

**An exploration of Intermediate Phase Natural Sciences and
Technology Pre-service Teachers' experiences of learning about
Education for Sustainable Development: A Case study at a South
African university**

By

Alvin Uchenna Ugwu

213569937

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Supervisor: Dr. A. Singh-Pillay

DECLARATION

I declare that this dissertation “An exploration of Intermediate Phase Natural Sciences and Technology Pre-service Teachers’ experiences of learning about Education for Sustainable Development: A Case Study at a South African university” is my own work, and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Researcher:

Date_____

Supervisor: Dr Asheena Singh-Pillay

Date_____

DEDICATION

This work is dedicated to my paternal and maternal family for their wholehearted support.

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Firstly, my most sincere gratitude goes to my supervisor, Dr. Asheena Singh-Pillay: I thank you for your patience and understanding throughout this whole process. Your untiring support and your guidance while ensuring that I adhered to the timelines established at the beginning of this journey have made this dissertation possible.

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ABSTRACT

United Nation's Global Action Programme for implementation of Sustainable Development recognizes teachers as key role players in promoting education for sustainable development (ESD). This research reports on a study which explored Intermediate phase pre-service Natural Sciences and Technology teachers (PSNSTTs) experiences of learning about ESD, at a selected university in KwaZulu-Natal province of South Africa. There has been little research on preservice teachers' experience of learning about ESD within the higher education context. This study intends to address this gap identified in the literature. This research has provided insight into how pre-service teachers understand ESD, and how it affects their attitudes and behavior towards sustainable development. It gives insight in understanding and interpreting their experience of learning about ESD in their science and technology modules. The study employed a qualitative case study research design to draw on the views and experiences of Intermediate phase pre-service Natural Sciences and Technology teachers, learning about ESD at university. Data were generated using questionnaires and focus group interviews and thematic and content analysis were carried out.

Results indicate that Intermediate phase pre-service Natural Sciences and Technology teachers perceived Education for Sustainable Development to be concerned primarily with educating about the environment, conserving, the 3Rs of resources, reducing, reusing and recycling. Education for a wider view of development goals concerning economic sustainability, food security and gender equity were also identified. Learning about ESD had enhanced positive behavioural attitudes towards the environment among the students, despite some challenges due to inappropriate pedagogical approaches and time constraints encountered in their studies. From the study, a pragmatic approach is advocated for all stakeholders to improve actualization of the sustainable development goals rather than their remaining romantic theoretical ideals.

Keywords: Education for sustainable development, Sustainable development, Sustainable development goals, Pre-service teachers, Science, Technology, Qualitative research, Case study

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ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
CAPS	Curriculum and Assessment Policy statement
DEAT	Department of Environmental Affairs and Tourism
DESD	Decade of Education for Sustainable Development
DBE	Department of Basic Education
DoE	Department of Education
DWAF	Department Water Affairs and Forestry
DST	Department of Science and Technology
ESD	Education for Sustainable Development
FAO	Food and Agricultural Organisation
HEI	Higher Education Institutions
HIV	Human Immunodeficiency Virus
IP	Intermediate Phase
NCS	National Curriculum Statement
NS	Natural Sciences
PCK	Pedagogical Content Knowledge
PSNSTTs	Pre-service Natural Sciences and Technology Teachers
SD	Sustainable Development
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
3Rs	Reduce, Reuse and Recycle

CHAPTER 1.

INTRODUCTION

1.1. INTRODUCTION

South Africa is emerging from 300 years of colonialism and apartheid, which had created an unequal education and training system. In an effort to overcome these inequities, the democratically elected government has attempted to equalize budget expenditure on all children, regardless of race. However, there are still some legacies of the old system, such as under-resourced schools, that continue to affect the quality of learning in the basic education and training system. Furthermore, many children are still affected by factors related to poverty, such as the lack of running water, adequate sanitation and waste management and the presence of violence in a community, which in turn affect their participation in education. Social justice, in the sense of providing an equal, high quality education for all learners, has not yet been achieved

South Africa, like most countries in Africa, also faces a number of sustainable development (SD) challenges, such as water scarcity, climate change, migration and adaptation, and loss of biodiversity. According to the Department of Environmental Affairs and Tourism (DEAT, 2008) as well as the Department of Science and Technology (DST, 2010), building capacity at community level for adaptable and sustainable livelihoods and lifestyles is also a critical challenge. The challenge is particularly relevant for people in rural areas, who are most vulnerable to the impact of social, economic and environmental risks.

