

3.12.1 Permission to conduct study

Permission to engage with this study was obtained from the Registrar of the tertiary institution. This is advocated by Wiersma and Jurs (2009) who state that it is imperative to acquire permission to conduct a study in an educational environment from the gatekeeper at the site. (See appendix 2 for gatekeepers' approval)

I wrote letters to the registrar of the university and obtained consent to conduct research. Further, I had applied for and received ethical clearance from the Human and Social Sciences Ethics Committee of the university which was granted. (See appendix 1 & 3)

3.12.2 Informed consent from participants

Cohen *et al*. (2007) state that informed consent involves explaining details and processes of the research to the participants for them to make an informed decision to contribute to the activities of the research. Bertram and Christiansen (2014) speak about autonomy which in this research was established by obtaining informed consent from participants. (See appendix 4). The participants were further made aware that their involvement is voluntary and that they could withdraw their participation in this study at any point in time.

3.12.3 Anonymity and confidentiality

McMillan and Schumacher (2010) state that the locations and identities of all participants should never be disclosed at any point in the research publications. Bertram and Christiansen (2014) discuss non-maleficence which means 'not to hurt'. The participants in this study were not hurt or embarrassed in any way and were not coerced into explaining anything with which they were uncomfortable. Participant confidentiality was sustained throughout this study by anonymising their identities and those of the schools. This was also stated explicitly in the informed consent letters to the gatekeepers and participants. Furthermore, pseudonyms and numbers have been used instead of actual names of participants and locations.

3.12.4 Data use and disposal

The outcomes and data of the research were explicated clearly and that is, it is to be used only for the Masters dissertation project and any publications arising from this. The research data will be stored for a minimum of five years at the university and thereafter it will be disposed of accordingly. The transcripts from individual interviews will be shredded, and audio tapes will be incinerated.

3.12.5 Beneficiaries of the study

Resnik (2015) states that findings of a research study should be able to help people and other researchers and it is important to present concepts, tools, principles, and methods that can be useful in resolving context specific dilemmas (*ibid*). This research produced findings that can be of benefit to curriculum developers, teachers, learners, subject advisors and the society.

3.13 Limitations of the study

A limited time for this study posed as a possible limitation as I was employed and registered as a part time postgraduate student. To address this, I planned research processes well in advance and executed them timeously. Maxwell (as cited in Cohen *et al.,* 2011, p. 236) assert that sometimes participants may not feel comfortable during face-to-face verbal communication. I addressed this by allowing participants to telephonically respond to the interviews if they wished.

Acquisition of determined and trustworthy participants became a problem as some chose to withdraw their participation. Furthermore, the number of participants may have been too few to generalize findings from this study. However, Opie (2004) states that in a case study research the number of participants is insignificant. Furthermore, the aim of case study research is to obtain a deep understanding of a phenomenon, and not the generalization of findings.

3.14 Conclusion

This chapter highlighted the research methodology adopted for this study. The study was viewed through an interpretivist paradigm accompanied by a qualitative approach in a case study design. The data generation methods that were adopted in this study were discussed and an interpretation of triangulation, data analysis and the research rigour was provided. Finally, consideration towards the code of ethics and limitations of the research were presented. The following chapter will delve into the presentation and analysis of the data that emerged from the study.

CHAPTER 4

Data Analysis and Presentation of Findings

CONTENTS **PAGE**

Chapter 4

Data Presentation and Analysis

4.1 Introduction

This chapter presents the qualitative data obtained through document analysis, and individual interviews which are analysed and presented. To explore how the selected science teachers, engage with the curriculum to teach socially responsive science (SRS) and responses that are related to the research questions are analysed.

4.2. Data analysis and presentation of findings

Data was generated using two methods. Firstly, the CAPS curriculum document along with the student portfolios were analysed using document analysis. Based on data obtained from these sources, an individual interview was conducted with each participant to obtain a deeper understanding of the information received as well as to generate more data.

The analysis of the data was informed by the framework that grounded this study. Firstly, constructs from Freire's humanistic science education approach was understood and created a structure of what is to be sought when studying responsive science practices. It is imperative as advocated by Aikenhead (2006) that SSIs be incorporated within humanistic science as it allows learners to interrogate social aspects using science knowledge. Further, Freire (1973) suggests active methods of teaching and learning that is focused on learner-centered activities. Additionally, humanistic science is valuable as it creates a transformation of thinking through self-reliance and self-sufficiency. The stages in executing humanistic science learning (mentioned in Chapter 2, Section 2.11.1) as explained by Freire, was further used to examine data relating to how teachers taught their lessons. Secondly, the social reconstruction ideology was used to analyse the data. This ideology focuses on an aim to solve society's problems by maintaining that education is a social action where learners must be exposed to solving critical problems to transform current situations. The ideas behind these two constructs allowed me to identify its relatedness to the data obtained and make links in order to further analyse and group the data and then develop related themes.

Through the data that was generated using the methods mentioned, responses to the critical questions that are central to this study were elicited. This study has one broad critical question that is explicated further in the sub-questions that follow:

Research question: How do science teachers engage with the curriculum to teach socially responsive science?

Sub questions:

1.1 Which topics do teachers choose to teach socially responsive science?
1.2 Why was that topic chosen?
1.3 How do teachers teach socially responsive science?
    1.3.1 Which strategies are used to teach socially responsive science?
    1.3.2 Why do teachers choose these strategies to teach socially responsive science?

Themes arose from the responses to the critical questions and through the analysis of data. Participants' views about their choice of teaching strategies and the relatedness to social responsiveness are mentioned. The arising themes were validated by the participants' responses through direct quotations. Lastly, the emerging themes were supported by literature and theoretical constructs. All findings were grounded in the theoretical constructs which underpin social responsiveness.

The following abbreviations were used to differentiate among data from multiple sources:

- Postgraduate module outline- PMO
- Participant portfolios- PP
- Individual Interview – II
- Participant 1- P1
- Participant 2- P2
- Participant 3- P3
- Participant 4- P4

An example of a code for a participant is as follows:

- II-P2: Individual interview- Participant 2
- PP-P4: Participant portfolio- Participant 4

The following seven themes were generated from the data to answer the critical questions.

Theme 1- Scope of the curriculum

Theme 2- Preparing to teach SRS

Theme 3- Compliance with curriculum

Theme 4- Delivering relevant science

Theme 5- Methods and tools used for teaching

Theme 6- Understanding learners' cultures

Theme 7- Relevance of activities

The themes are classified according to specific research questions that underpin this study:

For research question 1.1, which is: *Which topics do teachers choose to teach socially responsive science?* One theme emerged, which is:

- Scope of the curriculum

Research question 1.2 is: *Why was that topic chosen?* The following three themes emerged:

- Preparing to teach SRS
- Compliance with curriculum
- Delivering relevant science

Research question 1.3 is: *How do teachers teach socially responsive science?*

Further divided into two sub-questions:

→ *Which strategies are used to teach socially responsive science?* The following theme emerged:

- Methods and tools used for teaching

→ *Why do teachers choose these strategies to teach socially responsive science?* Two themes emerged, namely:

- Understanding learners' cultures
- Relevance of activities

As part of the postgraduate Honours degree, participants were required to study a module named "Curriculum Development in Science and Mathematics Education". This module required the students to engage in various tasks (Refer to Section 3.2 in Chapter 3) which involved compiling a portfolio of evidence of all the work done.

I analysed these portfolios to understand the topics taught, the reasons for choosing them and how these were related to social responsiveness in science education.

The module's purpose is to "provide educators with an understanding of the nature of (the Science and Mathematics) curriculum, factors which influence its development and the determinants of transformation and change" (University Module Template).

One crucial learning outcome of this module was to be able to critically evaluate existing curricula and case studies of curriculum transformation. This aspect relates to this study, where teachers make use of the curriculum in a more meaningful way. To achieve this, it is expected that transformation will take place, regarding ways of teaching and assessing that are not necessarily explicitly stated within the CAPS curriculum document.

This module required the students (four who were participants in this study) to submit one major assignment that included acquiring information about the school where they teach, the learners, the subject, and social challenges experienced by the learners and their communities.

Students were required to conduct a needs assessment (for example, to assess dominant social challenges, such as health and nutrition-related issues), and then to select a topic to teach from within the CAPS curriculum document to address the findings from the needs assessment. Further, students had to develop two lesson plans with activities based on these topics in ways that were contextually meaningful and socially responsive (Details of this task are in Section 3.6 in Chapter 3). All tasks completed were presented in a portfolio of evidence which I used as one data set.

4.3. Research question 1.1: Which topics do teachers choose to teach socially responsive science?

To answer this question, Theme 1 (scope of the curriculum) emerged.

4.3.1. Theme 1: Scope of the curriculum

The South African curriculum policy prescribes what should be taught and suggests how it should be taught and assessed. All of these are predetermined within the policy. However, based on the analysis of the curriculum, no guidance on teaching science in a way that is socially responsive appears.

Participant portfolios included details of the two lessons taught by teachers with the aim of teaching science in a way that revealed social responsiveness.

All the topics that participants selected were located within the categories of personal and environmental health. Table 4 that follows, illustrates the category of topics chosen by each participant for each of their lessons.

Table 4: Category of topics selected to teach by each participant for social responsiveness

			CATEGORY OF TOPICS	
		LESSON	**PERSONAL HEALTH**	**ENVIRONMENTAL HEALTH**
PARTICIPANT	**1**	1		Waste management Topic: Separating materials
		2		Waste management Topic: Recycling
	2	1	Animal Nutrition Topic: Causes & effects of malnutrition	
		2	Animal Nutrition Topic: Physical education *This lesson is excluded as it does not relate to the study*	
	3	1	Nutrition Topic: Healthy eating and a balanced diet	
		2	Nutrition Topic: Developing a food garden	
	4	1		Water availability Topic: Water pollution and shortage
		2	Food security Topic: Developing a food garden	Solid waste disposal Topic: The 3 R's

Table 4 indicates that the main topic area that participants focused on to teach were waste management, animal nutrition, water availability, food security and solid waste disposal. This data was generated from the analysis of portfolios.

Through the analysis of the CAPS curriculum document, it was noted that these topic areas are situated within Knowledge Strand 2 (life processes in plants and animals) and Knowledge Strand 3 (environmental studies) out of the 3 Knowledge Strands specified for grade 11 Life Sciences. Knowledge Strand 1 (diversity, change and continuity) however, was the strand that was excluded. The CAPS curriculum document for Natural Sciences (grades 7-9) prescribes the Knowledge Strand named Life and Living for term 1 and the Knowledge Strand named Matter and Materials in term 2. Participants selected topics from within these strands to teach their lessons. Participant 1 selected topics *Separating Materials and Recycling*, P2 selected *Causes and Effects of Malnutrition and Physical Education (PE)* (PE lesson was excluded from analysis as it does not relate to the study), P3 selected *Healthy Eating and a Balanced Diet*, as well as *Developing a Food Garden*, P4 selected *Water Pollution and Water Shortage*, *3R's and Developing a Food Garden*. During the individual interviews, however, participants suggested other topics from the prescribed curriculum that could be taught for social responsiveness.

The responses that follow highlight some of the additional topics suggested by the participants.

> *Other topics are sources of energy, saving energy, nutrition, reproduction & separating mixtures.* (II-P1)

> *Some of which I've seen include HIV AIDS education, solid waste disposal, food and water shortages, prevention & treatment of illnesses, human population growth also.* (II-P4)

The responses revealed additional topics suggested, but not necessarily taught in the lessons under review, from all strands specified for grade 11 Life Sciences and grades 7 and 9 Natural Sciences in the CAPS curriculum.

4.4. Research question 1.2: Why was that topic chosen?

Many of the practicing science teachers indicated that they have identified a need to re-teach other topics in a more socially responsive manner. This implies that teachers were convinced about the value of underpinning their teaching with an SRS approach. These views are indicated using the following three themes:

4.4.1. Theme 2: Preparing to teach SRS

This study explores how science can be taught to achieve social responsiveness and therefore this theme identifies ways in which it can be attained.

Responses from interviews as well as analysis of portfolios revealed that participants had discussed issues with learners to understand social challenges that learners had encountered. This indicated that they made informed decisions about preparing to teach specific topics and using strategies, through an unpacking of needs of learners and their communities. Participants communicated with learners in groups and individually through introduction discussions in the lesson. Each of the four participants proceeded to do research and conducted a needs assessment using questionnaires which were included in the portfolios, to identify problems that needed attention. They discussed their findings which emerged from the needs assessment with their learners. The following responses and excerpts are evidence of this.

> *These topics relate intricately to the lives and living of the learners. I know this as I did communicate with my learners about societal issues that they may be facing beforehand.* (II-P4)

The participants had shown pictures and presented a case study related to malnutrition and poor dietary choices (see appendix 8b figures 1 & 2) as well as poor waste management and water quality (see appendix 8d figure 1). This involved students in group discussions which highlighted some contextual issues.

> *Needs assessment pointed towards this social challenge*- Malnutrition. (PP-P2)

> *This photo was passed around the class, so that they would have a better understanding of the current state of the disadvantaged community.* (PP-P4)

In preparing to teach SRS, Participant 1 conducted a needs assessment using surveys through questionnaires directed to the learners. Each learner completed this survey and their responses were analysed by the participant. Participant 1 concluded that the topics that they chose to teach were due to the learners' responses in the survey and also through visual interpretation of the schools' surroundings. The topic that was thus taught was "Sorting waste". Participant 2 conducted a needs assessment. Information garnered in this way revealed the challenge of malnutrition in the learners' communities. Therefore, the topic selected by Participant 2 was "Causes and effects of malnutrition".

Participant 3 used a dialogic approach with learners to identify contextual challenges. Through enquiry of learners' daily habits around school and home, Participant 3 was motivated to further inquire from school staff about the learners' home environments in terms of eating habits and health. This assisted the teacher to teach the topic on "Benefits of healthy eating". Participant 4 used a visual stimulus to encourage thinking about SSIs. Participant 4 engaged learners in examining pictures which reflected informal dwellings. Discussions among the learners led to Participant 4 selecting the following topics "Water pollution and shortage of water as well as food insecurity along with the 3R's of recycling".

Additionally, through the analysis of participant portfolios, Table 5 shows how teachers carried out their needs assessments with their learners as well as what social challenges or needs emerged because of this.

Table 5: Types of social challenges that emerged as a result of needs assessment carried out

PARTICIPANT	METHODS/TOOLS USED TO CONDUCT NEEDS ASSESSMENT METHOD	EMERGING SOCIAL CHALLENGE
1	Surveys using questionnaires with the learners	Poor waste management
2	Group interviews with learners	Unhealthy lifestyle practices (Malnutrition & physical activity)
3	Planned enquiry and conversations through everyday interaction with learners	Poverty and malnutrition
4	Surveys in class with learners as an activity before the lesson as well as visual enquiry	Poverty, poor water quality & availability, food insecurity, waste management

Drawing from the literature in support of the preceding findings, Aikenhead (2006) asserts that to teach science in a humanistic manner and to develop social responsiveness, SSIs should form a crucial focus. In this study, SSIs based on a needs assessment, informed lessons. Santos (2008) extends the Freirean humanistic perspective to science education and posits that dialogic engagement about socio-scientific challenges is critical. Freire (1970) mentions that dialogue is an effective way of making learners understand the reality of their society so that they are better able to transform it. In this study, planned inquiry through discussions and regular everyday communication with learners created opportunities for dialogic engagement about SSIs, as Freire had suggested.

4.4.2. Theme 3: Compliance with curriculum

The first reason for choosing the topics according to the participants, are that these topics are expected to be taught as per the CAPS curriculum and work plan prescribed by the district. The following responses attest to this:

> *The reason for these topics and activities is mainly because CAPS instruct us to teach it.* (II-P2)

> *…indicated within CAPS as content to be taught… CAPS promote teaching for a sustainable environment.* (PP-P1)

> *Healthy eating is vital for optimal body functioning as stated in CAPS.* (PP-P3)

Other responses that were provided affirmed that some topics were either taught previously and needed enhancing or these topics were part of the syllabus that they were teaching at that moment. This is evident in the responses that follow from participants.

The responses indicated by P1 and P4 here, highlight a centrally controlled curriculum that determines pacing and sequencing of topics:

> *Also, these topics are to be taught in the second term during which I began planning my study.* (II-P1)

> *I thought it made sense to conduct my study based on the topics I was teaching at that time.* (II-P4)

The reason for selecting the topics to teach included the fact that these were prescribed in the CAPS curriculum. In addition, some participants selected topics conveniently, since these were being taught at the time this task was given, based on the prescribed work plan by the DBE.

4.4.3. Theme 4: Delivering relevant science

The responses from P2 and P3 which follow indicate that there are teachers who are motivated to transcend content in the curriculum by selecting topics which could be taught in a socially relevant way. Participant 2 taught the causes and effects of malnutrition and P3 taught healthy eating and developing food gardens.

> *…I taught this topic in term 2 and when I was planning my study I thought that the section could be taught in a new way, making it more practically beneficial rather than solely understanding content theory.* (II-P2)

> *I also chose this topic as I have taught it already and realised that it is a good topic that would relate very well with social responsibility and resilience.* (II-P3)

Some participants indicated additional purposes for the choice of topics to create socially responsive science lessons. One main purpose was connecting school science with daily life experiences and societal culture. I was reminded of the following excerpt by Paulo Freire who wrote in his book, *Pedagogy of Hope: Reliving pedagogy of the oppressed* the following in support of this:

> *"…let it not be said that, if I am a biology teacher, I must not go off into other considerations: - that I must only teach biology, as if the phenomenon of life could be understood apart from its historical-social, cultural and political framework.. As if life, just life, could be lived in the same way … in a favela (slum) … as in the prosperous area of Sao Paulo's Gardens! If I am a biology teacher, obviously I must teach biology. But in doing so, I must not cut off from the framework of the whole"* (Freire, 1994, p.78).

The following remarks by the participants are evident of this:

> *The purpose for these topics and activities are because it relates to the daily experiences and living of the learners and their society.* (II-P1)

This reveals that the teacher aims to create and pursue relevant science education.

> *The main purpose for me is the fact that what they learn at school can relate to how they live in their communities… I thought that the section could be taught*

in a new way, making it more practically beneficial rather than solely understanding content theory. (II-P2)

Participant 2 aimed to transcend theory and sought opportunities for practicing what was learnt to benefit learners by relating school science to their lives and communities.

The responses from P2 and P4 that follow revealed that teachers valued the application of science knowledge to lives of learners:

These topics relate intricately to the lives and living of the learners... (II-P4)

It is something experienced in everyday life (PP-P2)

Social issue that affects them in everyday life… (PP-P4)

Participant 1 provided a reason that went beyond applying science to daily life for benefitting learners and their communities. The notion of developing resilience emerged. This is crucial because it signals the teacher's plan to help learners identify suitable resources and opportunities to minimise current or future risks.

Encouraging resilience by linking theory to practice and including everyday life and community. (PP-P1)

These topics help me to help my learners develop certain community knowledge and skills to assist them with contextual issues… make changes and help learners understand the importance of self-reliance also to find alternative ways to solve issues using our own indigenous knowledge. Indigenous knowledge was very much specific to a community and its issues such as treating illnesses, or ways of life. These practices could be beneficial in addressing social problems today. (PP-P3)

Here, participant 3 intended to empower learners, who could in turn empower their communities.

Topics were chosen in compliance with curriculum requirements. Participants further aimed to link classroom science education to life experiences of the learners. The daily experiences are closely linked to societal culture and traditions and therefore some teachers promoted teaching and learning by making use of indigenous knowledge systems (IKS) within the classroom to teach specific SRS-related content.

Based on this data from the participants and the literature, it emerges that teaching socially responsive science involves getting to know our learners, their culture and their social challenges. By framing these challenges as SSIs, lessons can be designed to respond to these issues, and in this way, helpful knowledge and skills could be constructed during the teaching-learning dyad. It is crucial that before teaching any content, teachers must be informed through dialogue with learners about their social contexts to drive a humanistic science education that is suggested by Freire (1970).

4.5. Research question 1.3: How do teachers teach socially responsive science?

This research question is further divided into two sub-questions:

1.3.1 Which strategies are used to teach socially responsive science?

1.3.2 Why do teachers choose these strategies to teach socially responsive science?

4.5.1. Research question 1.3.1: Which strategies are used to teach socially responsive science?

One theme emerged in response to this question:

4.5.1.1. Theme 5: Methods and tools used for teaching and learning

The following theme presents the diverse methods which participants used in their lessons to teach learners specific SRS-related content. The constructs described here are derived from participant portfolios. From my analysis, I identified some dominant methods, resources and activities designed for teaching. They are shown in Table 6.

Table 6: Activities, strategies & resources identified

Learner activity	Strategy	Resources
• Reflections • Designing and presenting posters • Drawing • Storytelling • Photo analyses	• Group work • Role playing • Teacher demonstrations • Field work • Discussions • Problem solving • Investigative research	• Audio visuals • Pictures • PowerPoint • Lectures by guest speakers • Vegetable seeds • Gardening tools

Most of these strategies (in Table 6) exemplify the learning theory of constructivism and the inquiry-based learning approach. Shamsudan *et al*. (2013) as well as Singh and Yaduvanshi (2015) describe inquiry-based learning as learner-centered. Learners take active responsibility for their own learning and make meaning through their exploration with the subject content materials and in this way, they develop into critical thinkers.

The various activities and strategies used by each participant, the learning approaches, and details of lessons, are shown in Table 7. This data was sourced through the analysis of participant portfolios.

Table 7: Methods and activities adopted by each participant

PARTICIPANT	RESULT OF NEEDS ASSESSMENT	LESSON TOPIC	TEACHER ACTIVITIES	TEACHING METHODS, RESOURCES & ACTIVITIES	LEARNER ACTIVITIES	ASSESSMENT TASK
1	The needs assessment that was conducted using questionnaire surveys, identified that the school and surrounding community did not practice effective waste disposal. Further, the large dumpsite polluted the school grounds saw learners requiring knowledge to solve these problems.	1a Waste management-**Separating materials**	Introduce lesson with audio-visual and pose questions to learners to access prior knowledge and for discussion to facilitate new knowledge construction. Explain sustainable living and its relevance to science	Resources: Video on recycling, PowerPoint presentation & poster. Strategies: Teacher, group work, investigations.	Watch video, answer discussion questions, investigate current waste management at school	Investigate and present types and amount of waste generated in different areas around the school Audit of waste materials (learner-centered, hands-on task)
		1b Waste management-**Recycling**	Access prior knowledge, introduce guest speaker, teacher-learner discussion, elaborate strategies that learners can use to educate their communities	Strategies: Discussion between learners and guest speaker. Group work, problem solving. Resources: poster, PowerPoint presentation.	Answer questions, listen and observe presentation by a docufile (an archiving & document storage service) representative, engage in discussion with teacher, identify solutions to solve litter pollution.	Design and present a poster on a program for paper recycling and management at the school

2	Through interviews, it was identified that learners needed knowledge on maintaining a healthy lifestyle which included improved dietary choices as well as enough physical activity.	2a Human nutrition- **Effects & causes of malnutrition**	Facilitates group work and provides instructions on what to do	Strategies: Problem solving, presentation, group work discussions Resources: Posters	Work in groups, examine pictures related to malnutrition, discuss pictures, designing posters	Design and present a poster related to pictures chosen regarding malnutrition
		2b Human nutrition- **Physical education** *TOPIC EXCLUDED FROM STUDY*	Explains purpose of physical activity, the lack there of and its link to malnutrition.	Physical education	Engaged in aerobic exercise	Teacher stated that "assessment will be based on the participation in aerobic routines".
3	Teacher identified poverty-stricken learners that often did not bring a lunch pack to school. Some learners had not eaten before the commencement of the school day. This resulted in many learners fainting at school. Learners required ways to resolve this problem.	3a Human nutrition - **Healthy eating and a balanced diet**	Recaps prior knowledge, facilitates learner-learner discussions, emphasize vitamin and mineral functions in the body, exposes learners to nutritious types of foods as well as traditional imifino	Strategy: Discussion, identifying functions of vitamins & minerals, research Resource: Charts	Discuss why living organisms need food, design charts on components of feeds, tabulate functions of vitamin and minerals, discuss how to sustain nutritious foods in school	Research most nutritious foods that are high in vitamins and minerals.
		3b	Demonstrate how to prepare soil for seed beds and planting of seeds.	Strategy: Discussions,	Listen and take note of instructions. Prepare	Learners were given seeds to design their

		Human nutrition- **Developing a food garden**	Pest prevention and irrigation are explained. Traditional fertilizers for soil enrichment discussed.	demonstrations, field work (Practicals)	soil with forks, practice seed planting and pest prevention. Irrigate seed beds. Use kraal manure to fertilize soil and prepare mulching.	own food gardens at the school (field work)
4	Teacher identified (through the questionnaires and learner discussion) that learners required skills that would help them deal with poverty issues that lead to poor water quality and availability, food insecurity and poor solid waste disposal.	4a Water quality: **Water pollution and shortage**	Teacher-learner discussions on poverty. Questions are asked. Teacher discusses three major factors of poverty. Explains the global limited water supply and enquires about water quality and availability in learners' community. Highlights methods for water purification through discussion lecture. Summarizes the lesson and poses a short conclusion activity.	Strategy: Discussion using mind maps, reflections, research, group work, photo analysis Resources: Posters, photos	Learners respond to questions and engage in discussion. Investigates ways to solve the problem related to water quality. Learners discussed current social issues and raised awareness on them relating it to everyday life	Produce a mind map on poverty and its effects on rural communities and on education. Design posters on water pollution affecting poverty. Research ways to solve the issue of water pollution. (problem solving)
		4b Food security & Waste disposal- **Developing a food garden**	Recaps previous lesson using posters, discusses pollution and drives lesson towards waste disposal by discussion and questioning. Facilitates group work. Highlights strategies (3 R's).	Strategy: Discussion, group work, problem solving, field work (gardening) Resources: posters	Learners engage in developing their own food gardens. Respond to questions, engage in discussions,	Self-directed research Gardening project (field work)

		& The 3 R's of recycling	Teacher provides examples of various recycling methods related to the 3 R's. Teacher encourages learners to start their own vegetable garden as a strategy to alleviate food insecurity and consequentially poverty. Processes of garden preparation are explained.		provide solutions to specific problems.	

It is evident that the participants made use of a wide variety of activities which aided in teaching their learners SRS content. There were similarities with regards to the strategies used by the teachers as there were differences. The most frequently used strategies were discussions and group work. Participant 2 had designed lesson 2 around physical education which was excluded from the analysis as it did not relate to the study. It is important to note that Participant 4 chose to teach poverty by addressing underlying issues such as water shortage & quality, food insecurity and waste management. The approach participants took to deliver the lessons were learner-centered and included activities such as self and group directed investigations through research, problem solving, hands-on activities (practical/fieldwork), written classwork, class discussions and poster presentation based on research. All the mentioned activities are clearly apparent by description and illustrations within the student portfolios. (See appendix 8 as descripted below)

For Participant 1: Appendix 8a, Figures 1-5

For Participant 2: Appendix 8b, Figures 1-3

For Participant 3: Appendix 8c, Figures 1-4

For Participant 4: Appendix 8d, Figures 1-4

4.5.1.2. A further look at the dominant teaching strategies adopted

Each participant made use of various strategies in different ways. The excerpts that follow are descriptions of the ways some of the activities were used to teach SRS related content. These were documented by each participant in their portfolios and similarly identified from the individual interviews. Further, these activities were informed by needs which were recognized, with the aim of working towards a possible solution to a problem. The solutions may have emerged via a skill acquired through the activities in which the learners participated. Some of the activities that were conducted during the lessons along with documented evidence are as follows:

- **Discussion activities in class (learner-learner and teacher-learner discussions):**

Some participants used discussions and designed lessons (lessons 1a and 1b by participant 1, lesson 2a by participant 2 and lesson 3a by participant 3) to supplement teaching. They adopted a constructivist approach to teaching SRS. The discussions were used to stimulate thinking and encourage learners to contribute to the learning process. This dialogic approach assisted learners to gain new knowledge and identify existing knowledge.

> *Learners will be asked questions to provoke **discussion**, for example: do you consider recycling and waste management as a means of separation? …* (PP-P1)
>
> *…**discussion** to identify prior knowledge in mixtures and understand if they have their own unique ways of doing so.* (PP-P1)
>
> *Learners **discussed** their topics in groups* (PP-P2) (See appendix 8b, Figure 2)

*…**talk** about the high numbers of learners fainting in school due to the lack of nutritious food at home and the importance of components of foods.* (PP-P3)

- **Group work:**

Some participants valued the development of group work skills and designed lessons (lessons 1a and 1b by participant 1 and lesson 2a by participant 2) to promote this. This strategy is a constructivist one, which allows for cooperative work. The learners were given the opportunity to work with their peers rather than working individually. The participants revealed that the group work activities encouraged higher participation from learners and that they enjoyed working in this setting.

> ***Groups** will investigate the types and amount of waste generated in different areas within the school. Each group must report and present their findings*. (PP-P1) (See appendix 8a, Figure 1).
>
> *Each **group** will be given a topic based on malnutrition. Each group will present their ideas which may include their experiences and knowledge based on this.* (PP-P2) (See appendix 8b, Figure 3).

*Students enjoyed working in **groups**.* (II-P1)

- **Field work:**

Two participants designed lessons incorporating field work. (lesson 3b by participant 3 and lesson 4b by participant 4). Learners had the opportunity to engage in hands-on learning in the gardening activity. The learning activity took place outside the classroom which provided learners with excitement to work in a different environment.

> *…learner activities included preparing vegetable gardens in stages from soil preparation to seed planting*. (PP-P3) (See appendix 8c, Figures 1-3)

Educator explains the process of starting a food garden…. Learners are empowered through this lesson as educator attempts to transform their thinking and move learners towards self-reliance. (PP-P4) (See appendix 8d, Figure 4- learners show the seeds in which they intend to plant)

- **Problem solving**

Participant 1 in lesson 1a, P3 in lesson 3a and P4 in lesson 4a valued the development of problem-solving skills and designed lessons to promote this. Since learners were learning in the context of transformation and overcoming difficulties, teachers agreed that allowing learners to practice problem solving will assist them in addressing real-life challenges.

> *Learners engaged in activities to provide solutions to the issue of poor waste management at school.* (PP-P1) (See appendix 8a, Figure 5)

The learners are required to research in order to identify solutions to the problem of learners fainting at school. (PP-P3)

Learners are to engage with a diversity of learners to think critically and become problem solvers when addressing a given issue such as methods to eliminate water pollution. (PP-P4) (See appendix 8d, Figure 2)

- **Investigative research**

Participants 1 (lesson 1a), participant 3 (lesson 3a), and participant 4 (lesson 4a) made use of investigative research in their lessons to stimulate thinking and gain information constructively. Investigative research was represented in two ways namely practically (hands-on) and desktop based using the internet and computer. This strategy aimed to develop science inquiry skills within a problem-solving setting.

> *Learners will be investigating the type and amount of waste generated in these areas of the school. The waste should be categorized, and findings recorded on the activity sheet.* (PP-P1) (See appendix 8a, Figure 1).
>
> *Learners will discuss, based on their research, the most nutritious foods.* (PP-P3).

Participant 3 indicated that the results from this desktop research were recorded and evaluated by learners, to construct knowledge about foods which were nutrient-dense.

> *Learners are required to research to identify the problem and suggest ways to rectify the issue.* (PP-P4).

Participant 4 alluded to research based on water pollution and purification, which was conducted by learners, and learners' views about addressing the problem.

- **Role playing**

Participant 1 designed lessons (lesson 1b) using role play to teach learners more about recycling in a fun and creative way. This task provided learners with the opportunity to enact contextual issues being experienced and their solutions of addressing this challenge in the community.

> *The essence of the role play was enacting how they would go out into the community to educate them on waste management and the program that they intend to develop to solve the issue*. (PP-P1) (See appendix 8a, Figure 4).

- **Demonstrations**

Participant 3 used demonstrations in teaching her lesson (lesson 3b). The demonstration was conducted by the participant to show the preparation of a seed bed (for a food garden).

> *The educator shows the learners how to prepare a seed bed*. (PP-P3) (See appendix 8c, Figure 2).

4.5.2. Research question 1.3.2: Why do teachers choose these strategies to teach socially responsive science?

Several responses to this research question were driven by the anticipation and enthusiasm by participants to develop self-reliance among learners. Further, the main aim was to develop a sense of social responsibility in their learners so that they are better equipped to address societal needs. Participants described the types of activities that should be adopted when teaching science in a socially responsive way. The views are highlighted by the following two themes that emerged through the analysis of participant portfolios and individual interviews.

4.5.2.1. Theme 6: Understanding learners' cultures, creating culturally inclusive opportunities for teaching and learning

Participants shared a view that teaching for social responsiveness means understanding cultural backgrounds of their learners. This resonates with the view by Santos (2008) about accessing personal and societal information through dialogue. Ladson-Billings (2009) emphasizes that culturally responsive teaching is a pedagogy where learners become empowered socially, because cultural situations are used to inform knowledge, skills, and attitudes. Teachers should begin by understanding learners' cultures, so to prepare to teach, they must have insight into the cultural settings of learners. Sadler *et al.* (2017) state that socio-scientific teaching and learning (SSI-TL) draws on societal issues and on the connection between science and learners' experiences and therefore, there should be a link between school and home.

The value of culturally responsive lessons was also echoed in an interview:

> *Also, education about understanding cultural settings of learners helps us design culturally specific lessons that will be better relatable in ways to develop necessary knowledge and skills.* (II-P4)

> *…understanding the culture of learners in order to teach and provide solutions to societal challenges is what I feel social responsiveness could be seen as.* (II-P1)

The data revealed that teaching science in a manner that is socially responsive should lend itself into tapping into traditional knowledge of learners, that is, science teaching should also be culturally inclusive. Prior knowledge of living habits and practices as well as culture within a specific social context raises discussions about IKS in science education. According to Ismail (2013) IKS has not been given much attention at schools nor in pre-service teacher training education. The implementation of Life Sciences lessons, by connecting culturally embedded IKS with societal issues (challenges) can make for more relevant school science. The relevance of science in learners' daily lives is enshrined as a key aim within the CAPS curriculum (DBE, 2011, p.10). However, the CAPS curriculum does not provide additional guidance and support related to addressing social challenges through science lessons.

The following quotations highlight the participants' views about IKS during lesson preparations.

> *Also, many nutritional deficiencies were aided through traditional practices. I use IKS in my teachings which is actually part of the Life Sciences curriculum.* (II-P3)

> *The use of IKS can be reached further and more teachers will able to assist learners understanding as it is what learners are familiar with in their communities. I think it is very beneficial to the learners if they are taught in a way that is more relatable.* (II-P3) – Participant 3 had prepared lesson activities using indigenous knowledge for the preparation of seed beds.

> *By doing this (incorporating IKS in science lessons), I can get learners to solve real life problems using scientific knowledge.* (II-P3)

In developing food gardens, Participant 3 sought traditional knowledge regarding the types of crops to be grown and how to execute it to assist learners in their activity. Participant 3 also indicated that the choice of topic and activity allowed her to incorporate IKS in teaching and learning.

The following responses attest to this:

> *Traditional indigenous knowledge was used to decide type of crops that would treat the disease… Kraal manure was used as it doesn't burn crops as compared to commercial fertilizers.* (PP-P3)

> *Growing food gardens for consumption or income is taught by using organic matter as compost.* (PP-P4)

> *…many nutritional deficiencies were aided through traditional practices. I use IKS in my teachings which is actually part of the Natural Sciences curriculum…It gave me the opportunity to make changes and help learners understand the importance of self-reliance also to find alternative ways to solve issues using our own indigenous knowledge. Indigenous knowledge was very much specific to a community and its issues such as treating illnesses, or ways of life. These practices could be beneficial in addressing social problems today.* (II-P3)

4.5.2.2. Theme 7: Relevance of activities

This theme describes the participants' justification and explanation for the activities conducted. Four reasons have been identified:

1. Valuing cooperative learning
2. Development of skills, knowledge, attitudes and values
3. Context of learners
4. Creating a caring and responsive science

1. **Valuing cooperative learning:**

Several participants explained that activities which required learners to collaborate and cooperate were valuable when teaching SRS.

Allowed learners to work together. (II-P1)

The activities brought about collaboratively working members that shared creative ideas. (II-P2)

…allowing learners to work together to solve the problem and share ideas and to address malnutrition and unhealthy lifestyles through physical activity… (PP-P2)

Reflections that follow are reasons why particular activities were used to teach SSIs and exemplify a learner-centered constructivist approach to science instruction:

…allowed for learner-centered knowledge construction which enhanced creativity giving learners the opportunity to become creative in developing solutions to challenges. (PP-P1)

The activities help learners gain a hands-on experience to learning for better understanding. (II-P3)

The extracts revealed highlight reasons which included gaining experiences, driving learner centeredness in teaching and learners working together when dealing with a challenge.