To achieve educational equality and address issues of sustainable development, teacher's knowledge is a key concern. In this regard, according to Rosenberg (2010) and Lotz-Sisitka (2011), teachers show poor understanding of sustainable development and they have little capacity for integrating these issues into teaching and learning. Other studies by the Department of Environmental Affairs and Tourism (DEAT, 2008), the biodiversity sector of the Human Sciences Research Council (HSRC, 2010) and the Department of Science and Technology (DST, 2010) all allude to the need to improve South African teachers' knowledge of and capacity to teach Education for Sustainable Development (ESD) and its related values and skills. These studies confirm that practising teachers have inadequate knowledge of sustainable development to lay the foundation for further education and career

path development in sustainable development for youth in South Africa, or simply for associated citizenship development.

Investing in teachers' knowledge for sustainable development is a recognised global need (Hopkins and McKeown, 2002). Hence, The United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2002, at the World Summit on Sustainable Development, declared the period 2005-2014 as the United Nations (UN) Decade on Education for Sustainable Development (DESD). The goal of the DESD is to: "integrate the principles, values, and practices of sustainable development into all aspects of education and learning." The idea being that such an input will "encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations" (UNESCO, 2005, p. 9). Recognising that human behaviour can be altered to limit environmental harm, sustainable development philosophy has evolved to include more than simply recycling or constructing buildings with solar panels, but now encompasses how individuals and communities behave and interact with the Earth. When the decade plans were reviewed in 2009 it was found that little had been done to improve teacher education with regard to ESD. Consequently, as a priority for the second half of the decade, global agreements were reached by UNESCO and governments to improve teacher training initiatives by foregrounding ESD (UNESCO, 2009a). To this end, UNESCO (2009a, p. 21) identified two unique opportunities for higher education institutions (HEIs) to engage in sustainable development. First, "Universities form a link between knowledge generation and transfer of knowledge to society, for example preparation of teachers, who play the most important role in providing education at both primary and secondary school levels. Second, they actively contribute to the societal development through outreach and service to society". Thus, HEIs have a critical and tangible role in developing the principles, qualities and awareness needed, not only to perpetuate the sustainable development philosophy, but also to improve upon its delivery. UNESCO (2009) has once again affirmed the global call for higher education institutions, in particular teacher training institutions, to integrate ESD into their teaching and learning programmes.

Due to the foregoing concerns, Education for Sustainable Development (ESD) has become a political buzz phrase across the world and as a result, education for social change has gained prominence, both globally and locally (Singh-Pillay, 2015). Education for Sustainable Development demands a new vision of education: a vision that enables people to understand better the world in which they live in, as well as to realise that they have a critical role to play

in addressing the complex problems that threaten our future. Sustainable development objectives can be traced to Section 24 of the Bill of Rights in the South African Constitution, which includes a focus on poverty alleviation, equitable access to natural resources, sustainable use of natural resources for present and future generations, and the right to an environment that is not harmful to health or well-being. The constitution also secures the rights of present and future generations to protection of natural resources. Aligned to these constitutional goals, the Medium Term Strategic Framework 2009-2013 of the National Government includes a strong focus on quality education, skills development, rural development, sustainable human settlements and the sustainable use of natural resources. Sustainable use of natural resources is thus defined as a specific goal. These issues are also included in Vision 2030, and in new Green Economy plans, and the strategy for Climate Change mitigation. These issues are also powerfully linked to poverty reduction, a social justice approach to sustainable development of South African society and economy, and the national system of innovation.

The White Paper on Education and Training (Department of Education [DoE], 1995) calls for the integration of ESD into all levels and phases of the education and training system. Accordingly, in the post-apartheid curriculum transformations in South Africa, the key principles of ESD have been incorporated into the National Curriculum Statements (NCS) for General Education and Training (GET) and Further Education and Training (FET) phases for schools (Grades R-12). This is best captured in the principles given in the National Curriculum Statement, which required all schools and teachers to ensure that the relationship between a healthy environment, social justice, inclusivity and human rights was incorporated into the curriculum through teaching and learning activities (DoE, 2000).

In the most recent curriculum reform, ESD has become integrated into one of the seven principles behind the National Curriculum Statement known as Curriculum and Assessment Policy Statement (NCS-CAPS) for Natural Sciences and Technology (Department of Basic Education [DBE], 2011, p. 5). It is envisaged that by including ESD into the guiding principles of the curriculum, learners will be able to “use Science and Technology effectively and critically showing responsibility towards the environment and the health of others” (DBE, 2011, p. 5). This policy framework requires that teachers attain the requisite knowledge and pedagogical content knowledge (PCK) skills for integration of ESD into the South African curriculum. There are also specific associated assessment requirements, which include aspects of Education for Sustainable Development. For instance, within the NCS-

CAPS Intermediate Phase (IP) (Grade 4-6) Natural Sciences and Technology curriculum, the strands energy and change and structures and electrical systems, are both directly linked to content that foregrounds the teaching of ESD. This means that through the NCS-CAPS Intermediate Phase Natural Science and Technology curriculum, teachers of both Natural Sciences and Technology are tasked with the responsibility of ensuring their learners are taught to use scientific knowledge responsibly in the interest of society, the environment and the economy. Put simply, this means that science and technology teachers are seen as agents of change, who can bring about the desired transformation in respect of ESD via their teaching.

1.2. RATIONALE BEHIND THE STUDY

This study is driven by several observations related to the curriculum, the role of teachers, personal observations and the literature.

Firstly, there is a need to respond to the key principles of the NCS-CAPS IP NS and Technology curriculum pertaining to ESD. The focus is on teachers in pre-service training for the intermediate phase is because, in this early phase, Natural Sciences and Technology are integrated as one subject so as to provide the learners with the rudiments of scientific and technological concepts. By so doing, “learners will be able to demonstrate understanding of the interrelationships between science and technology, society and the environment” (DBE, 2011). If the two aspects are not integrated, and so learners are not properly directed at this stage, they may lose track of the relationship between the two.

Secondly, there is global concern about ESD and the role of teachers as agents of change as given by UNESCO (2016 a), which emphasizes that “teachers have enormous potential to bring about change in society. They affect the lives of their students, they help shape worldviews and attitudes, nurture potentials and skills. Well-trained teachers can empower learners to become global citizens and sustainable development actors who will help secure a more just, peaceful, tolerant, inclusive and sustainable world.” (p. 5).

Thirdly, I have personally observed that learners are unaware about ESD and sustainable development issues.

Fourthly, a survey of literature reveals that there are studies that focus on practicing teachers’ views, perceptions and experiences on teaching about environmental education and

sustainable development. There is however a paucity of literature with regard to the experiences of pre-service Natural Sciences and Technology teachers (PSNSTTs) on learning about ESD in South Africa. PSNSTTs are trainee teachers who are learning how to teach about ESD in their Natural Science and Technology classroom. Therefore, seeking their views is important: both on their experiences of learning about Sustainable Development in the NS and Technology modules as well as the factors that may enable or challenges them to learn about ESD. This research intends to contribute to the above-mentioned gap in the literature.

1.3. PURPOSE OF THE STUDY

The purpose of this study is to explore Intermediate Phase pre-service Natural Sciences and Technology teachers' (PSNSTTs) experiences of learning about education for sustainable development with particular focus on a university college of education.

1.4. OBJECTIVES OF THE STUDY

The objectives of this study are:

- i. To explore intermediate phase pre-service Natural Sciences and Technology teachers' understanding of ESD.
- ii. To determine the effect that learning about ESD has on their attitudes and behavioral actions.
- iii. To establish their views on the ESD content included in the Natural Sciences and Technology modules.
- iv. To discover what presents challenges to or enables their learning of ESD in Natural Sciences and Technology modules.

1.5. RESEARCH QUESTIONS

This study is guided by four research question, as follows:

1. What are intermediate phase pre-service Natural Sciences and Technology teachers' understanding of ESD?
2. How does learning about ESD affect the attitudes and behavioral actions of intermediate phase pre-service Natural Sciences and Technology teachers?
3. What are the views of intermediate phase pre-service Natural Sciences and Technology teachers on the ESD content included in the Natural Sciences and Technology modules?

4. What challenges or enables intermediate phase pre-service Natural Sciences and Technology teachers to learn about ESD in science and technology modules?