2. **Development of skills, knowledge, attitudes and values in learners:**

Developing critical thinking and problem-solving skills are aims in the CAPS document. Several participants designed SRS lessons to facilitate development of knowledge, skills, attitudes and values, as is evident in the following excerpts:

These topics also develop necessary skills and values in the learners… Additionally, my activities allowed learners to work together to solve a problem and they learned how to approach the community to discuss issues of adversity. (II-P1)

The activities further enhanced critical thinking in problem solving. (II-P4)

The participants indicated that the engagement of learners with the activities created a deepening of understanding through concrete experience:

The activities help learners gain a hands-on experience to learning for better understanding. (II-P3)

Lessons were designed to empower learners through novel activities that make them lead learning activities:

Students observed various areas around the school and made notes about waste produced and what was done with it…Learners' confidence was boosted, and they felt like mini journalists. (PP-P1)

Learn the importance of developing their own gardens. (PP-P4)

Additionally, an important skill taught to deal with clean water scarcity was water purification methods by boiling. A skill that was advised to be taught to disadvantaged community members facing water shortages and polluted water in lesson 4a.

The water needs to be boiled so that it is purified as it contains germs and pathogenic micro-organisms. (PP-P4)

Further, participant 4 indicated that, learners were taught about diseases acquired through drinking unclean water and how it results in absenteeism. This is confirmed by the following extract:

Polluted water cause health hazards to those living in informal communities as they obtain their water from here... Diseases can be transmitted which leads to absenteeism as learners are unwell to attend school. (PP-P4)

Within lesson activities, learners were instructed to develop ways to properly dispose of waste in disadvantaged communities to not inflict any cost on residents and it should be done in a manner that improves living conditions. The teacher had brought sustainability into the lesson when teaching recycling. The extracts that follow confirm this:

emphasis on the solution of re-use, reduce and recycle. Learners are to think about each of these and suggest how they would apply this in an everyday context in a disadvantaged area… Re-using items such as glass jars for storage. Using plastic bottles to collect rainwater for watering crops. (PP-P4)

The activities of the lessons further aided in the development of science process skills:

This task developed observational skills that drove toward solving a problem. (PP-P1)

Gaining research skills… Practiced how to approach community with regards to waste management and pitching for sponsorships (PP-P1)

Acquire observation and record keeping skills through fieldwork. (PP-P3)

Participant 1 and 3 engaged learners in activities that contributed towards developing science research and process skills which is mentioned in Specific Aim 2 of grade 7 and 9 NS.

3. Context of the learners:

The participants were aware of challenges encountered by learners, based on their experiences of working at the school, as well as on the needs assessment. They documented details of these challenges within particular contexts in the portfolio of evidence. Many of the SRS-related activities that were designed to respond to challenges within the school context. This was made possible because the teacher had some knowledge of the community. This motivated one, for example, to choose food garden generation as a teaching activity in order to enable learners to respond to food insecurity. The following extract illustrates this:

… I noticed that in this community where the school is located, people are exposed to poverty and that affect our learners, thus results in having ill and sick learners suffering from diseases associated with hunger and poverty. (PP-P3)

This participant (P3) had started a food garden with her learners (evident through pictures in the portfolio, see appendix 8c, figure 1) to alleviate hunger.

In addressing the issue of poor nutritional choices in lesson 2a, learners spread knowledge about healthy eating as well as the importance of physical activity around the school using posters made in class. The teacher mentioned that the feeding scheme supplies unhealthy foods which the learners enjoy and chose not to opt for fruit instead. (This is a disquieting observation which lies outside the scope of my study and warrants further research).

Learners resist purchasing fruit. (PP-P2)

The information gathered from the needs assessment related to their living experiences as mentioned in the portfolios;

Malnutrition indicated to have an effect on academic performance. (PP-P2)

Lack of nutrition linked to illnesses which brings about fatigue and lack of concentration…knowledge will help to decrease lifestyle diseases. (PP-P3)

These challenges helped learners understand (identified through class discussions) the importance of healthy eating and improved dietary decisions that proved beneficial towards their personal health as well as their academic performances. This greatly demonstrates the change in thinking of the learners in becoming more resilient in their living.

4. **Creating a science of care that is conscious, responsive and responsible:**

Participants stated that these lessons were taught in order to advance an SRS and a potential for self-reliance that provides the confidence needed to address societal challenges. To this end, participants alluded to the importance of self-reliance, caring for the environment and addressing poverty.

The following excerpts relate to participants' goal to develop greater self-reliance among learners:

The reason for this (lesson design) *further allows learners to take up social responsibility and become self-reliant.* (II-P1)

Learners develop a sense of self-reliance and accomplishment. They further assist others in their community to develop such characteristics that may be beneficial to their lives. (II-P2)

The reason I chose these topics and activities further allowed me to assist my learners in developing a sense of social responsibility in order to address societal needs thereby becoming self-sufficient. (II-P4)

These participants explained that learners were taught how to develop food gardens to grow healthy food crops that could be utilised to treat vitamin deficiency diseases,

to develop resilient practices towards self-reliance. It reveals how the teaching and learning of science allowed learners to respond to food insecurity.

> *Learning how to develop food gardens to address nutritional requirements and as a strategy for resilience.* (PP-P3)

> *Learning about food gardens is a good way of sustaining food sources to alleviate this issue* (food insecurity). (PP-P4)

Participants in this study also sought to develop an ethic of care towards the environment. To this end, teachers taught that proper disposal of waste also contributes towards preventing water pollution. The following excerpt confirms the participants choice for the topic chosen:

> *Disposal may help in sustaining healthy water sources in the poverty-stricken communities.* (PP-P4)

Participant 1 indicated that, learners identified discarded vegetable scraps and peelings and used these as natural composts in the school garden. The lesson 1a also helped learners to identify additional ways to assist the community, such as clean-up campaigns and educating the community about hazardous waste disposal and clean environments. It was suggested that unemployed parents from the neighbourhood could be recruited to help in the school waste management and recycling programme. This was a way to address the high unemployment in their community, and to generate income for poor people, while caring for the environment. This was one very important recommendation made by the learner's discussions with teachers that was documented in participant portfolios.

> *Sustaining the environment is related to science education. A healthy environment promotes a healthy life and sustainable development for future generations…* learners g*ained a sense of responsibility and understood the importance of disposing of waste in an environmentally friendly manner.* (PP-P1)

This response revealed the vision for learning to transcend immediate needs of learners and to work towards sustainable development for future generations.

As mentioned earlier, another prominent social challenge in the community is unemployment and poverty. Through crop production at school, participants stated

that learners could use the produce to generate income and to become wiser in financial management and entrepreneurship.

> *Crops planted can be sold for an income to the school feeding scheme. Income can be used to purchase new seeds and maintaining the garden.* (PP-P3)

> *They also got excited at the fact that they could use their produce to generate income.* (II-P1)

Although the income that would be received would not be used for personal purposes, this is a good skill to possess to teach others in the community so that they understand that there are ways in which they could generate income. According to participant 3, skills that can be used for the rest of the learner's lives are mentioned and can also be transferred to following generations so that they are better able to take care of their needs. The following response indicates this.

> *skills can be transferred to the community in uplifting the community knowledge about nutrition, poverty, and food insecurity.* (PP-P3)

4.5.2.3. Motivating factors for choice of teaching strategies

In addition to the reasons that have been explained, there were several factors identified as motivation behind the teaching strategies that was selected to teach SRS. Through analysis of the data, overall reasons for choosing the implemented teaching strategies for SRS lessons were identified through the following factors.

Material factors: the participants conducted their activities with resources that were readily available. These resources were supplied by the teachers themselves or used any that were available at the school. The following experts form participant 3 highlight this.

> *I wrote a letter wrote a letter to the municipality to supply seeds.. they arrived after 3 weeks.* (See appendix 8c, figure 5)

> *The neighbour sold livestock, so I asked for kraal manure*
>
> *use the schools' garden hoe and spade.* (PP-P3)

Human factors: some participants requested assistance from sources outside the classroom to present information that aided their lesson. Evidence from participants' portfolios are shown in the following extracts.

> *representative from docufile management specialists will be available to do a presentation on recycling and waste management.* (PP-P1)
>
> *school gardener assisted learners with the garden*. (PP-P3)
>
> (See appendix 8a, figure 2 & 8c, figure 4 for visual evidence from PP)

School ethos: participants sought consent before conducting particular activities. The participants also indicated that the school management realised the importance of the values being taught through their science lessons. The following are evidence of this.

> *The school authority gave permission for every aspect.* (PP-P1)
>
> *management understood the importance of healthy living and allowed me to do activities during cleaning period on Fridays*. (PP-P2)
>
> *I saw land available and school allowed me to use it for gardening.* (PP-P3)

Learner factors: the participants claimed that the learners showed eagerness and excitement to engage in the activities that they designed. They further mentioned that the learners were motivated to engage in the activities because it was different to how they usually learn daily within their classrooms and it was fun. The following excerpts allude to this.

> *learners were excited to be a part of something different instead of daily rote classroom activities.* (PP-P1)
>
> *learners learned while having fun.* (PP-P2)
>
> *learners and educators can have fun together when learning outside the normal class setting.* (PP-P3)

Ideological factors: participants indicated that the learners engaged well with the lessons and eventually showed signs of self-sufficiency through their responses to the activities. Learners were empowered as they could make use of the knowledge and skills learned through these lessons and apply it to their daily living. Participants views are indicated by the following extracts:

> *this was a great opportunity for learners to make observations that they can come up with solutions to solve daily problems.* (PP-P1)
>
> *the information they have will make them to be self-sufficient.* (PP-P2)
>
> *gardening allowed learners to gain lifelong skills and apply skills that they got at school at their home too.* (PP-P3)

4.6. Discussion

Findings from the data, framed around three key research questions, are presented, using literature and theoretical insights from existing theories. In understanding findings from research question 1.1 (*Which topics do teachers choose to teach socially responsive science?)*, teachers stated the need to recognize the learners background contexts prior to designing lessons, and therefore engaged in dialogic discussions to gain more understanding. Freire (1970) additionally advocates for dialogue in his educational approach to identify socially relevant themes for discussion. The dialogue between teacher and learners was encapsulated via one on one conversations and a needs assessment survey which gave learners the opportunity to express and divulge information surrounding their social contexts.

The participants explained that many learners became very emotional in responding to certain topics and the participants expressed sensitivity towards the way they approached the learners. Through individual interviews with the participants, a sense of care and personal desire to assist the learners emerged. Freire (1970) admits that a humanistic process embodies education to conduct, replicate and create values. The approach of a humanistic science education formed part of the framework for this study and suggests care and transformation of human conditions to improve the quality of life. The results from the needs assessment revealed socially contextual challenges being experienced among many people in South Africa presently. Through the analysis of data, these challenges have been located within the categories of personal and environmental health which influence each other. Additionally, the topics that the participants chose to teach exemplify their position within these two categories that have been identified. The topics which were selected were waste management, water availability and quality as well as human nutrition.

According to Espeja and Couso (2020) SSIs use motivating topics to learn argumentative skills in developing critical thinking and decision making. This is executed by discussing socially relevant controversial issues. The topics that were taught were embedded within current social challenges, and many of these have been presented in analytic reports by STATS SA (2017). Ogude *et al.* (2005) mention that becoming responsive to context-based issues develops responsible citizens who occupy responsible roles in society. The development of these responsible roles

exemplifies the need to deliver SRS in which SSIs are embedded. The topics that the participants chose to teach have demonstrated their relation to SRS and have been identified as critical SSIs that require effective solutions to be derived.

In response to research question 1.2 (*Why was that topic chosen?)*, participants revealed that the reasons behind the choice of topics were based on their compliance to the requirements of the CAPS curriculum for Life Sciences and Natural Sciences, during that particular schooling term. Additionally, results from the needs assessment pointed towards a need to teach these specific topics. Participants indicated that the results they obtained from the needs assessment allowed them to navigate through the subject content prescribed in the CAPS curriculum. Understanding the knowledge that they received from learners' responses (to assess their needs) provided the teachers with key ideas that they used to link to topics in the prescribed curriculum. A clear link was made between learners' needs and the topics selected to be taught. This link contributed to the goals and objectives of the curriculum which envisage the use of content knowledge and practices in society. Instead of addressing generalized societal issues that may be vast, the lesson topics that the teachers taught addressed specific societal challenges. These challenges were experienced by each learner and were identified through their responses generated from the needs assessment surveys. The knowledge and skills developed were applied to daily living in meaningful ways. According to Santos (2008) meaningful living involves putting learned knowledge into practice to overcome problematic conditions. For this process to be meaningful, learners would have to develop and transform the way in which they think and feel which involves being alert and compassionate to the needs of their communities. This is what Freire (1970) depicts in a humanistic approach to education.

Teaching and learning through humanistic education, as espoused by Freire, was adopted as a framework in this study. Through the humanistic lens used in my study, the lived experiences and challenges of learners and their communities were rendered more visible. In my study the teaching of SRS made science lessons more meaningful and beneficial, theoretically and practically. After understanding more about social responsibility and the role of science education in promoting this, participants revealed that it was a personal choice to re-teach specific topics in a way that stimulated a critical, resilient and socially responsive mindset. Allenn and Alther (2015) view human development and humanitarian action as relevant to the way resilience is used to

describe real-life situations. Further, Furman *et al*. (2020) state that teaching by incorporating SSIs promotes the development of skills that allows learners to be active members in society are promoted.

Research question 1.3 (*How do teachers teach socially responsive science?)* which further broken down into (*Which strategies are used to teach socially responsive science? & Why do teachers choose these strategies to teach socially responsive science?)* provided insight into how teachers designed and implemented science lessons using the SRS-related topics which they had identified. How teachers taught could be understood by examining strategies which were implemented and understanding why these strategies were adopted to teach SRS. As teachers shift from fact-based science teaching, a need for reformed pedagogical tools arises to assist learners in addressing the sophistication and uncertainty involved in dealing with complex issues (Furman *et al.,* 2020). For this to happen, teachers are required to utilise different pedagogical approaches to expose learners to different insights in the classroom especially those that influence and engage young learners actively (*ibid*).

Through the analysis of participant portfolios, it was revealed that the teachers had adopted a variety of active teaching strategies that they used to teach SRS effectively. According to Freire (1970) humanistic science teaching and learning which resembles SRS should be an active process. Rokos (2015) posits that teaching that involves methods of active learning eliminates distraction and increases interest in science. Additionally, making science relevant to learners increases their interest in the subject (Evagorou & Dillon, 2020). Participants understood that teaching science towards social responsiveness required active engagement of learners. The participants in this study sought ways to incorporate their SRS-related content in lesson designs that were portrayed through actively engaging and collaborative efforts by the learners. Strong similarities between teachers' lesson strategies were identified where all lessons included discussions and group work. However, there were some differences in the strategies used where some teachers used field work while others did not.

All four participants used discussions which included group and class discussions which aided their lesson design to supplement teaching. According to Dallimore, Hertenstein and Platt (2017) discussions within the classroom allow teachers to be

spontaneous through learner responses which increases learning. Further, discussions impact learning by increasing learner engagement, and getting to know learners better. Discussions also helps learners to retain and remember information, reinforces what they had already learned, clarifies prior knowledge and also deepens understandings when complemented with hands-on and application-based activities. The main ideas behind discussion here, was to gain insight into learners' prior knowledge and how they could use their knowledge in new situations. Additionally, discussions brought about conversations between learners and teacher. The teachers were able to use discussions to enquire about learners' backgrounds, needs and context so that they were better able to design context specific science lessons.

All four participants also encouraged developing group work skills and they designed science lessons to promote this. This strategy involves a constructive approach which allows for cooperative work. According to Burke (2011) groups have a larger well of resources to access and more information is obtainable because of the variety of backgrounds and experiences of different members of the group. Groups are regarded as being able to stimulate creativity and group problem solving allows more commitment to finding solutions (*ibid*). Teachers indicated that using group work allowed learners to work on their own, creating a defined learner-centered classroom. Learners were able to share ideas and work collaboratively with one another to strengthen what they know and correct what they misunderstood, on their own, with the teacher facilitating this process. According to the teachers, this process allowed learners to work together as they would in their communities to formulate ways to solve societal issues. Teachers therefore valued collaborative activities in their SRS lessons.

Two participants designed lessons incorporating field work. This revealed that learning is not always theoretical and about mastering facts but can have a pragmatic element. Involving learners in field work put theory into practice. According to Millar (2004) working practically is valuable because it enables learners to manipulate or observe objects and materials that they engage with, in any teaching and learning activity. Similarly, Science Community Representing Education (SCORE) (2009) refers practical work in science to stimulate thinking about the world in which we live and viewed as a "hands-on" learning experience. Millar (2004) further instructs that the new knowledge is to be taken on by the actively involved learner. He/she must construct meaning from making sense of the experiences and theory of the lesson.

Additionally, Bencze *et al.* (2020) posit that action-oriented science makes learning relevant between school and society.

This constructivist approach is also advocated by Piaget (as cited in Millar, 2004). Field work equips the learners with the necessary skills needed to solve that particular problem. Learners will be better able to address the challenge as they would have hands on experience. Furthermore, P3 and P4 made use of field work in teaching learners about developing food gardens through a problem-based inquiry. Participant 3 additionally mentioned that this activity provided learners with life-long skills. Critical thinking was enhanced as the context of the activity lends itself to real world issues.

Three participants out of the four further valued the development of problem-solving skills and designed lessons to promote this. Wantanabe (2011) states that learning through problem solving is important as we all experience some difficulty in our lives. We may be trying to save our company or our family in need or even trying to solve a major communal problem. Teachers indicated that involving the learners in problem solving set the stage for them when working towards a real-life problem. They become familiar with the process and understand how to go about beginning to solve an issue. Problem solving allowed the learners to work constructively through inquiry.

Three participants made use of investigative research in their lessons to stimulate thinking and gain information constructively. Enteria, (2016) posits that a just and sustainable global society is built on research and developing skills of critical thinking and not solely on finding facts. These skills assist to respond to challenges, and guide learners to think creatively. Meaningful learning is described as exposing learners to the wonders of science by doing investigations on their own. In addition, Schuster (2011) asserts that by doing investigatory activities through science research, learners would be able to construct meaningful science knowledge and scientific skills. Participant 1 engaged learners in investigation where they searched through specified areas around the school regarding amount of waste produced. After completing the investigation, learners were asked to record results using diagrams and graphs. Participant 3 and Participant 4 used investigative research to direct learners in acquiring and synthesizing knowledge around poor dietary choices and dietary diseases related to it. Learners aimed to identify causes of these illnesses and provide solutions to these issues. The investigation prompted inquiry-based learning.