1.6. SIGNIFICANCE OF THE STUDY

The findings of this study will help the researcher and other scholars to understand the level of awareness among pre-service teachers of ESD, and its integration in higher education, particularly in the context of teacher training. In particular, it will also shed light on the level of integration of ESD into the teaching and learning of the Natural Sciences and Technology module at the chosen university. Furthermore, the study intends to stimulate further research on integration of ESD at higher education institutions and schools. The study will be valuable to participants (pre-service teachers) as future educators because it may widen their PCK on ESD. The study ought to contribute to the gap identified in the literature concerning PSNSTTs learning about ESD.

1.7. CLARIFICATION OF KEY TERMS

In this section, to guide the reader I explain the terms used in this study.

- **Pre-service Natural Science and Technology Teachers (PSNSTTs):** these are trainee teachers who are enrolled for the Natural Science and Technology module at a teacher education college.
- **Intermediate Phase (IP):** In the context of the South African Curriculum and Assessment Policy Statement (CAPS), intermediate phase is a lower school phase which involves teaching learners at Grades 4-6.
- **Education for Sustainable Development:** As defined by UNESCO (2009a), “Education for Sustainable Development (ESD) is a learning process (or approach to teaching) based on the ideals and principles that underlie sustainability and is concerned with all levels and types of learning to provide quality education and foster sustainable human development – learning to know, learning to be, learning to live together, learning to do and learning to transform oneself and society” (UNESCO 2009 a, p. 26).
- **Sustainable Development:** is a paradigm projected by the United Nations, which was first described by the 1987 Brundtland Commission Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations [UN], 1987, p. 43).

1.8. OVERVIEW OF THE DISSERTATION

This dissertation comprises five chapters, as illustrated in Figure 1. **Chapter 1** is an introduction to the study to give an overview of the background of the study. It outlines the focus, purpose, and objectives of the study, states the key research questions guiding the research, the rationale of the study and its significance. Chapter one also incorporates clarification of terms used in the study and lastly gives an overview of all the dissertation chapters.

Chapter 2 focuses on the literature review and conceptual framework. A number of related studies will be cited and scholars' voices on ESD will be heard when addressing the definition and conceptions of ESD. The context, relevance and need for ESD in science and technology education will be reviewed. The literature reviewed falls into the following categories: the evolution of ESD – both internationally and in South Africa, the goals of ESD, the need for ESD, teaching of ESD, learning of ESD, ESD and pre-service teachers in South Africa, ESD and teaching and learning in higher education. Lastly, the chapter ends with a discussion of the conceptual framework that will be used to analyse the data and frame this study.

Chapter 3 addresses the research methodology. It explains the choice of qualitative case study as the research design, and outlines the underpinning research paradigm, methods of data generation, sampling method, the process of data analysis, reporting and presentation of findings, and considers ethical issues.

Chapter 4 will address the data analysis and presentation of research finding, to deduce answers to the main research questions and sub research question

Finally, **Chapter 5** will include the discussion of the findings, recommendations and conclusion.

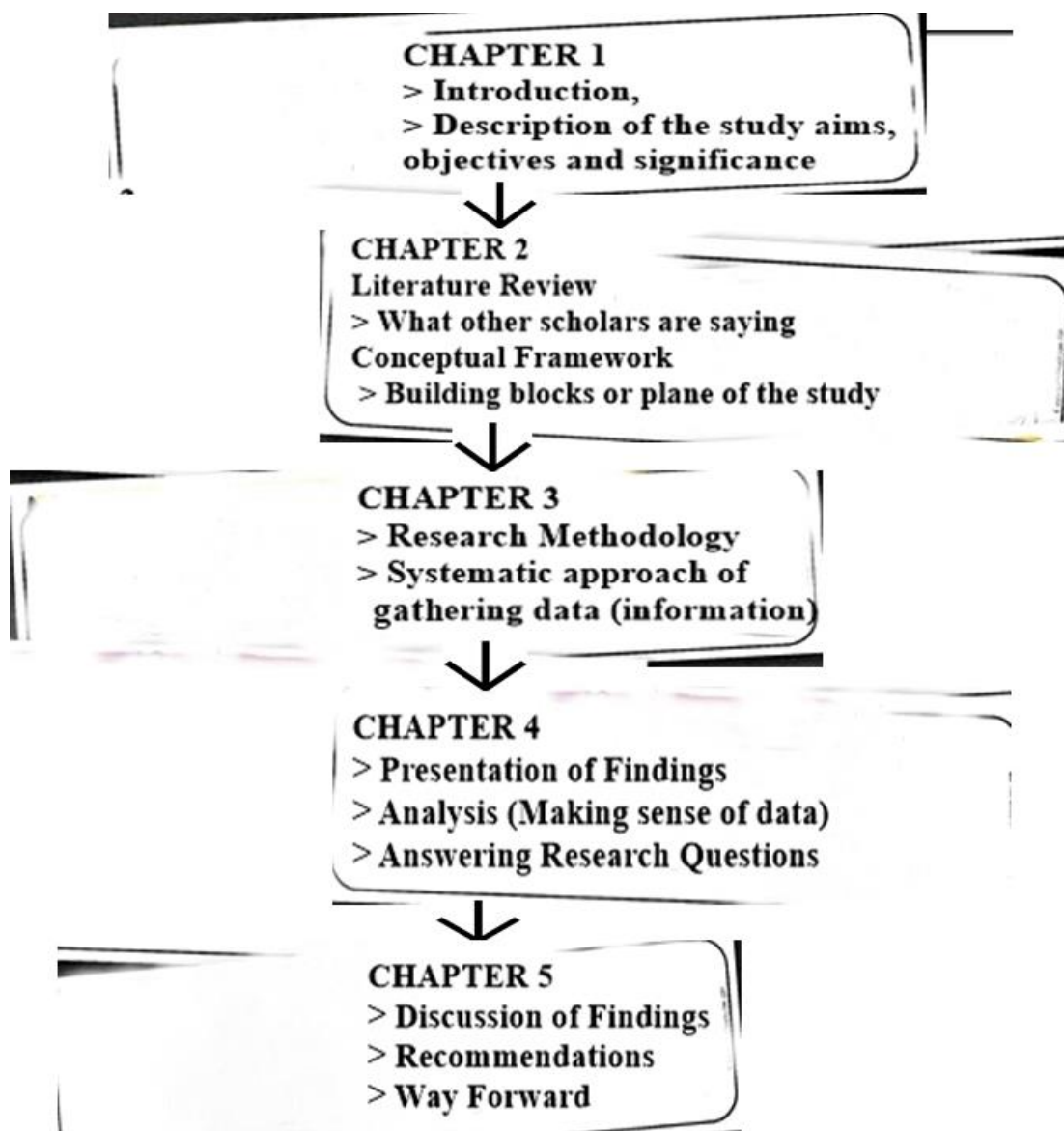


Figure 1: Organization of chapters

1.9. CONCLUSION

This chapter has given an overview of the dissertation. The study is concerned with education for sustainable development, which is a globally recognized concern. The role of teachers in such education is hampered by poor knowledge and teaching skills. In response to this concern this study will provide insight into the views of pre-service teachers of science and technology and their experiences in learning at a College of Education. There are four research questions. The terms used in the study have been clarified and an outline of the dissertation given. The next chapter will be the literature review, where relevant scholarly materials on ESD will be critically examined

CHAPTER 2.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

“Education for Sustainable Development is Everyone’s Business” (UNESCO, 2005, p. 1).

2.1. INTRODUCTION

This section consists of two major parts. First there is a review of the literature, where I examine previous literature and scholarly contributions towards Education for Sustainable Development. This literature review falls into seven categories: evolution of ESD, goals of ESD, Need for ESD; teaching of ESD, learning of ESD, ESD and pre-service teachers in South Africa; ESD and teaching and learning in higher education. Secondly, I present the conceptual framework that is used to frame the study. In the conceptual framework section, I critically examine the concepts of ESD and sustainable development. The section is primarily focused on ways in which ESD can be achieved through natural sciences and technology education, with particular emphasis on the Sustainable Development Goals (SDGs) that are relevant to science and technology.

2.2. EVOLUTION OF ESD

In this section I focus on the evolution of ESD internationally and locally.

2.2.1. International Perspective of evolution of ESD

The concept of Sustainable Development dates back to the United Nations (1987) Brundtland commission report (Thomas, 2014). In 1992, the United Nations general assembly endorsed the ‘Agenda 21’ at the Rio de Janeiro Earth Summit. Agenda 21, is “a program of action for sustainable development worldwide and a comprehensive blueprint for action to be taken globally into the twenty-first century by Governments, United Nations organizations, developmental agencies, non-governmental organizations and independent-sector groups, in every area in which human activity impacts on the environment” (Thomas, 2014, p. 3). Agenda 21 thus foregrounds the interconnectedness of three pillars - Society, Economy and Environment - on which Sustainable Development depends (United Nations [UN], 2013). To further promote ESD, the UN General Assembly also declared the period from 2005 to 2014 as the ‘Decade of Education for Sustainable Development’ (DESD) (UNESCO, 2007). Moreover, a fundamental part of the action plan in Agenda 21 and the DESD is to promote education towards sustainability, through teaching and public awareness in society (Grubb, 1993; Tilbury and Mulà, 2009). Similarly, McKeown, Hopkins, Rizzi, and Chrystalbridge (2002) assert that ESD is a political movement to sensitize people on natural resource usage,