Shamsudan *et al*. (2013) describe that through Inquiry Based Science Education (IBSE) learners learn best by adopting active roles when they practice what they have learned. While learning through IBSE, Amos *et al*. (2020) suggest that SSIs should be incorporated to make learning relevant and meaningful.

One teacher (participant 1) illustrated using role play to teach learners more about recycling in a fun and creative way. According Erturk (2015) role play is an active learning and teaching strategy. It can include drama, representations, games, and speech of real-life cases related to any topic. Teachers are encouraged to design engaging activities instead of lectures that keep learners passively involved. Participant 1 allowed learners to enact contextual challenges encountered in the community, by so doing learners were able to provide possible solutions to remedy the harsh situation. Ertutk (2015) further describes the learning design process as one that encourages learner-centered lessons involving authentic and innovative activities that engage learners. Mudaly and Ismail (2016) argue for innovation in science classrooms as it enables more meaningful teaching and learning. Role play then, is a constructive strategy that promotes these elements.

One Participant (P3) used demonstrations in teaching her lesson. Basheer, Hugerat, Kortam and Hofstein (2017) suggest that demonstrations can be used by teachers as a process of triggering discussions between learners which values cooperative learning. Significant learning takes place when learners process information actively. Cooperative learning activities can create a learning environment in which learners actively complete their tasks. Additionally, Basheer *et al*. (2017) state that demonstrations are good strategies to gauge the attention of learners to constructively participate in the lesson. Participant 3 demonstrated techniques and sequences involved in developing food gardens and showed learners how to prepare seed beds for planting in responding to their inquiry-based activity. The demonstrations encouraged active engagement of learners.

It is evident that the teachers adopted various teaching strategies to execute their SRS lessons. Research question 1.3 further elicited responses towards the reasons for the choice of strategy used. Bassey (2016) posits that to deliver a socially and culturally responsive curriculum successfully, teachers are required to tap into the cultural and societal settings of the learners. Challenges and discomforts need to be recognized

as they will serve as aspects to which lessons will be designed to address. Specific Aim 3 in the CAPS curriculum encourages the inclusion of IKS to teach science. By incorporating IKS in teaching and learning, lessons become context specific and a link between home and school is exposed. IKS teaching reveals culturally responsive understandings to which Ladson-Billings (2009) asserts as an instruction that empowers learners because cultural orientations are used to inform knowledge, skills, and attitudes. Sadler *et al.* (2017) further states that SSI-TL envisages societal issues and the connections between science and learners' experiences. This therefore encourages a link between school and home to be formed. Participants' lesson designs revealed the inclusion of IKS and considerations toward culturally based practices which Ismail (2013) asserts is an effective way to deliver meaningful science education.

The final research question identified further relevance of the teaching strategies utilised. Firstly, the lesson designs had to embody necessary values and approaches to learning. Cooperative learning in groups driven by learner-centered constructivist approaches were identified as well as developing value towards the care of the environment. Singh and Yaduvanshi (2015) suggest that teaching under the learning theory of constructivism is essential in contemporary learner-centered classrooms. Constructivist approaches to teaching and learning ignite practical interest in the learners and allows cooperative learning to take place.

Secondly, the activities promoted the development of necessary skills, knowledge, attitudes and values in the learners. Some of these include building skills such as critical thinking, problem solving and science process skills which included recording and analysing data. These are some characteristics that the CAPS curriculum envisions. Schiro (2008) maintains that teaching under the guidance of the social reconstruction curriculum ideology favours the development of necessary values and skills including those of problem solving to challenge and respond to problematic situations. When teaching SRS, the development of critical thinking is important to which Singh and Yaduvanshi (2015) suggest is required to deliver meaningful lessons. The activities further created deepened understanding through concrete experiences and empowered learners by engaging in novel activities such as debating and conducting interviews amongst each other on the condition of developing journalistic attitudes.

Thirdly, some participants stated that the activities were to be adopted in relation to the context of the learners and the school. Understanding learners' daily living in their communities as well as the resources available at school provided the teachers with ideas of what strategies should be used in their teaching. Cohen *et al.* (2020) state that the link between science and society is essential for all citizens apart from active engagement for the safety of lives and the environment. The CAPS curriculum encourages the application of science in society (DBE, 2011) and for this to occur, the participants stated that they needed to tap into the cultural and contextual setting of learners. Further, the teachers executed their planned activities based on the resources and willingness of the school where they were teaching. Participant 3 identified vacant land on the school premises and was supported by the school management in the development of food gardens.

Fourthly, participants indicated that the modes in which they taught required the development of conscious and responsible learners. They further mentioned that the activities showed signs of gradual development of self-reliance, care for the environment and solutions to poverty. Cohen *et al*. (2020) assert that incorporating SSIs in science lessons increases public awareness and practical involvement which is required by all citizens due to its direct effect on society.

Lastly, through the process of engaging in the postgraduate module, the participants asserted that they designed lessons in these ways because they felt a personal responsive desire to assist learners and the community. They aimed to do this by engaging learners in SSI content related activities to drive SRS. Schiro (2008) posits that SSIs be incorporated in the teaching of science through the lens of the social reconstruction curriculum ideology. It is through this method that learners would be better empowered and equipped to engage with socio-political issues in context.

An additional note to include are the challenges experienced by the participants throughout their teaching of SRS. Drawing on responses from the individual interviews and participant portfolios, participants revealed that there were minor difficulties faced when incorporating SSIs in their science lessons. Participant one indicated that it was not an easy task to carry out as she had never been exposed to such practices during her schooling career. She had stated that it was a challenge designing lessons to teach in a socially responsive manner. However, she overcame this by reading and

studying the concept on her own. The participant further felt that the investigation outside the classroom became problematic and suggested that it would be conducted during the break the next time. The participant mentioned that her lessons were too busy and that she needed to reorder the activities in a more time efficient manner.

Participant two indicated that it was a difficult process to execute but had become familiar and confident in SRS as it progressed. Another challenge experienced was the lack of resources for specific activities and getting other teachers involved. The participant reflected that most equipment was either borrowed or purchased with personal funds. The participant further indicated that the topics that were taught were sensitive to the learners and suggested that it could be approached with more sensitivity and calmer the next time.

Participant three indicated that aside from implementing SRS, a challenge that was experienced was getting the learners to understand the concept so that they would be better able to grasp lesson constructs. The participant stated that this provided an opportunity to educate the learners on social responsiveness and self-reliance along with their benefits. Additionally, teaching SRS provided a space for IKS to be enhanced and brought to light.

Participant four shared the same view as participant 3 regarding IKS and like the other participants it was a confusing task to implement at the start. The main challenge that was experienced by participant four was time to complete the task, as the learners were preparing for examinations. The participant did not reflect major challenges regarding the implementation of SRS.

The teaching of Life Sciences (grade 11) and Natural Sciences (grades 7 and 9) by the participants in this study revealed pedagogical constructs that were underpinned by the social reconstruction curriculum ideology. This ideology was privileged in teaching science with a socially responsive approach that involved the incorporation of SSIs to meaningfully understand science and further link theoretical knowledge with contemporary societal contexts (Sadler *et al.,* 2017).

South Africa has shown various difficulties experienced in the past, and according to Badat and Sayed (2014) the introduction of the new democratic order in 1994 has shown very little progress in addressing challenges in the economic and socio-political spheres. Jansen (2017) asserts that the control of the South African curriculum is rooted within the apartheid ideology. According to Mudaly (2020) the marginalisation of alternative knowledge systems, the national call to eradicate colonial ideas from the curriculum, and notions of the democratic education within society are interrelated and provide a motivation for science instruction that incorporates SSIs as a response. This assertion pointed toward a need to include SSIs to teach science through a method to reconstruct society and address current and contextual challenges (Sadler *et al*., 2017).

4.7. Conclusion

This chapter presented the inductively emerged findings through my analysis. The ways in which teachers used the science curriculum to enhance social responsiveness were analysed and coded into seven themes that responded to the research questions that framed this study. The data was obtained through document analysis and open-ended individual interviews. The findings expressed the way in which Life Sciences and Natural Sciences teachers taught SSI content related science in a more socially beneficial way. Scientific topics, activities and reasons for using them in teaching of SSIs have been presented.

The activities that supplemented teaching were hands-on, getting learners involved in solving issues that are socially contextual. These strategies follow a constructivist style valuing collaborative learning including problem-based inquiry lessons that are related to real world issues. Most of the topics that were taught are located within the environmental education and personal health spheres.

The major reasons for the choice of topics and activities that have emerged are to create awareness of social challenges and develop resilience in learners so that they are able to respond to societal challenges. Additionally, many stated that the lessons were taught this way because it was seen to develop necessary knowledge and skills that are required to become self-sufficient, especially within disadvantaged communities. These strategies also valued learning goals and development of necessary scientific process skills. Further, relevance between science education taught in the classroom and daily life experiences incorporating IKS were exemplified.

The following chapter will provide a summary of findings as well as recommendations and conclusion for this study.

CHAPTER 5

Summary, Recommendations and Conclusions

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Chapter 5

Summary, Recommendations and Conclusion

5.1. Introduction

This qualitative study focused on an exploration of pedagogical constructs and practices underpinning humanistic science education. The purpose of the study was to explore how teachers use the curriculum to teach socially responsive science (SRS). This chapter provides a summary of the findings that emerged from the data, which was obtained from four practicing science teachers, who participated in face-to-face interviews. Participants also developed lesson plans, taught lessons, and recorded their activities in portfolios of evidence which were analysed. The findings aimed to answer the critical question that was divided into three sub questions which guided this study. Data related to each question was analysed and used to generate the findings that are summarised in this chapter. Additionally, an overall summary and discussion of recommendations directed to teachers, curriculum designers, subject advisors and educational institutions brings this chapter to a conclusion.

5.2. Summary of key research findings

This chapter encapsulates the responses by participants to the following research questions that framed the study, namely:

How do science teachers engage with the curriculum to teach socially responsive science?

Sub questions:

1.1. Which topics do teachers choose to teach socially responsive science?
1.2. Why was that topic chosen?
1.3. How do teachers teach socially responsive science?
1.3.1. Which strategies are used to teach socially responsive science?
1.3.2. Why do teachers choose these strategies to teach socially responsive science?

5.2.1. Research question 1.1:

Table 8: Summary of findings from Research Question 1.1

Research question 1.1	Overall finding	Theme
Which topics do teachers choose to teach socially responsive science?	Participants chose topics within strands 2 and 3 in Life Sciences and strands that fell within terms 1 and 2 in Natural Sciences. The topics that were taught were classified within the topic area of each knowledge strand within the CAPS curriculum. The broad topics which were selected include Food insecurity, waste management and water availability & quality	• Scope of the curriculum

Through the analysis of the curriculum statement for Life Sciences and Natural Sciences and from suggestions provided by participants, it was noted that there were many additional topics that could be taught for social responsiveness. These included *sources of energy, saving energy, nutrition, reproduction, separating mixtures, waste disposal, water availability, food shortages, malnutrition, human population growth, recycling, systems in the human body, forces, electricity and power, HIV/AIDS awareness, water shortages, prevention & treatment of illnesses*. The South African education policy provides a variety of topics to be taught and the skills to be developed. However, the curriculum does not provide guidance on how to teach in a socially responsive manner. Participants indicated that the topics they selected surrounded environmental concerns and contextually personal stresses. These topics were taught to the learners in a way that equipped learners with necessary skills to address context specific challenges.

Figures four and five illustrate the knowledge strands and the topics selected from each within Life Sciences and Natural Sciences.

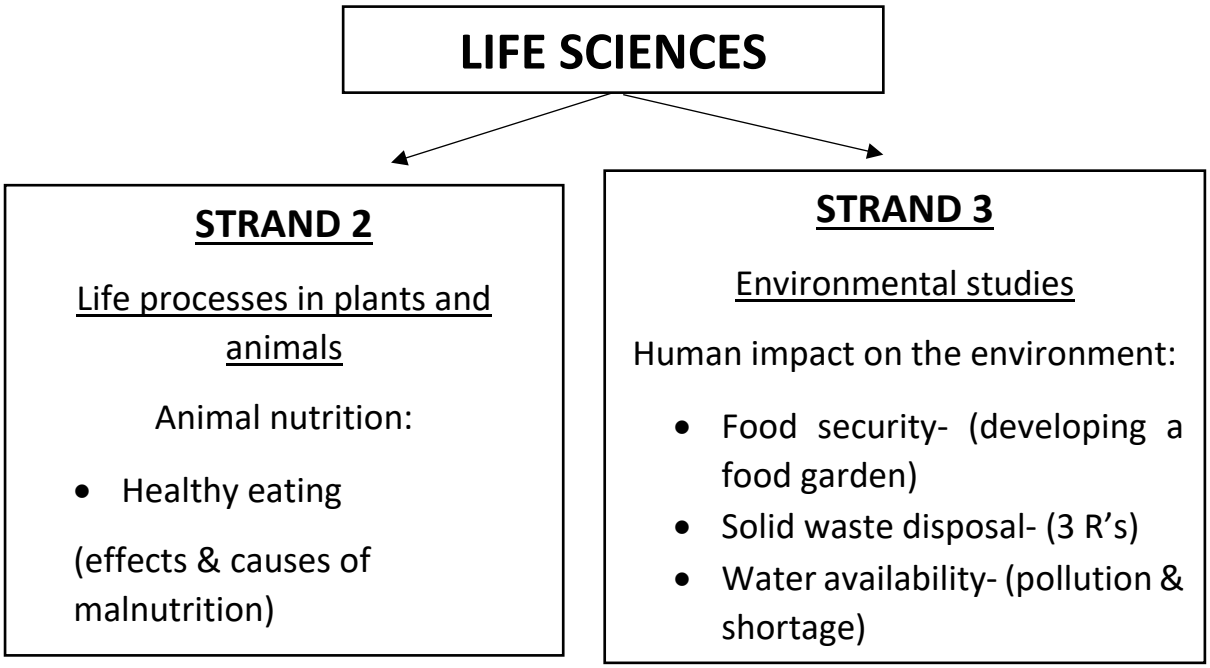

Figure 4- Topics taught within Life Sciences

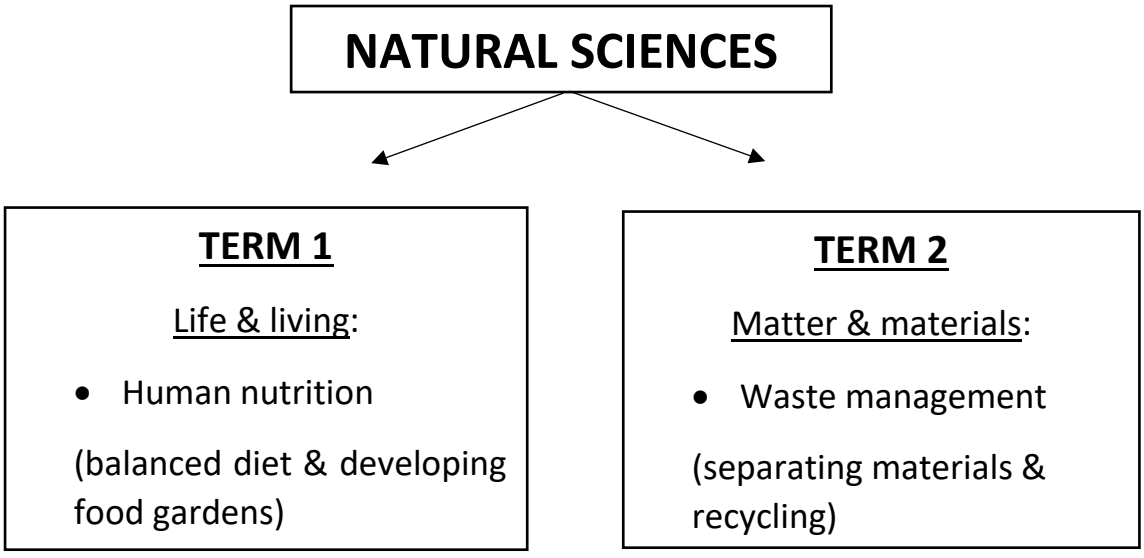

Figure 5- Topics taught within Natural Sciences

The topics that were chosen are located within categories of personal health and environmental health. The topics that were taught satisfied requirements of SA 3 as stated in the CAPS curriculum in that they value scientific discoveries, inclusion of indigenous knowledge and application of learning Life Sciences in everyday life (DBE, 2011, p.17). Achieving these goals of the South African curriculum, can occur by changing the way science is taught and working in a socially and environmentally conscious manner. This resonates with the view of Onwu and Kyle (2011) who contend that altering the role of science education is a key to address global environmental challenges.

5.2.2. Research question 1.2:

Table 9: Summary of findings from Research Question 1.2

Research question 1.2	Overall finding	Theme
Why was that topic chosen?	Teachers taught to familiarise learners with culturally based knowledge under constructs of humanistic science education. The CAPS curriculum provided an instructional framework while desiring delivery of a socially relevant science.	• Preparing to teach SRS • Compliance with curriculum • Delivering relevant Science

The main reasons for the choice of topics was because they are prescribed in the CAPS curriculum for Life Sciences and Natural Sciences, because teachers recognised that these lessons could be taught in an improved way that underscores social responsibility. Participants revealed that to teach a more meaningful science, they had to understand their learners' backgrounds. To this end a constructivist approach to teaching was adopted. Singh and Yaduvanshi (2015) describe constructivism as a theory in which learners build knowledge from experiences that are unique to each of them.

Therefore, in preparing to teach SRS, participants conducted a needs assessment through questionnaires and discussions to acquire knowledge about the learners as well as the types of social challenges they were experiencing. In this study, teachers engaged in a dialogic process by discussion to identify learners' existential situation to assess learners' needs. Freire (1970) encourages such dialogue between teachers and learners and describes it as an active process in understanding context and situations.

The major social challenges that emerged included:

- Poor waste management
- Unhealthy lifestyle practices
- Poverty and malnutrition
- Water availability and quality
- Food insecurity

These topics were chosen because they reflected contextual challenges of learners. According to Bassey (2016) teaching and learning by tapping into societal settings creates a socially responsive curriculum. Participants indicated that teaching these topics helped learners gain independence and confidence when faced with a challenge. They also expressed that learners displayed characteristics that showed resilience, which means that learners had begun to feel self-reliant. Additionally, participants indicated a personal need and care towards learners' attitudes and the environment in the teaching of these topics to foster change in the way we interact with our world. Schiro (2008) confirms this by stating that teachers must be responsible for helping learners construct meaning and understanding about societal problems to reconstruct society.