consciousness of environmental issues and sociocultural activities, including economic activities. ESD has continued to be promoted so that, recently, at the end of the specified decade (2005-2014), the Global Action Programme on ESD was launched at the World Conference on ESD in Japan (Laurie, Nonoyama-Tarumi, McKeown, and Hopkins, 2016). According to UNESCO (2017), the global action programme “focuses on generating and scaling up ESD action at all levels and in all areas of education, and in all sustainable development sectors” (p. 3). By implication, DESD was a period of sensitizing nations, capacity building and experimentation, which yielded positive results (Laurie et. al., 2016). The global action programme prioritizes five critical areas of attention by all ESD stakeholders, which are: “1). Advancing policy; 2). Transforming learning and training environments; 3). Building capacities of educators and trainers; 4). Empowering and mobilizing youth; and 5). Accelerating sustainable solutions at local level” (UNESCO, 2017, p. 3). To achieve the foregoing, UNESCO (2015) developed 17 sustainable development goals that ascribe responsibilities to all stakeholders, as outlined below:

- Goal 1: End poverty in all its forms everywhere.
- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3: Ensure healthy lives and promote well-being for all at all ages.
- Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Goal 5: Achieve gender equality and empower all women and girls.
- Goal 6: Ensure availability and sustainable management of water and sanitation for all.
- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- Goal 10: Reduce inequality within and among countries.
- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.
- Goal 12: Ensure sustainable consumption and production patterns.
- Goal 13: Take urgent action to combat climate change and its impact.
- Goal 14: Conserve and use sustainably the oceans, seas and marine resources for development.

- Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development (United Nations, 2015, p. 14).

McKeown et al. (2002, p. 10) have noted that “as the concept of sustainable development was discussed and formulated, it became apparent that education is key to sustainability”. In a similar vein, Siraj-Blatchford, Smith and Samuelsson (2010) explain that ESD challenges educators to develop educational systems, curricula and pedagogical practices that promote sustainable actions with respect to each of the three pillars of sustainable development. Likewise, Laurie et al. (2016) highlight that with the introduction of the Global Action Programme, ESD stakeholders are tasked to expand projects in more schools and institutions, including institutions of higher learning. The expansion involves reviews of teaching and learning policy, pedagogical practices, and community engagement; all contributing to the overall quality of education (Laurie et. al., 2016). In accordance with these ideas, ESD has gained grounds in mainstream science and technology education, especially in developed nations according to Mochizuki (2016), who concludes that the Global Action Programme is a transformation agenda towards the 17 Sustainable Development Goals.

2.2.2. Evolution and contribution of ESD in the South Africa Context

In South Africa, the idea of sustainable development can be traced through post-apartheid policies such as the Department of Education’s (1995) white paper on education and training, culminating in the Department of Basic Education National Curriculum Statement (DBE, 2011), which focuses on transformation and inclusion, and seeks to equalize sociopolitical and economic structures. Similarly, the Department of Environmental Affairs and Tourism DEAT (2008, p. 12), clarifies that “the 1994 constitution obliges stakeholders in civil society and government to secure ecologically sustainable development. The constitution set in motion a range of policies such as the white paper on national climate change response, promotion of renewable energy and clean energy development, sustainable forest development in South Africa and procedures to reverse the formal legal right to systematically exploit the nation’s natural resources for the benefit of a minority”. The new

South African constitution explains its stance on sustainable development as a nation and explains its vision for the country “to be a sustainable, economically prosperous and self-reliant nation by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations” (DEAT, 2008, p. 8). Furthermore, DEAT (2008) notes that “the negotiated outcome of the World Summit on Sustainable Development held in September 2002, is the Johannesburg Plan of Implementation (JPOI) which sets out 37 targets for achieving sustainable development, inclusive of the Millennium Development Goals” (p. 6).