The foci of these topics resonate with data sourced from STATS SA (2017) which confirms that food insecurity in the country has increased since the year 2011. In addition, the report of the global FAO state that millions of citizens are undernourished, more especially in African countries, which include South Africa. This further exemplifies the economic struggles that exist and therefore the teaching of healthy diets and the development of food gardens were identified to address these adversities.

The Department of Environmental Affairs and Tourism of South Africa (2014) confirms that negative health impacts are due because of poor waste management are also supported by research conducted by Alam and Ahmade (2013). They state that when waste is not collected and managed appropriately, then it may contribute to air pollution, and public health which increase the development of various health issues. The teaching of recycling and waste sorting in these science lessons was valuable in addressing these challenges.

According to Fobosi (2013), poverty is rife in South Africa and is more dominant in many rural areas that where access to clean water is reduced. Additional challenges arise when residents seek for water at communal taps. Gupta (2010) identifies that the poor water quality has numerous negative effects on health. Incorporating topics related to the water crises within science lessons, helped learners to develop care and responsibility toward the environment in dealing with these challenges as pointed out by the participants.

Pasteur (2011) mentions that people may have reduced ability to become resilient if their social vulnerability cannot be addressed. This is often caused when people cannot gain access to avenues that govern institutes and policies that may be responsible for acquiring resources and making informed decisions. However, this research identified how science was taught to develop socially responsible participants in school, at home and in society through learning about socially relevant topics. The topics chosen by participants are of major concern nationally and globally and research study reports such as STATS SA, Global FAO and environmental affairs departments in SA support this. They represent the SSIs that are prevalent and require to be addressed. This study has revealed that the need for relevant science education to address these challenges is desired, and this study therefore underscored the value of SRS. It also revealed how innovative and creative lessons could be designed and implemented to successfully achieve the goals of teaching these topics and the science curriculum in a socially responsive way.

5.2.3. Research question 1.3:

How do teachers teach socially responsive science?

This question is divided into the following 2 sub questions illustrated in Table 10a and 10b:

Table 10a: Summary of findings from Research Question 1.3.1

Research question 1.3.1	Overall finding	Theme
Which strategies are used to teach socially responsive science?	Participants taught using methods that encouraged cooperative learning through the constructs of constructivism and inquiry-based learning. A list of these strategies are documented in points that follow this table.	• Methods and tools used for teaching

Teachers developed various activities using diverse ways to teach SRS content. Some of these included: Teacher-learner and learner-learner discussions, group work, field work, problem solving, investigative research, role play and demonstrations.

Participants indicated that these activities were learner-centered and gave learners the responsibility to drive their own learning. Most of the activities involved collaborative efforts from learners regarding thinking and doing. Schiro (2008) asserts that learners share their social understanding and can assist each other in reconstructing their social knowledge. These activities which participants in this study designed were underpinned by constructivist approaches to teaching and learning. Participants indicated that more meaningful learning was enabled in this way. In support of this, Shamsudan *et al*. (2013) compare inquiry based and traditional methods of teaching in Table 11 that follows Table 10b.

Table 10b: Summary of findings from Research Question 1.3.2

Research question 1.3.2	Overall finding	Theme
Why do teachers choose these strategies to teach socially responsive science?	The activities used were because these equipped learners with necessary skills and knowledge to address social challenges. They value learning goals and develop conscious, caring teachers. Participants mention that these activities connect school science to everyday life and culture of learners.	• Understanding learners' cultures • Relevance of activities

Through analysis of the data, overall reasons for choosing the implemented teaching strategies for SRS lessons were identified in the following factors:

Material factors: Participants indicated that most resources for the implemented activities were easily available. According to the participants, these resources were purchased and available at the school. Some of these included, paper, newspapers along with magazines, garden plots, plant seeds and organic manure. The municipality was also involved in providing resources at the request of the teacher.

Human factors: There were experts from outside the classroom who assisted and offered expertise about the topic being taught. Gardening using indigenous methods (IKS) was one example and a representative informing the learners about waste sorting and document storing was another.

School ethos: The school management was supportive in the activities conducted as they realised the benefits of cooperative learning projected through these activities. Participants stated that the principal and management teams gave their permission to use class time to conduct investigative research around the school, allowed outside personal to address and inform learners, make use of school equipment and use school ground property to develop food gardens.

Learner factors: Learners were motivated to learn and found these strategies to be fun. Participants indicated that learners got excited to engage in hands on tasks which motivated them to learn. Learners were eager to engage in tasks especially those that involved them actively. This can be seen in their participation and responses to activities illustrated in appendix 8. (See appendix 8a: figures 1, 3, 4; 8b: figures 1 & 3; 8c: figure 3; 8d: figures 3 &4).

Ideological factors: Engaging learners in various learning activities, raised understanding of social justice. This enabled critical thinking which empowered learners toward transformation and thereby developing resilience. Through the needs analysis, teachers understood that the learners experience particular contextual challenges. Their participation and enquiry into the topics and activities revealed their willingness to transform their living contexts.

Further, Shamsudan *et al.* (2013) illustrate in Table 11 that follows, how inquiry-based learning offers a more constructive approach to teaching and learning where learners are actively engaged problem solvers. Learning science in this way is supported by Mnguni (2017) as learning for SSIs through active participation in science lessons allows learners to be alert and question situations.

Table 11: Comparisons between inquiry-based and traditional teaching methods

Characteristics	Inquiry-Based	Traditional
Principle Learning Theory	Constructivism	Behaviourism
Student Participation	Active	Passive
Student Involvement in Outcomes	Increased Responsibility	Decreased Responsibility
Student Role	Problem solver	Direction follower
Curriculum Goals	Process oriented	Product oriented
Teachers' Role	Guide/facilitator	Director/ transmitter

Constructivist teaching is viewed as the principle learning theory to inquiry-based learning as illustrated in Table 11 and underpins the methods used to enable learners' active construction of concepts and principles. This is done through lectures, demonstrations, collaborative learning activities and textbook study. The

characteristics related to inquiry-based teaching methods highlight the direction towards a science that is responsive to societal issues.

The participants in this study taught using strategies that represented learning in constructive and active ways. The learning activities focused on the process of acquiring knowledge and were learner driven which increased learner responsibility. Teachers merely guided learning processes of the learners by providing valuable prompts in the direction towards problem solving and transformation. However, the process of teaching SRS was not an easy task. The participants reflected some challenges encountered which involved that the concept of SRS including SSIs was not familiar to them as they were not taught using these methods. Being entirely new to the concepts, the participants learned and studied on their own until they became more familiar with what is expected. Using the knowledge that they gained, they designed lessons that they felt were socially responsive. Some participants explained that it was difficult to make the learners understand the concept and others stated that time management posed a problem in completing the tasks. Participants further stated that the lack of particular resources posed an issue, but it was an issue that was easily overcame. Some participants indicated that SRS provided an opportunity to delve into IKS in their lessons. In this way, the lessons became relatable to home practices and it assisted in keeping indigenous knowledge alive. Furthermore, teaching SRS provided a platform to the teachers to become agents of change and transformation by helping the learners engage in relatable ways to solve common problems.

Drawing from the findings of this study, it can be noted that teaching SRS involves close relationships between teachers and learners. Teachers adopted compassionate roles to understand learners' feelings and societal contexts. These understandings assisted teachers in the direction in which meaningful lessons are driven. Through SRS displayed in this study, learners had come to learn how to connect science to aspects of life which include home and other environments around them. Incorporating familiar ideas and practices makes learning more relevant to the lives of the learners which was seen through the study.

5.3 Discussion

This study aimed to explore how teachers taught science to embody a meaningful and conscious learning in the lives of the learners. The study was influenced by theoretical constructs of Freire's humanistic science perspective as well as the social reconstruction curriculum ideology. Santos (2008) illustrates Freire's educational approach (identified in Chapter 2, Section 2.11.1), which is broken up into 3 phases. These phases are related to the findings of this study and are documented in the points that follow.

1. Identifying socially relevant themes within context for discussion

In this study, participants used the CAPS curriculum and visual enquiry (location of the school) in order to identify socially relevant topics. The participants identified socially relevant topics from the CAPS curriculum and related them to the school and community. Many topics related to SRS were additionally identified through individual interviews with the participants. Further, the assumptions that the teacher's made (through visual enquiry) about the community in which the school was located, were communicated with the school staff and learners. This was done to get a better understanding of the social contexts related to the school and community.

2. Dialogic process by discussion to identify learner's existential situation

In this study, teachers adopted varied strategies to assess learners' needs. This included a needs assessment that teachers conducted prior to designing SRS-related lessons. This took place through questionnaires and surveys which were accompanied by dialogic discussions between the teacher and learners as well as between the teacher (participant) and other teachers at the school. The discussions were probed from the responses that were received through the surveys and further provided the teacher with additional information regarding the learner's social backgrounds and living experiences. The participants further received contextual information about specific learners from other teachers. These teachers have taught the learners for numerous years and have gained understanding of the learner's background throughout the years of teaching them.

3. Engagement of learners in discussing and taking up socially responsive actions

In this study teachers prepared lessons which involved active learner participation, with a view to developing skills to enable self-reliance and social responsibility. Many of the activities that were conducted, encouraged collaborative efforts from the learners and which simultaneously involved discussions between the learners. Some participants indicated that the learners displayed socially responsive attitudes through the engagement with the activities. This occurred more especially with the activities that enabled the learners to act out and practice community education in the classroom. The participants asserted that the learners were motivated to participate in the activities because they felt empowered and enabled to make valuable decisions about positive change within their societies.

Santos (2008) considers Freire's humanistic approach to science education as significant and states that the purpose of education should be humanistic in order to address the oppressive state of modern society. The South African curriculum and teachings represent westernized methods of knowledge construction (Jansen, 2017) and therefore making use of the theoretical constructs that frame this study is imperative for an emancipatory and transformational science education. Teachers that formed the participants in this study sought to personally understand the learners by tapping into their lived experiences and social backgrounds through discussions and surveys. The teachers consequently realized the need for SRS and began to design lessons that would portray a pre-eminent and meaningful science. In this study, teachers engaged learners in collaborative activities through group work and role-playing strategies. According to Singh and Yaduvanshi (2015) the constructivist approach to science is necessary as a means of moving away from the conventional science instruction methods to one that is relevant in contemporary classrooms. Learning constructively encourages learners to reflect and question their own understanding by the process of actively making meanings. Learners in this study engaged in collaborative efforts and investigative research to make meanings between pollution and water quality, as well as waste management. Poverty in relation to food insecurity which was also a focus. Within this learning theory, learners learned actively in their own contexts and in so doing learned in a more meaningful way.

Problem based inquiry was used as an approach to teach science constructively. This approach included fieldwork activities by the teacher which were related to real world issues. In this study, teachers developed food gardens with the learners where they demonstrated gardening techniques and educated them about the benefits of the foods grown. These benefits included food security, health management in response to nutrient deficiency and under-nutrition, and possibilities for entrepreneurship. Learners developed their knowledge through research to provide solutions to the issues of food insecurity and nutrient disorders in the community.

With reference to inquiry-based learning, Shamsudan *et al.* (2013) state that the traditional form of science instruction commonly focuses on content mastery with the development of necessary scientific skills and attitudes not being adequately emphasised. Learners are positioned as passive receivers while the teacher is the dispenser (*ibid*). This study saw teachers delivering learner-centered lessons, based on a needs assessment, to redirect the path of science instruction from the traditional style. Shamsudan *et al.* (2013) further state that the traditional form of instruction does not help learners learn in a meaningful manner and suggests an inquiry-based science teaching approach. Cohen *et al*. (2020) state that SSIs integrated with inquiry-based learning as a practical and pragmatic approach promotes active citizenship in science education. This approach encourages active involvement from learners. The inquiry-based approach was used by some participants in order to create critical thinkers and dynamic problem solvers (Shamsudan *et al.*, 2013). Amos *et al.* (2020) encourage SSIs to be incorporated into inquiry-based science education (IBSE).

Teachers as well as researchers have advocated the use of SSIs in science because it creates a link between theoretical knowledge and the contemporary societal context (Cohen *et al*., 2020; Sadler *et al*., 2017; Parker & Lo, in press; Topcu & Genel, 2014; Yoon, 2011). Socio-scientific issues- teaching and learning (SSI-TL) is subsequently an effective approach that can be used to meaningfully (Sadler *et al*., 2017; Sadler, 2009) teach and learn socially responsive science education.

As cited by Sadler *et al.* (2017), SSI-TL shares features with project, case and context-based learning. SSI-TL and the types of learning function on the premise that learning should be contextually connected to provide meaningful learning experiences (*ibid*) which is also a general objective of science education in South Africa. This is

documented within the CAPS curriculum for Life Sciences and Natural Sciences as: “This curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives” (DBE, 2011, p.4). However, Sadler *et al*. (2017) identify limitations of project, case and context-based learning towards inadequate or rather absent social considerations. Limitations in science classrooms can be mitigated by SSI-TL in which learners are engaged in addressing societal challenges using scientific knowledge. It is therefore important to note that although SSI-TL shares common features with other closely linked approaches, it should not be confused as a synonym of the other approaches. SSI-TL stands out as an effective approach with regard to the teaching and learning of socially responsive science. I therefore view SSI-TL appropriate for teaching and learning socially responsive science. This is based on its goals to be achieved, which include contextual learning, using personal experiences to delve into science understanding and knowledge, and becoming aware of societal issues and their relevance in science education (Sadler *et al.*, 2017). Teaching, involving SSIs draws on societal issues and on the connection between science and learners’ experiences, and engages learners to critically analyse and negotiate through socially contentious issues (*ibid*).

With the emerging social challenges in the context of these participants’ schools, they suggested that to implement SRS teaching, IKS should be included in the process of teaching and learning. Jansen (2017) believes that western knowledge has neglected alternative knowledge systems that are identified to have a strong cultural background. The participants suggested that by using IKS in science classrooms, school science could be connected to everyday living which is another way of teaching context specific lessons. Teachers in this study sought and used traditional knowledge to teach certain lessons. Participant 3 made use of IKS when teaching learners about garden preparation techniques and the food crops that were required to assist with the disorders related to hunger, poor concentration in school and unhealthy diets. In support of this, Taylor and Mulhall (2001) state that for teaching to be considered good, there must be some evidence of a link between the school, society and home environment of the learner. Each of these three spheres create their own experiences and learning is only effective when they become related.

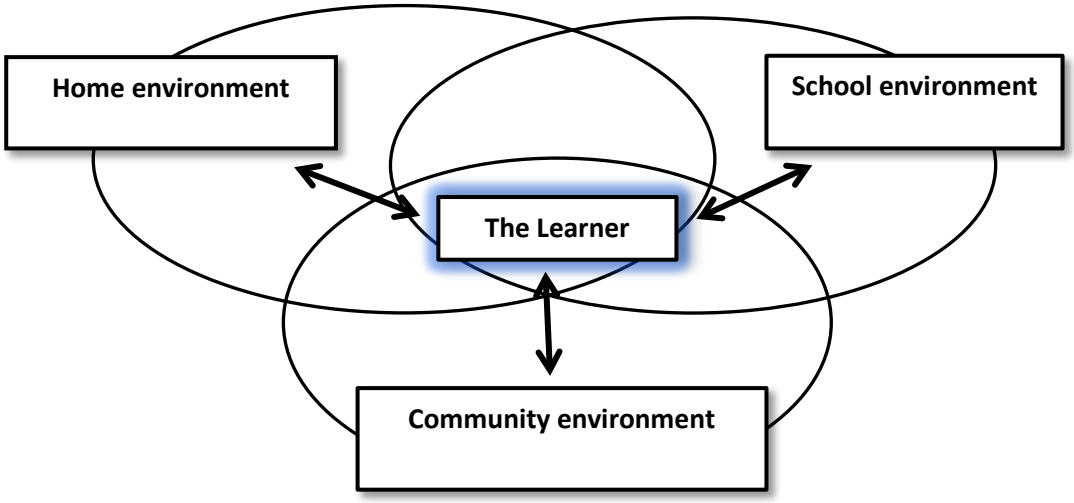

Figure 6: Linking the learning environments

Adapted from Taylor & Mulhall (2001, p. 138)

Figure six shows a connection between the three environments. Taylor and Mulhall (2001) assert that if the teacher is aware of the indigenous knowledge possessed by learners and makes use of it during teaching, then this can allow for the "development of appropriate teaching and learning methods and materials" (p.145). Teaching by implementing IKS has an influence on the community and consequently the home environment in explicit or obscured ways (Ismail, 2013). If the links between the home and school environments are not present, then learners may find difficulty engaging with the learning concepts. My study reveals that teaching SRS required culturally based knowledge that articulated with learners' lived experiences and assisted them in understanding school science. In this way, the links between home and school potentially became more tangible.

The lesson activities used in this study encouraged learners to work collaboratively where strengths were shared. Activities were learner driven and teachers served in guiding roles. Bencze *et al.* (2020) posit that critical and action-oriented science proves more relevant to school science and societies. Most of the activities that teachers used in this study were hands-on which meant that all learners actively participated in the same way they would to address challenges in their community. Through these activities, learners gained knowledge about solving real life problems, as well as knowledge of science process skills including observation, record keeping and

disseminating results. Chapoo *et al.* (2014) assert that merging content and pedagogy into the knowledge of topics and how they are represented to diverse aspects of learning develops an inquiry-based mindset to deal with issues outside the classroom. Sadler *et al.* (2017) assert that learning should be connected to contexts that provide meaning to content by incorporating SSIs in teaching responsive science. In this study, teachers taught topics as SSIs based on learners' needs with a focus to developing the capacity to respond to challenges.

Therefore, the main idea underpinning SRS was developing learners who are socially responsive to context-specific challenges. Through SRS lessons, learners developed skills and acquired knowledge to apply it in more than one circumstance. For example, the development of food gardens to generate healthy foods for better dietary choices which was linked to addressing poverty by selling surplus crops to generate income.

Zeidler *et al.* (2005) and Sadler *et al.* (2017) confirm that SSIs should be incorporated into science lessons so that learners are able to engage in social dialogue using scientific skills and knowledge in real life contexts. Introducing SSIs into the lesson helps to develop problem solving, critical thinking and decision-making skills along with learning to be argumentative and providing solutions to complex problems (Furman *et al.,* 2020). In this study, teachers prepared lessons which involved discussions, investigative research to identify solutions to problems and active learner participation, with a view to developing skills to enable self-reliance. Teachers' lesson plans and implementation of lessons revealed engagement of learners in discussing and adopting empowering actions, using the skills they learned as advocated by Schiro, (2008).

Learners are expected to engage in socio-political issues because of learning framed by the social reconstruction ideology. Glatthorn (2005) states that this is a social classification within the curriculum ideology. Social reconstruction curriculum theory, as Glatthorn (2005) describes, is a critical perspective on society and schools to drive meaningful lessons. Teachers in this study, directed learning towards society and its challenges and ways in which these challenges could be reduced. By adopting this ideological stance to the curriculum, learning for the reconstruction of society, albeit to a limited degree, was advanced. Schiro (2008) states that social reconstruction ideology provides learners with practical knowledge about social issues and how to

effect change through reconstruction. To do this, teachers were encouraged to help learners develop conscious attitudes, acquire meaningful skills so that when they encounter social problems they can analyse and understand them, and take action to address the problem. Participants in the study demonstrated a pedagogy of care by their drive and concern towards developing an understanding in their learners about social challenges, and their responsibility as citizens to address these challenges.

According to Schiro (2008) the social reconstruction ideology has introduced a social dimensional knowledge of education to schools, which helps to comprehend education as a social process, and that all knowledge is value laden. Teachers must be encouraged to take value stances and attend to the socio-political and moral values of the learners they teach to bring about transformation. Lebeloane (2017) states that education must be recognised as a tool to empower people. According to Freire (1970) social transformation can only occur when disadvantaged people take responsibility of achieving their own liberation. By integrating science with social issues, personal meaningfulness and relevance of science to learners are increased (Mudaly, 2020).

Teachers viewed SSI-based instruction as a potential instrument for developing contextual learning by integrating daily life contexts into science lessons. They further stated that SSIs could be used to develop learning materials that are context-based and closely linked to their learners' personal needs (Nida *et al.,* 2020). In this study, teachers designed lessons around socially relevant topics and taught using various strategies to develop necessary skills, knowledge, attitudes and values in the learners to enable them to take up transformational roles. The undertaking of such roles contributes to effecting positive changes in the society around them.

5.4. SSI instruction through an SRS model design

Through a review of literature, it was identified that emphasis on SSIs in science teaching has not been adequately emphasised. The findings of this research highlight the need for incorporating SSIs in teaching SRS. Teaching by incorporating SSIs should be carefully planned, addressing necessary goals of the science curriculum. Some of these objectives include developing scientific process skills and conscious attitudes towards others and the environment. With little, if any guidance from curriculum documents about adopting an SRS, this study has contributed a model design for teaching SRS.

Figure seven illustrates Naidoo's model which recommends a strategy that can be adopted to teach Life Sciences and Natural Sciences with an SRS approach by incorporating SSIs. This model has been designed from the review of literature, findings obtained from this study as well as the social reconstruction ideology model as illustrated by Mnguni (2017) and which also formed part of the framework for this study.

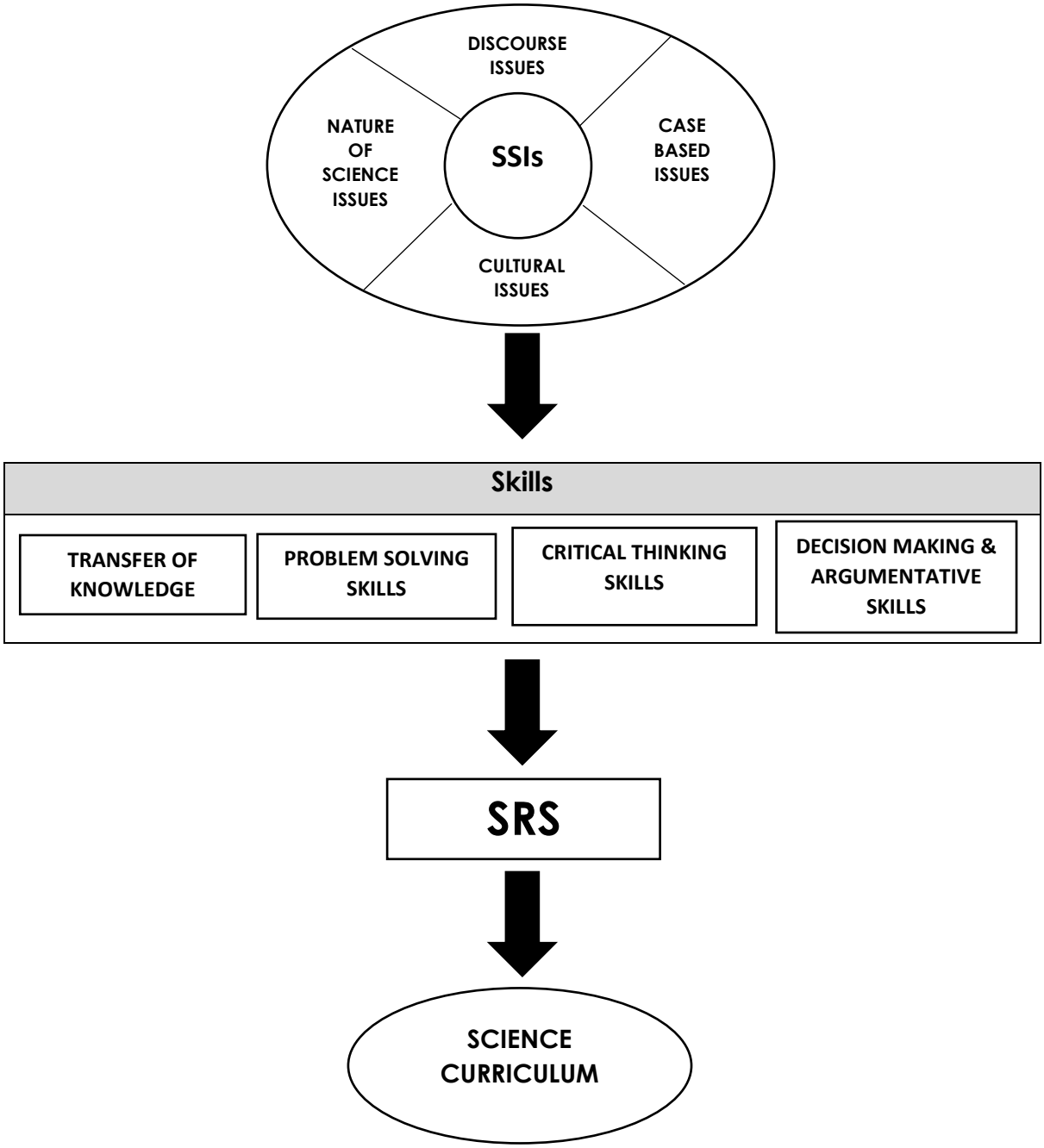

Figure 7: Naidoo's model for an SRS approach to learning Science

(Adapted from Mnguni, 2017)

Figure seven suggests an approach to teaching and learning SRS in science classrooms. From the top, SSIs can be viewed as a starting point towards SRS. According to Mnguni (2017) the functional and academic knowledge around SSIs namely, cultural issues and case-based issues allow learners to reflect and challenge the context and society in which they live, by developing a respect for differing worldviews. Incorporating the discourse on SSIs gives learners the opportunity to engage effectively in social dialogue so that scientific knowledge and skills may be transferred to real life contexts. Further, to stimulate learners' critical and reflective thinking about scientific knowledge, Mnguni (2017) states that learners need to be taught the nature of science when engaging in SSIs. Understanding SSIs through these knowledge constructs and skills, consequently, empowers teachers and learners to render the learning of Life Sciences and Natural Sciences relevant and applicable to daily lives.

The model further shows that through the engagement with SSIs in the classroom, learners can utilise and develop necessary skills to address these issues while using academic knowledge. Socio-scientific issues are formed through issues related to discourse, issues which are case based, depicting the nature of science as well as culture. Each of these knowledge issues drives the development of specific skills when engaging with these knowledge constructs. The skills developed do not assist in addressing SSIs only, but also aid in learning Life Sciences and Natural Sciences as an SRS. SRS is a science that encourages learners to apply learned scientific knowledge and skills to engage with context specific societal issues and to develop appropriate responses. Therefore, when learning SRS, it is beneficial to address SSIs so that learners are better equipped to deal with real life challenges.

Acquiring such knowledge and skills through learning SSIs is a positive way forward in making the learning of Life Sciences and Natural Sciences a socially responsive endeavour. This ultimately meets the objective that is portrayed by the science curriculum, where the learning of science should transcend boundaries of the classroom. It is crucial that the knowledge and skills gained in science classrooms can reach the lives of learners and people within the society. SRS aims to make the teaching and learning of science an endeavour which is conscious and responsive to the lived experiences of the citizens.

The model illustrated in Figure seven, is my contribution to the body of knowledge about conscious and responsive science pedagogy which aims to develop necessary skills through science education for social transformation through raised consciousness.

5.5. Recommendations

Through the analysis of data, the study recognised that assistance is required by helping teachers to improve their proficiency in teaching SRS. The challenges that appeared can be addressed through the recommendations made in this study so that future teachers are better prepared to teach SRS within the South African educational system. Taking indigenous knowledge into consideration and teaching for a sustainable environment is advocated within the CAPS curriculum. However, strategies and examples in executing such lessons are not well documented and provided to teachers. Thus, SRS requires more attention and a practical approach in pre-service science teacher education.

5.5.1. Recommendations for pre-service teacher education

Teacher education institutions should include SRS teachings in all science modules. Despite the growing advocacy of SSIs in secondary science, there remains a gap between theoretical ideal and current practice of teachers (Leung *et al*., 2020). Pre-service teachers should be exposed to SSI-related pedagogy to teach SRS Resources for teaching SRS lessons should be constructed within the university and workshops should be conducted to assist pre-service teachers with the implementation of an SRS curriculum. When the pre-service teachers are engaged with the content, they will become more familiar and efficient in utilizing various, methods of teaching SRS before they enter the profession formally.

5.5.2. Recommendations for in-service teacher education

Practicing science teachers need to be aware of how social challenges can be adopted as SSIs in the science classroom. Inservice teacher education programmes could emphasise the importance of teacher knowledge of context and learners, as a starting point to work towards SRS. This is important as this critical information can help teachers design meaningful and context specific science lessons which address and respond to the needs of learners and their communities. Teachers should seek to

understand previous knowledge and relevant knowledge gaps so that learners are well supported during their learning.

5.5.3. Recommendations for subject advisors

Teachers need to incorporate various teaching styles and strategies required to implement an SRS. Many practicing teachers lack knowledge on the concept and varied teaching strategies that can be adopted. SSIs and their pedagogical possibilities seem to be unknown to teachers (Nielsen, 2020). Subject advisors could host teaching workshops as part of professional development programmes, in which teachers could be taught the importance of SRS. This study revealed how teachers taught various topics in varying ways to transcend intellectual boundaries and develop higher levels of knowledge and skills in their learners by engaging in activities related to SRS. The development of self-reliant learners as critical thinkers and problem solvers, who are responsible for their own learning can be achieved if teachers were taught and encouraged by their subject advisors and subject leaders to carefully design socially scientific relevant lessons.

5.5.4. Recommendations for curriculum designers

Curriculum designers both at university and school level need to provide support to teachers (practicing and pre-service) to deliver an SRS curriculum. Furman *et al.* (2020) state that there is a missing link with regard to the way science is conventionally taught and the approaches required to solve socio-scientific problems in real life. School policy documents should be designed in a way that makes them possible to implement, which is crucial. SRS topics and content should be explicitly inserted in curriculum policies and textbooks, as well as teacher and learner guides. These should include examples of how SSIs can be integrated into school science. These materials should incorporate content and examples and highlight how the policy aims can be achieved. The curriculum implemented at university, should incorporate SRS in both content and pedagogical content knowledge (PCK) modules designed for pre-service teachers.

5.5.5. Recommendations for future research

Studies related to the use of the science curriculum as a vehicle to respond to social difficulties appear to be scarce. In particular, research into the science curriculum to equip learners, teachers and ultimately the society which they educate with necessary skills required to address social dilemmas within South Africa is sparse. This study contributes to the discourse related to SRS education. Studies that are specifically related to how teachers teach science by addressing SSIs are of importance. Further studies on how teachers teach science for social responsiveness should be undertaken. The findings can be synthesised to provide vital insights to teachers and institutions that train teachers. Furthermore, this can lead to the improved development and delivery of the science curriculum.

5.6. Limitations

The sample size did not represent the total population of science teachers and learners and therefore the findings from this study cannot be generalized. Further, acquiring the commitment of participants to complete the project posed a problem as some chose to revoke their participation. It is important to mention that the findings obtained are dependent on the expressions of the participants that were diverse and had unique personal experiences. However, the differences in their experiences can be viewed as a strength as not all the teachers necessarily yielded the same results. It is suggested that further studies should be done to include more teachers. Other data generation methods could also be used to reveal richer insights into teaching SRS.

5.7. Conclusion

In this chapter, each research question was addressed by the summary of main research findings that is clearly presented. Recommendations were made based on the findings that emerged from this study and they are directed towards teachers, curriculum designers, subject advisors and teacher training institutions.

Social challenges encountered within the country represent a perpetual battle to be fought and it is therefore vital that teacher training, which underscores SRS, is executed. Incorporating SSIs in the teaching and learning of SRS is recommended to be an effective approach that supports meaningful learning, yet the lack of adequate knowledge and understanding creates limitations to the development and implementation of a curriculum that accommodates SSI learning experiences. This study delved into understanding the tools and strategies used to teach SSIs in a science that is socially responsive.

The theoretical constructs that framed this study, i.e. humanistic science education and the social reconstruction curriculum ideology have laid the foundation for the behaviours of feeling, thinking and acting. Participants in this study used these to assist learners to deal with issues related to poverty as well as the environment and personal health. In relation to the framework of this study, the participants revealed signs of empowerment, responsibility and responsiveness, from themselves and their learners through the reflections within their portfolios. Furthermore, the participants were conscious practitioners of science as they taught SSI content through SRS. If the consideration of teaching science through SRS with a humanistic approach is adopted then practicing teachers will be better able to deliver a more meaningful science education which is critical to the welfare of individuals, societies, countries, and the world at large.

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APPENDICES

1. Ethical clearance from the University of KwaZulu- Natal
2. Gatekeepers approval
3. Ethical clearance letter to the University of KwaZulu- Natal
4. Informed consent to participants (Life Sciences and Natural Sciences teachers)
5. Document analysis schedule
6. Individual interview schedule
7. Individual interview transcript
8. Photo evidence from participant portfolios
9. Professional editing approval letter
10. Turnitin originality report

APPENDIX 1

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

17 September 2018

Mr Thishen Naidoo 210504581
School of Education
Edgewood Campus

Dear Mr Naidoo

Protocol Reference Number : HSS/1212/018M
Project title: Exploring how Science teachers engage with the curriculum in order to teach Socially Responsive Science

Full Approval – Expedited Application

In response to your application received 10 August 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application 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.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Professor Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committe

/pm

Cc Supervisor: Dr Ronicka Mudaly
cc Acting Academic Leader Research: Dr SB Khoza
cc School Administrator: Ms Sheryl Jeenarain

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

APPENDIX 2

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

24 July 2018

Thishen Naidoo (SN 210504581)
School of Education
College of Humanities
Edgewood Campus
UKZN
Email: 210504581@stu.ukzn.ac.za

Dear Thishen naidoo

RE: PERMISSION TO CONDUCT RESEARCH

Gatekeeper's permission is hereby granted for you to conduct research at the University of KwaZulu-Natal (UKZN) towards your postgraduate studies, provided Ethical clearance has been obtained. We note the title of your research project is:

"Exploring how science teachers engage with the curriculum to teach socially responsive science."

It is noted that you will be constituting your sample by conducting a document analysis and/or conducting interviews with Life Sciences academics on the Edgewood Campus.

Please ensure that the following appears on your notice/questionnaire:

- Ethical clearance number;
- Research title and details of the research, the researcher and the supervisor;
- Consent form is attached to the notice/questionnaire and to be signed by user before he/she fills in questionnaire;
- gatekeepers approval by the Registrar.

You are not authorized to contact staff and students using 'Microsoft Outlook' address book. Identity numbers and email addresses of individuals are not a matter of public record and are protected according to Section 14 of the South African Constitution, as well as the Protection of Public Information Act. For the release of such information over to yourself for research purposes, the University of KwaZulu-Natal will need express consent from the relevant data subjects. Data collected must be treated with due confidentiality and anonymity.

Yours sincerely

MR SS MOKOENA
REGISTRAR

Office of the Registrar
Postal Address: Private Bag X54001, Durban, South Africa
Telephone: +27 (0) 31 260 8005/2206 **Facsimile:** +27 (0) 31 260 7824/2204 **Email:** registrar@ukzn.ac.za
Website: www.ukzn.ac.za

APPENDIX 3

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

To The Registrar
University of KwaZulu-Natal

Dear Mr Mokoena

Application for permission to conduct research at UKZN (Edgewood)

I wish to apply for permission to conduct research at UKZN- College of Education as part of the requirements for my Masters of Education (M.Ed) degree. The title of my study is: **"Exploring how science teachers engage with the curriculum to teach socially responsive science".** I seek permission to conduct this research within the School of Education.

The purpose of this project is to explore and understand how science teachers use the science curriculum to teach learners how to become socially responsive to difficulties. In addition, the study will focus on how teachers use the content topics from the science curriculum to teach in order to develop resilience among learners that may benefit their lives and of others too. I will collect data from six Life Sciences teachers who engaged in their B.Ed Honors degree, using individual interviews, and document analyses. The interviews will be audio recorded with the permission of the participants. The findings of the research will not be used for any other purpose other than the Masters dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants. All information disclosed will be kept in confidence. The participation in this research is voluntary and should participants desire to withdraw or terminate their participation in the research, this may be done without any negative consequences

A review of literature, as well as the experience of the current state in the inability of coping with adversity within the country and globally, provide a compelling rationale for this study. I plan to do this work by adopting a multi-methods approach, which would involve engaging B.Ed Honors students in three research activities, for which I seek permission from your office.

The research process is planned as follows:

First, teachers will be asked to volunteer to participate in individual interviews to explore this area in greater depth.
Second, the participants will be asked to provide their portfolios which they would have developed based on the following guideline: Develop a unit of work which clearly illustrates how, through the curriculum, you can:

- Improve the quality of life of learners and their communities
- Empower learners and their communities to become self-sufficient
- Address contemporary challenges such as poverty, food insecurity, disease.

- Transform thinking of individuals towards increasing their self-reliance and resilience.

This portfolio containing lesson plans will be analysed using qualitative content analysis to obtain ideas and concepts required for the study.

Informed consent forms, which include detailed information about the project, and the fact that participation is voluntary and that participants can withdraw from the project without negative consequences, will be designed. The anonymity and autonomy of respondents will be ensured. Respondents' permission for audio-recording interviews will be sought. Pseudonyms will be used to anonymise respondents when findings are disseminated (through reports and presentations). Data will be securely stored and available only to my supervisor and I.

I have included copies of the informed consent document and the instruments with this letter.

I look forward to a positive response to my request for permission to begin with the study.

Yours sincerely

Thishen Naidoo
M.Ed student

Student number: 210504581
Contact number: 0832715132
Email: thishennaidoo@gmail.com or 210504581@ukzn.ac.za

My supervisor: Dr R Mudaly (Senior lecturer- School of Education)
Contact number: 031- 260 3643
Email: mudalyr@ukzn.ac.za

APPENDIX 4

Informed Consent for Participant

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Dear Science Teacher

I am a Master of Education (M. Ed) student at the University of KwaZulu-Natal, Edgewood campus. I am currently engaged in a research project entitled, **"Exploring how science teachers engage with the curriculum to teach socially responsive science"**. The purpose of this project is to explore and understand how science teachers use the science curriculum to teach learners how to respond to social difficulties. In addition, the study will focus on how teachers use the content topics from the curriculum to teach in order to develop resilience among learners that may benefit their lives.

I would like to collect data from you, using multiple methods. These include individual interviews, of 30 minutes duration which will be audio recorded and an analysis of portfolios which you will develop as a requirement for the B.Ed Honours module (this includes lesson plans). This study is purely for academic purposes and there will be no financial gain involved. The significance of this study is that it is expected that through this study, Life Sciences teachers obtain understanding of using the science curriculum to enhance resilience among learners. The findings of the research will not be used for any other purpose other than the M. Ed dissertation. The data will be stored and disposed of at the end of the research.

Please note that:

- Your participation is voluntary
- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- The interview sessions will last for about 25-30 minutes.
- 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 portfolios and interview transcripts and will be stored in secure storage and destroyed after 5 years.
- You may withdraw from the project without negative consequences.

Thank you.

Yours faithfully

Thishen Naidoo (student no. 210504581)
Cell no: 0832715132
Email: thishennaidoo@gmail.com / 210504581@ukzn.ac.za

Should you have any queries you can contact my supervisor Dr. Ronicka Mudaly.
Telephone no: 031- 260 3643
Email: mudalyr@ukzn.ac.za

Mr P. Mohun from the Research Office may also be contacted. His details are:
University of KwaZulu-Natal
Humanities and Social Sciences Research Ethics
Govan Mbeki Centre
Tel +27312604557
Fax +27312604609
Email: mohunp@ukzn.ac.za

Acknowledgement – Participant

I _____ (full name and student number) hereby confirm that I understand the contents of the document and the nature of the research project. I grant consent for my participation in the research and for data to be collected. In doing this permission is:

- Given/not given (delete that which is not applicable) to digitally record individual interviews.
- Given/not given (delete that which is not applicable) for my portfolio (this includes lesson plans) to be admitted in the study.

I am aware that my participation in this research is voluntary and I am at liberty to withdraw permission, should I so desire, without any negative consequences.

_____
Signature of teacher

_____
Date

_____ _____
Phone number Email address

APPENDIX 5

Document analysis schedule

Topics chosen	Reason for this topic	Methods used to teach the topic	Reason for using these methods	Reflections and additional notes on portfolio
	•	•	•	

APPENDIX 6

Individual interview schedule

1. Explain to me further about your understanding of socially responsive science.
2. How do you use the science content to teach learners how to become socially responsive if it is the case?
3. What methods/ activities do you use to do this?
4. In your portfolio, you focused on a specific content/topic in which you drove towards enhancing resilience. Are there other topics within the science curriculum that you can do this with?
5. What are some of them?
6. What is the purpose and reason for choosing these particular topics and activities from this strand?
7. What else can you say about this?
8. Tell me about your experiences of learning to incorporate socially responsive learning in your teaching of science. Challenges and opportunities?
9. What about your challenges?
10. How did you know that the topic you chose to teach actually allowed learners to become aware and conscious of responding to social issues through science education?
11. If you had more exposure, content and background knowledge on the concept of socially responsive science, how would that impact on your learning to teach science lessons to enhance resilience?
12. What are the challenges you experienced when teaching socially responsive science? How do you think these challenges could be overcome in the future?
13. Can you suggest how teacher education (specifically content and how to teach it) influences/ can influence your learning to teach socially responsive science through the science curriculum?
14. Can you tell me how this can benefit the learner and others/ their communities?

APPENDIX 7

II-P1

Thishen- Good morning, I am sitting with participant 1, and I am interviewing them on how they use the curriculum to teach socially responsive science

Participant 1- Good morning

Thishen- Explain to me further about your understanding of socially responsive science.

Participant 1- I would say a science that responds to social challenges or difficulties…. Or understanding the culture of learners in order to teach and provide solutions to societal challenges is what I feel social responsiveness could be seen as.

Thishen- How do you use the science content to teach learners how to become socially responsive if it is the case?

Participant 1- CAPS provides the content to be taught and provides some suggestions on how it should be taught… but the main thing here is that you have to link all knowledge construction to what learners are familiar with, looking at more than just individual needs but also including needs of the society.

Thishen- What methods/ activities do you use to do this?

Participant 1- I use videos, powerpoints, investigations with research, guest speakers, group problem solving activities, role playing…

Thishen- In your portfolio, you focused on a specific content/topic in which you drove towards enhancing resilience. Are there other topics within the science curriculum that you can do this with?

Participant 1- Yes, there are many more

Thishen- What are some of them?

Participant 1- Other topics are sources of energy, saving energy, nutrition, reproduction & separating mixtures

Thishen- What is the purpose and reason for choosing these particular topics and activities from this strand?

Participant 1- The purpose for these topics and activities are because it relates to the daily experiences and living of the learners and their society… also these topics are to be taught in the second term during which I began planning my study.…

Thishen- What else can you say about this?

Participant 1- Well, they also develop necessary skills and values in the learners and it also allows learners to take up social responsibility and become self-reliant… My activities allowed learners to work together to solve a problem and they learned how to approach the community to discuss issues of adversity.

Thishen- Tell me about your experiences of learning to incorporate socially responsive learning in your teaching of science. Challenges and opportunities?

Participant 1- Well it wasn't something that came easy to me, like I didn't clearly understand the concept and how to teach it. I wasn't even exposed to this type of learning when I was in school. However, through constant research and reading my understanding increased.

Thishen- What about your challenges?

Participant 1- Errr,… my challenges were developing ways to teach the content in a socially relevant manner.

Thishen- How did you know that the topic you chose to teach actually allowed learners to become aware and conscious of responding to social issues through science education?

Participant 1- Through the responses of the learners. They would get surprised at the things that can be done to decrease solid waste. For example,…. using vegetable peels and unwanted parts as compost.. Other learners showed a lot of interest in getting involved in clean up projects… They also got excited at the fact that they could use their produce to generate income.

Thishen- If you had more exposure, content and background knowledge on the concept of socially responsive science, how would that impact on your learning to teach science lessons to enhance resilience?

Participant 1- Aah, it would have a greater enhancement on how I teach it right now. I would know more and be able to assist learners even better and erm.. having more knowledge of the concept may broaden the ways in which solutions can be brought forward.

Thishen- What are the challenges you experienced when teaching socially responsive science? How do you think these challenges could be overcome in the future?

Participant 1- Well, since the investigation involved working out of the classroom during the lesson, it meant that all learners had to be outside and could not be left alone. This could be improved the next time by having this particular aspect done during the break… Another challenge experienced was that I felt the lesson was not ordered appropriately. At the end I felt that there were too many activities to get through during that double lesson. I could've structured it in a different way.

Thishen- Can you suggest how teacher education (specifically content and how to teach it) influences/ can influence your learning to teach socially responsive science through the science curriculum?

Participant 1- Having adequate knowledge and instruction gives you better understanding and therefore it can make me better able to teach science in this way.

Thishen- Can you tell me how this can benefit the learner and others/ their communities?

II-P2

Thishen- Good morning, I am sitting with participant 2, and I am interviewing them on how they use the curriculum to teach socially responsive science

Participant 2- Good morning

Thishen- Explain to me further about your understanding of socially responsive science.

Participant 2- My understanding is that we must be able to teach science in a way that it is able to make our learners think more about caring for the society and the environment.

Thishen- How do you use the science content to teach learners how to become socially responsive if it is the case?

Participant2- I choose topics from the curriculum guideline and develop ways to teach. For example, I try to figure out how this concept can be linked to making their life and society better

Thishen- What methods/ activities do you use to do this?

Participant 2- I use problem solving activities, group work where the learners share information, poster presentations and I also incorporate physical education to emphasize importance of good physical health.

Thishen- In your portfolio, you focused on a specific content/topic from strand 2 in which you drove towards enhancing resilience. Are there other topics within the science curriculum that you can do this with?

Participant 2- Yes, there is a lot of topics within the curriculum

Thishen- What are some of them?

Participant 2- Ok errr, waste disposal, water availability, food shortages, malnutrition, human population growth… ya

Thishen- What is the purpose and reason for choosing these particular topics and activities within this strand?

Participant 2- The main purpose for me is the fact that what they learn at school can relate to how they live in their communities. The reason for these topics and activities is mainly because CAPS tells us to teach it and it links very well with specific aim 3, also I taught this topic in term 2 and when I was planning my study I thought that the section could be taught in a new way, making it more practically beneficial rather than only understanding content theory.

Thishen- How did the activities help you?

Participant 2- The activities brought about collaboratively working members that shared creative ideas.

Thishen- Tell me about your experiences of learning to incorporate socially responsive learning in your teaching of science. Challenges and opportunities?

Participant 2- It has been a long and extensive journey of learning a concept I was unfamiliar with. At first, I thought it would be difficult to understand and put a lesson together, but as I worked more it became easier. It allowed me to also grow and become socially responsive as well

Thishen- How so, please explain?

Participant 2- Ok some of my activities involved music, but the school did not have a music player and so I had to hire one. The school had never held sports events or activities as they had said that they had no time. Looking back, I feel that it actually is important to teach science in a much more socially uplifting way.

Thishen- How did you know that the topic you chose to teach actually allowed learners to become aware and conscious of responding to social issues through science education?

Participant 2- Ok.. so I noticed a positive change in learners attitude towards the concept as well as engaging in it. I saw good dietary changes in the feeding scheme programme. Their presentations showed transformed thinking towards self-reliance…. Also, learners requested for the aerobics programme to be continued every week.

Thishen- If you had more exposure, content and background knowledge on the concept of socially responsive science, how would that impact on your learning to teach science lessons to enhance resilience?

Participant 2- If I had more knowledge it will help me in planning more effective lessons around the concept. I would have more understanding and I will be better at teaching it.

Thishen- What are the challenges you experienced when teaching socially responsive science? How do you think these challenges could be overcome in the future?

Participant 2- The issue of malnutrition was quite sensitive. Many learners actually experience this, so my way of approaching this topic had to be clear and calm. Talking more about it at the beginning and making learners feel good about talking about their issue.

Thishen- Any other challenges?

Participant 2- Other challenges included getting teachers involved too. So maybe in future I could do talks about the topic with them to make them aware and understand.

Thishen- Can you suggest how teacher education (specifically content and how to teach it) influences/ can influence your learning to teach socially responsive science through the science curriculum?

Participant 2- Teacher training within this concept can provide extensive information about the concept. Through teacher training I will have more to work with, better understanding and creativity.

Thishen- Can you tell me how this can benefit the learner and others/ their communities?

Participant 2- Learners develop a sense of self reliance and accomplishment. They further assist others in their community to develop such characteristics that may be beneficial to their lives. Knowledge about physical health and maintenance can be spread.

Thishen- Thank you for your time, we're done now.

II-P3

Thishen- Good day, I am sitting with participant 3, and I am interviewing them on how they use the curriculum to teach socially responsive science

Participant 3- Hello

Thishen- Explain to me further about your understanding of socially responsive science.

Participant 3- To teach the learners about responsible living and taking care of the environment through the learning of science.

Thishen- How do you use the science content to teach learners how to become socially responsive if it is the case?

Participant 3- I use CAPS as a guide to help me plan. I read up on the topics and lessons to incorporate familiar settings that would help learners understand. By doing this, I can get learners to solve real life problems using scientific knowledge.

Thishen- What methods/ activities do you use to do this?

Participant 3- I use problem solving activities, group work, field work where learners become hands on, discussions and research

Thishen- In your portfolio, you focused on a specific content/topic which you drove towards enhancing resilience. Are there other topics within the science curriculum that you can do this with?

Participant 3- Yes, there are lots more

Thishen- What are some of them?

Participant 3- Ok so there is food insecurity, recycling, separating mixtures, systems in the human body, forces, electricity and power, HIV/AIDS awareness which are some of them

Thishen- What is the purpose and reason for choosing these particular topics and activities within this strand?

Participant 3- These topics help me to help my learners develop certain community knowledge and skills to assist them with contextual issues. I also chose this topic as I have taught it already and realised that it is a good topic that would relate very well with social responsibility and resilience. My reason for the activities chosen to assist in teaching the topics were to mainly help address societal needs, to become resilient and responsible in their community.

Thishen- What else can you tell me about the activities?

Participant 3- The activities help learners gain a hands-on experience to learning for better understanding. Also, many nutritional deficiencies were aided through traditional practices.

Thishen- Yes, tell me about using traditional practices…

Participant 3- Ok, so I could use IKS in my teachings which is actually part of the Natural Sciences curriculum.

Thishen- Tell me about your experiences of learning to incorporate socially responsive learning in your teaching of science. Challenges and opportunities?

Participant 3- It gave me the opportunity to make changes and help learners understand the importance of self-reliance also to find alternate ways to solve issues using our own indigenous knowledge. Indigenous knowledge was very much specific to a community and its issues such as treating illnesses, or ways of life. These practices could be beneficial in addressing social problems today.

Thishen- How did you know that the topic you chose to teach actually allowed learners to become aware and conscious of responding to social issues through science education?

Participant 3- Through the work learners submitted, through our interactive discussions, learners voiced their feelings and understandings about social responsiveness and how science is helping them do this... Some learners even mentioned that in their community, food security was a problem. So, getting them engaged in food gardens helped them find solutions to that problem and also they could generate income.

Thishen- If you had more exposure, content and background knowledge on the concept of socially responsive science, how would that impact on your learning to teach science lessons to enhance resilience?

Participant 3- Having more knowledge would help me help my learners more, as I would have developed more resources to help their understanding.

Thishen- What are the challenges you experienced when teaching socially responsive science? How do you think these challenges could be overcome in the future?

Participant 3- Eh, getting the learners to understand what it is and how to learn science with keeping that in mind. But overall, I think the learners had a good understanding because it was easy to understand that sicknesses require adequate nutrients in order to be reduced.

Thishen- Can you suggest how teacher education (specifically content and how to teach it) influences/ can influence your learning to teach socially responsive science through the science curriculum?

Participant 3- Teacher training is important. Having teachers learn more about this concept can help better informed lessons around the concept as they will have more ideas and understanding. IKS can be reached further and more teachers will able to assist learners understanding as it is what learners are familiar with in their

communities. I think it will be very beneficial to the learners if they are taught in a way that is more relatable.

Thishen- Can you tell me how this can benefit the learner and others/ their communities?

Participant 3- Learners will be able to develop ways to solve problems in their communities. They can take responsibility for making positive changes in their homes and help educate others in the community.

Thishen- What are some changes?

Participant 3- Like solving food security problems. They also able to generate income from the vegetables they grow. Many learners were ill HIV related illnesses and required nutrient rich foods, these gardening skills with the incorporation of IKS would help them in their treatment.

Thishen- Thank you for allowing me to interview you

II-P4

Thishen- Good afternoon, I am sitting with participant 4, and I am interviewing them on how they use the curriculum to teach socially responsive science

Participant 4- Good afternoon

Thishen- Explain to me further about your understanding of socially responsive science.

Participant 4- I understand it to be a science education that teaches and helps learners to develop particular skills that will help them in addressing societal and other contextual issues.

Thishen- How do you use the science content to teach learners how to become socially responsive if it is the case?

Participant 4- Many of the topics I find within the curriculum is easy to relate to life issues. Research and planning are very important.

Thishen- So, what do you do next?

Participant 4- Understanding the content, I find ways in which to teach it so that learners gain more than just content knowledge but also skills that will help them with that specific issue.

Thishen- What methods/ activities do you use to do this?

Participant 4- Discussion, reflections, group work, posters, research, consolidation/ feedback, photo analyses, problem solving , field work, story telling, drawings

Thishen- In your portfolio, you focused on a specific content/topic from strand 3 in which you drove towards enhancing resilience. Are there other topics within the science curriculum that you can do this with?

Participant 4- Yes, there are

Thishen- What are some of them?

Participant 4- Some of which I've seen include HIV AIDS education, solid waste disposal, food and water shortages, prevention & treatment of illnesses, human population growth also

Thishen- What is the purpose and reason for choosing these particular topics and activities within this strand?

Participant 4- These topics relate intricately to the lives and living of the learners. I know this because I did communicate with my learners about societal issues they may be facing beforehand…. Oh, also I thought it made sense to conduct my study based on the topics I was teaching at that time.

Thishen- In terms of resilience, why did you choose these?

Participant 4- The reason I chose these topics and activities is because it allowed me to assist my learners in developing a sense of social responsibility in order to address societal needs thereby becoming self-sufficient. The activities also enhanced critical thinking in problem solving.

Thishen- Tell me about your experiences of learning to incorporate socially responsive learning in your teaching of science. Challenges and opportunities?

Participant 4- It was a bit daunting at the beginning, it took a lot of thinking to understand what it actually was. Through lecture discussion and with peers I slowly began to grasp the essence of it.

Thishen- How did you know that the topic you chose to teach actually allowed learners to become aware and conscious of responding to social issues through science education?

Participant 4- Many of the learners had expressed that they lived across the school in informal settlements and that they were deprived of clean water and sufficient food. So when we started this topic they were interested… but more interested in how they could use their food gardens to generate income and also ensure healthy meals daily.

Thishen- If you had more exposure, content and background knowledge on the concept of socially responsive science, how would that impact on your learning to teach science lessons to enhance resilience?

Participant 4- It would definitely help me as I would've had more background knowledge especially if it was taught when I was in school. Ideas and knowledge would've been expressed in more dynamic and unique ways through long exposure and experience.

Thishen- What are the challenges you experienced when teaching socially responsive science? How do you think these challenges could be overcome in the future?

Participant 4- In the context of my teaching, I was given a short space of time to complete my design of lesson because their exams were going to start. In future I could probably discuss topics at the end of the previous term and get students to generate ideas during their term break. Also, an environmental club could be put in place to overcome the limited time issue.

Thishen- Can you suggest how teacher education (specifically content and how to teach it) influences/ can influence your learning to teach socially responsive science through the science curriculum?

Participant 4- Having adequate knowledge and training within the concept will help teachers be more prepared and efficient when teaching responsive science. Also education about understanding cultural settings of learners helps us design lessons that will be better relatable in ways to develop necessary knowledge and skills.

Thishen- Can you tell me how this can benefit the learner and others/ their communities?

Participant 4- Like I said, many of the learner's experience disadvantages in places of work, study and living. These skills will certainly help them uplift their living conditions, these skills can be taught to the community, thereby increasing social conditions peculiar to the community.

Thishen- Ok we're done, thank you for allowing me to interview you.

APPENDIX 8- Evidence from participant portfolios

8a:

Figure1: Students seen engaging in investigative research around the school enquiring about waste management

Figure 2: Representative from Docufile seen presenting document disposal and storing processes to the learners

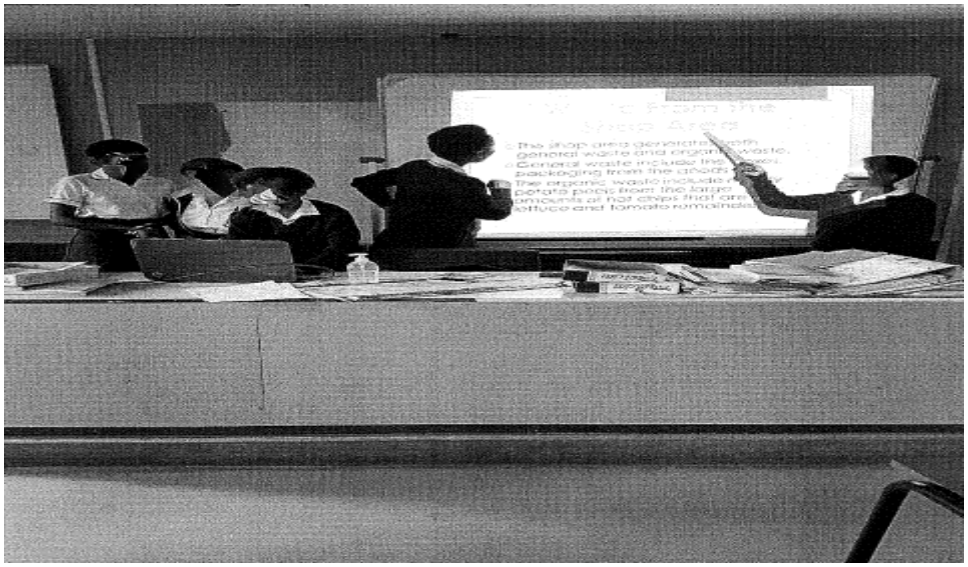

Figure 3: Learners presenting information retrieved from investigations

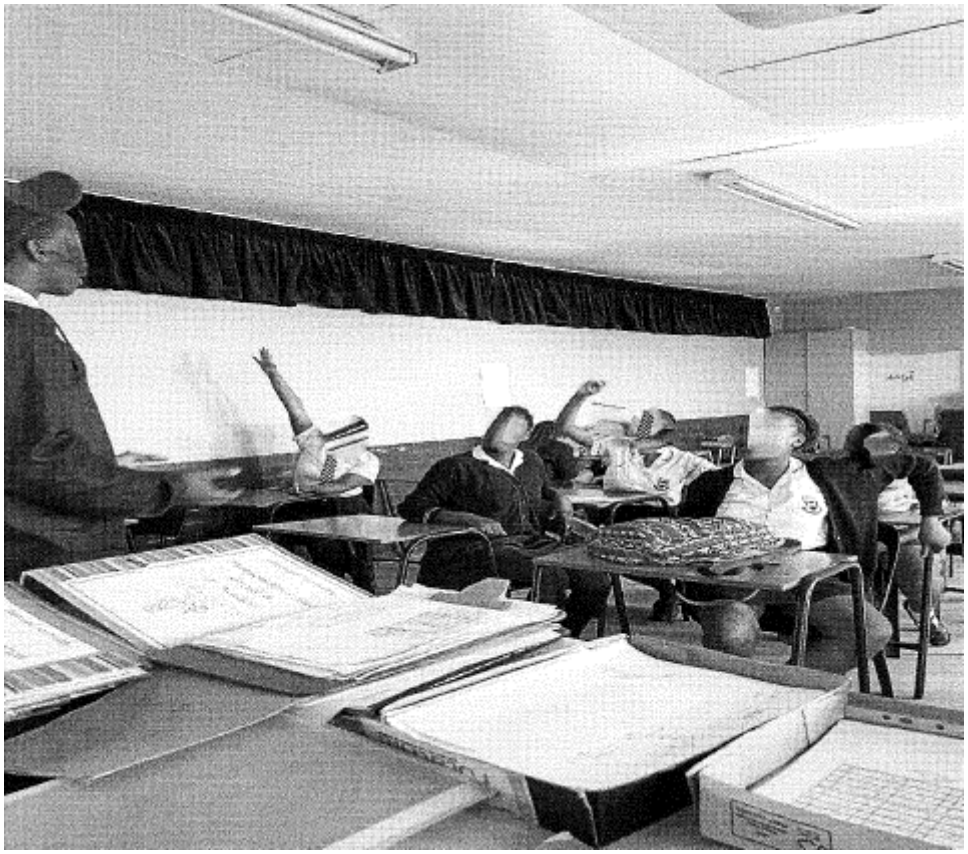

Figure 4: Learners seen engaging in the role play activity

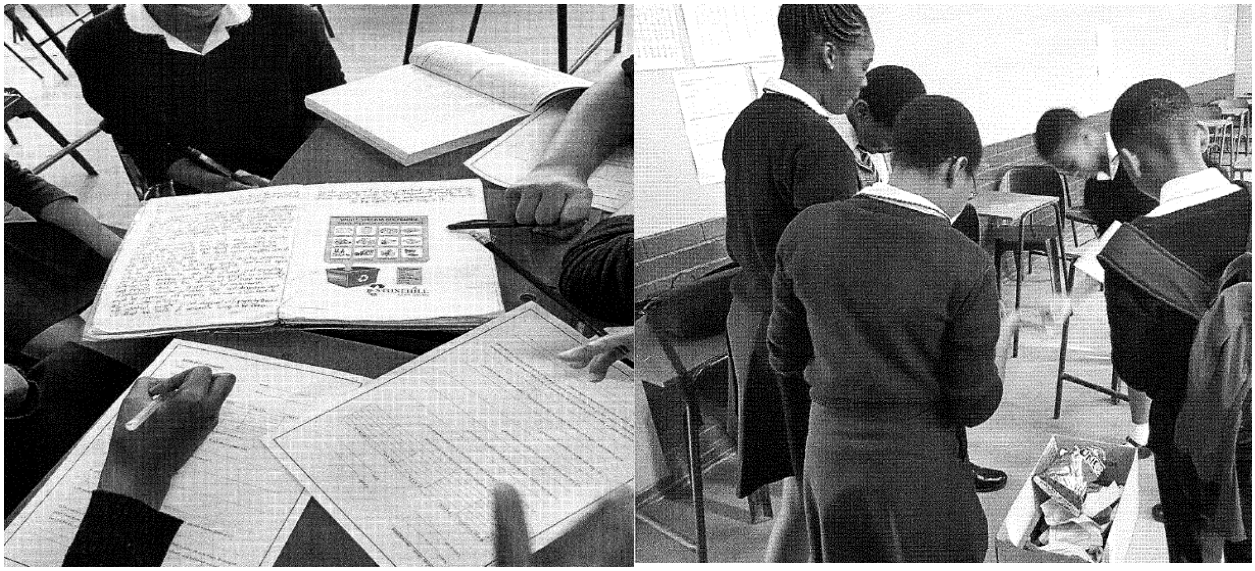

Figure 5: Learners seen engaging in group problem solving about waste management

8b:

Figure 1: Pictures that the teacher presented to learners related to malnutrition

Figure 2: Learners seen engaging in discussion based on the case study presented around malnutrition and poor dietary choices.

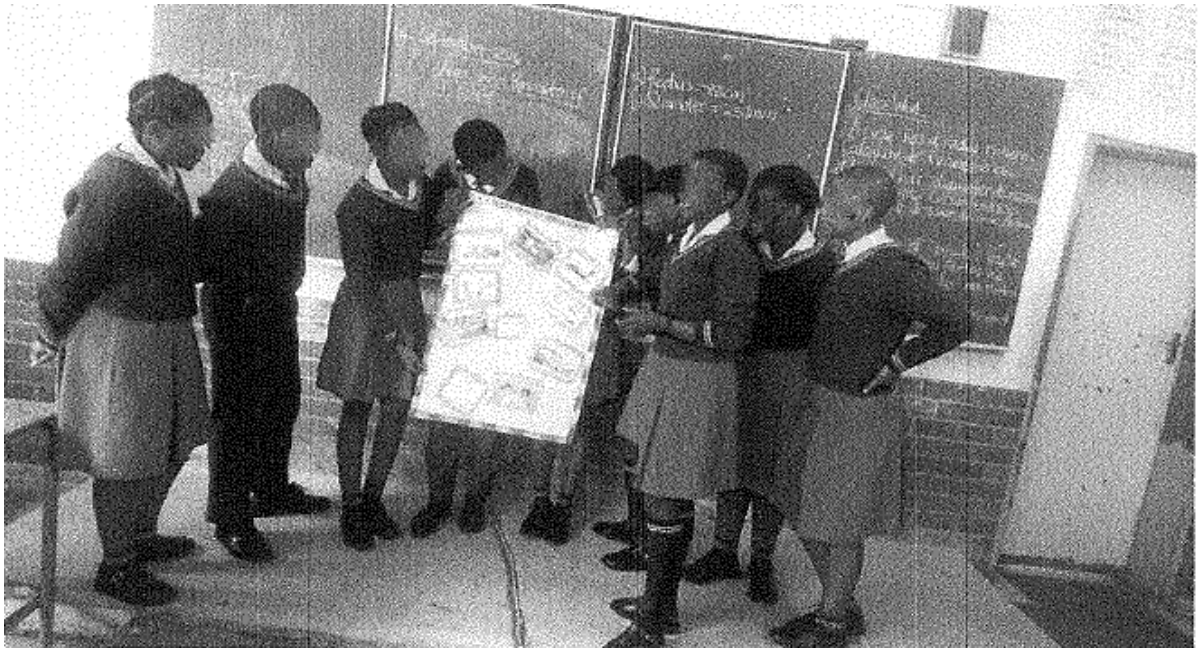

Figure 3: Learners engaging in a group presentation on malnutrition

8c:

Figure 1: Food garden developed at the school

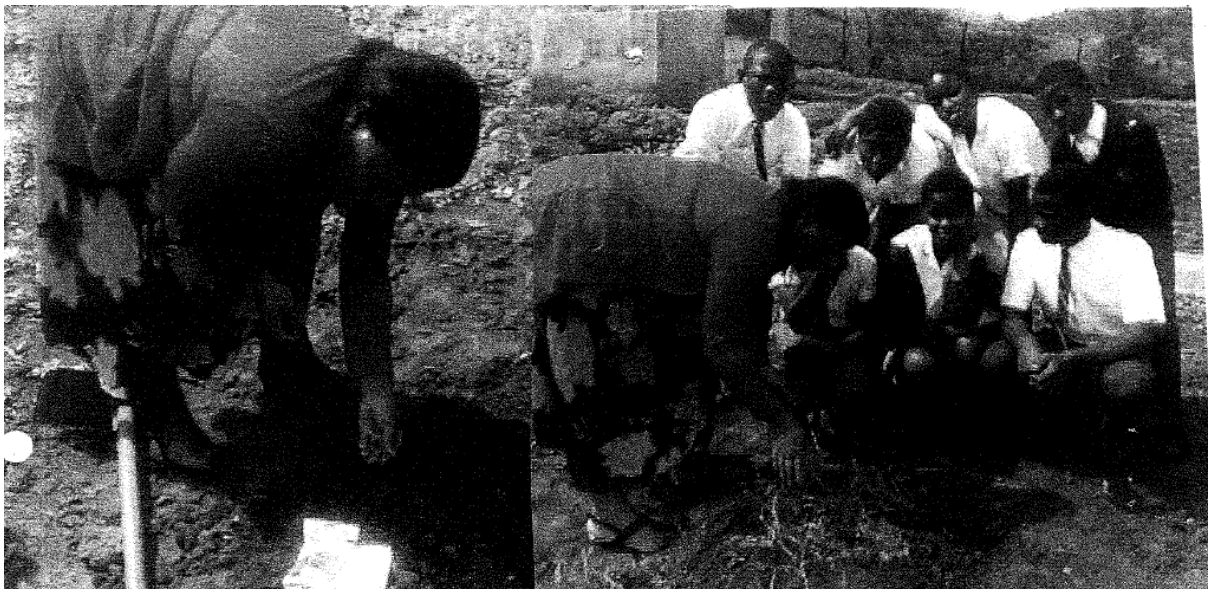

Figure 2: Teacher seen demonstrating process of seed bed preparation and planting

Figure 3: Teacher demonstrates planting techniques while learners engage in the fieldwork

Figure 4: A demonstration by school gardener on planting techniques

The Municipal Manager

Umzumbe Municipality

Box 404

UMZUMBE

4240

Dear Sir / Madam

re: REQUESTING DONATIONS OF VEGETABLE SEEDS

We at the above mentioned school, kindly request your support in terms of donating us with vegetable seeds.

The school has a big yard with wide available land, so we have planned to start the project of school garden. This project (school garden) will help the learners that come from poor background to have something to cook and to sell in order to get financial support.

We have planned to teach the learners how to grow seeds (making seed beds),how to transplant the seeds and how to take care of the plants. Some of the crops will be used in the feeding scheme as the school has a feeding scheme and others will be given to learners, others will be sold for the benefit of the learners.

I shall be gratified if our request receives your immediate attention.

Yours Faithfully

Nzimande M.R.Z. (Deputy Principal)

PROVINCE OF KWAZULU NATAL
UMNYANGO WEZEMFUNDO
DEPARTMENT OF EDUCATION
2016 -08- 02
073 2[illegible]168
P.O. BOX 10197, UMZINTO 4200
MALANGENI SEC. LWIS 338254

Figure 5: Letter to the municipality

8d:

Figure 1: Photographs that the teacher used to illustrate the current state of the disadvantaged community

Figure 2: Learners seen engaging in group discussions and problem-solving activities

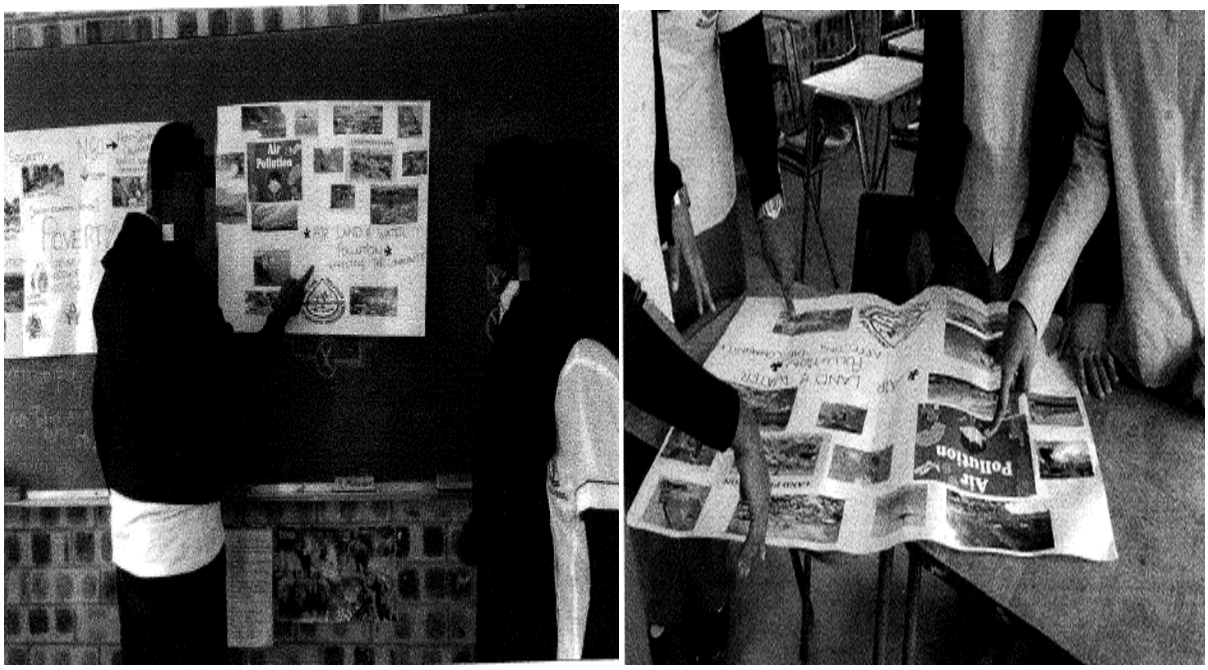

Figure 3: Learners presented and discussed issues related to poverty

Figure 4: Learners seen holding vegetable seeds in which they intended on planting

APPENDIX 9

Angela Bryan & Associates

6 Martin Crescent
Westville

Date: 10 June 2020

To whom it may concern

This is to certify that the Dissertation: Exploring How Science Teachers Engage with the Curriculum to Teach Socially Responsive Science written by Thishen Naidoo has been edited by me for language.

Please contact me should you require any further information.

Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312

APPENDIX 10

Exploring how science teachers engage with the curriculum to teach socially responsive science

ORIGINALITY REPORT

10%	5%	1%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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6	"Science Teacher Education for Responsible Citizenship", Springer Science and Business Media LLC, 2020 Publication	<1%
7	Submitted to Leeds Beckett University Student Paper	<1%
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14	Second International Handbook of Science Education, 2012. Publication	<1%
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26	Tamara S. Hancock, Patricia J. Friedrichsen, Andrew T. Kinslow, Troy D. Sadler. "Selecting Socio-scientific Issues for Teaching", Science & Education, 2019 Publication	<1%
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	Student Paper	<1%
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Exclude quotes	On	Exclude matches	< 12 words
Exclude bibliography	On		