The concept of sustainable development can be defined within a context in which it is to be applied and based on its significance to a particular society. The implementation strategies of sustainable development may differ according to contexts (DEAT, 2008). In the South African context, sustainable development refers to measures taken to enhance the well-being of people in the society, to improve the quality of life for all generations, especially the vast majority of the population affected by poverty and inequality (DEAT, 2008). To that effect, wise use of resources and bearing in mind their availability are the core principles behind sustainable development in South Africa (DEAT, 2008). As a developing nation, issues such as air pollution, waste management, recycling, energy management, poverty eradication, improved health of the citizens, service delivery and decongestion of cities have high priority in the national policies. DEAT (2008, p. 13) further indicates that “by improving our planning tools, developing our human resources appropriately, raising awareness and applying cutting-edge technology for sustainable development, we can counteract the above trends”. The DEA thus sees improved education as a means of sensitizing South Africans to the present challenges and vision. This vision is critical if South Africa is to be one of the ‘giants’ of Sub-Saharan African nations (DEAT, 2008). In addition, the overarching nature of the three key elements of sustainable development, society, the economy and the environment, calls for a reorientation of all sectors of the society including educational institutions (DEAT, 2008).

UNESCO’s Decade of Education for Sustainable Development (2005) affirms that in South Africa, “the journey has been a vibrant one that has evolved in diverse contexts and engaged people from all walks of life in processes of social change. ESD processes have grown and evolved from a strong environmental education practice-based community that has extensive knowledge and experience of supporting active learning, working with environment within curriculum and working with educational and environmental change” (UNESCO DESD

2005, p. 56). Thus, the key agenda of transformation and inclusion are peace and reconciliation, social justice, human rights, gender equality, HIV and AIDS awareness, cultural and religious diversity, rural education and development and poverty eradication (UNESCO DESD, 2005).

2.3. GOALS OF ESD

“Education can, and must, contribute to a new vision of sustainable global development” (UNESCO, 2017, p. 7). The goal of ESD is to achieve the sustainable development goals by developing conscious citizens through formal and informal education (UNESCO, 2015; 2017). For formal education, United Nations organizations and government agencies, including curriculum developers, have advocated the inclusion of ESD as a fundamental part of a modern-day school curriculum, including in science and technology learning areas (UNESCO, 2017). As UNESCO (2017, p. 7) indicates: “education that promotes economic growth alone may well also lead to an increase in unsustainable consumption patterns. The now well-established approach of Education for Sustainable Development (ESD) empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society for present and future generations”. ESD in natural sciences and technology learning areas therefore must have the aim of developing competencies that will empower individuals towards responsible citizenship, by understanding and valuing their sociocultural, economic and environmental activities. Therefore, in order to achieve sustainable development goals through any subject specialization, teaching and learning activities must be developed in a holistic manner to address all three spheres (society, the economy and the environment) of sustainable development. ESD encourages individuals to be critical decision makers towards sustainability, in all aspects of the society. Therefore, the philosophy behind quality education in any society must reflect creating individuals with critical thinking and decision-making abilities (UNESCO, 2012; 2017). All educational institutions, from pre-school to tertiary, are mandated to take responsibility for teaching and fostering sustainable development competencies (UNESCO, 2017). Hence, the curriculum, as a driver of educational activities, must respond to innovative ways of knowledge development and desired consciousness among learners. In order to achieve ESD, Educators, as key implementers of the curriculum, should be well equipped with the Pedagogical Content Knowledge (PCK), skills and values because PCK influence educational outcomes

(UNESCO, 2012; 2017). In summary, the underlying philosophy of ESD echoes the need to rather improve teachers' practices than their theory (UNESCO, 2012).

2.4. NEED FOR ESD

Given three elements of sustainable development (UNESCO, 2015), the needs of ESD can be summarised from three perspectives, as follows:

2.4.1. Social Needs

Social problems are contextual in every society (Winter, Sterling and Cotton, 2015). According to Mensah and Castro (2004), developing nations, on the one hand, share similar challenges and concerns about overpopulation, the struggle against diseases, and politically driven social unrest. On the other hand, developed nation struggle to contain issues of infrastructure deterioration, industrial pollution, and population explosion due to rural-urban migration, which has led to "unlimited urban expansion with limited resources" (Mensah and Castro, 2004, p. 3). Winter et al. (2015) support the view that societies are faced with interrelated "financial instabilities, social and economic inequalities, threats to food and energy security, increased health risks, climate change, shrinking biodiversity and declining water and fossil fuel resources" (p. 1). Both rural and urban communities face environmental problems. For instance, among rural communities in Africa, cultural practices such as deforestation and bush burning are common, especially before the farming season (Eriksen, 2007), possibly because people have no idea of the damage they cause to the environment. Likewise, urban communities with more developed infrastructure, also contribute to environmental degradation through activities related to industrialization. It can be argued, however, that government, through taxation and policies, monitor the level of unsustainable practices perpetuated by urban societies (Du Plessis, 2012). Nevertheless, education is considered to be a suitable vehicle to tackling social problems and attaining social transformation (Sterling and Huckle, 2014; Singh-Pillay, 2015). Education towards citizenship and stewardship, sustainable behavior, civic engagement, as well career orientation, are all attempts to develop individuals with the necessary skills to tackle social problems (Armstrong 2011). Education for sustainable development is therefore a transformative tool to enable humans to live in harmony with nature and to enable them to understand the consequences of human impact on the environment (Armstrong, 2011).

2.4.2. Economic Needs

Social and environmental cannot be separated from the economy. Wals (2014) asserts that this nature of societies makes it impossible to isolate any one arm of ESD from another. Both rural and urban communities need to be educated to sustain local and national economic structures. Studies in many African and Asian developing countries have identified a growing trend of rural-urban migration, based on the one hand on the notion that cities provide better opportunities of income and amenities (Tacoli, McGranahan and Satterthwaite, 2015). On the other hand, the UN (2013), suggests that a growing urban population puts pressure on the available resources and increases the demand for resources and improved government capacity to support the resources. However, empowering people with the knowledge, skills, and values that societies need, through holistic individual development from ESD, could reduce the need for migration in search of better economic opportunities. Thus, ESD may enable societies to maintain socio-economic balance and standard of living.

2.4.3. Environmental Needs.

Climate change is a major issue of discussion because it has contributed to recent global environmental crises (Shi, Wang and Yang, 2010). There has been evidence of extreme weather conditions around the globe; in particular: “the last decade of the 20th Century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record, starting in the mid-19th century” (National Oceanic and Atmospheric Administration [NOAA], 2007). Recent evidence from the National Aeronautics and Space Administration (NASA, 2016), shows that the earth’s carbon dioxide level has increased from 320 parts per million (ppm) in 1950 to 400ppm today. Recent studies (e.g. Pavlova, 2011; UNESCO, 2012; Burns, 2012; Du Plessis, 2012) have shown that stratospheric ozone layer depletion and the greenhouse effect resulting from human activities of urbanization and industrialization such as mining or gas flaring, and the related global warming are the current crises faced by planet Earth. Thus, all countries face these global problems to our immediate environment. But developing countries may also face other more local problems such as famine, food insecurity, poverty, wildlife extinction and drought. Therefore, researchers, organizations and institutions have declared ESD as a sure strategy to curb the emerging global sustainability crisis.

2.5. TEACHING OF ESD

Sustainability action requires creative teaching approaches, by which educators “deconstruct and reconstruct their personal theories and practices of teaching in more emancipatory ways” (Kostoulas-Makrakis, 2010, p. 19). The goals for teaching of ESD in a Natural Sciences and Technology classroom should focus on whole learner development. ESD accounts for teaching to achieve the sustainable development goals which cut across the three sustainable development (socio-cultural, environmental and economic) spheres (UNESCO, 2015). The South African Norms and Standards for Educators outlines seven key roles for teachers as learning mediator, leader, administrator and manager, scholar, researcher and lifelong learner, community, citizenship and pastoral mentors; assessor, and specialist in a learning area, subject, discipline or phase (DOE, 2000, p. 14). These roles contribute to the holistic quality of education in all learning areas, including Natural Sciences and Technology. Armstrong (2011) agrees that ESD teachers must play the role of facilitators, collaborators and fellow learners in order to demonstrate a true consciousness of sustainability. They must “allow the learners to direct their own learning and guide course content, although this does not necessarily indicate relinquished control or authority” (Armstrong, 2011, p. 5). Arbuthnott (2009) cited by Armstrong (2011) indicates on the one hand that ESD instruction must encompass “topics focused on behavioral change, including feedback on behavior, specific ways to take alternative action, and incentives that support for behavioral change” (p. 5). On the other hand, Sterling (1996) suggest that teaching for sustainability involves applying the principles of critical pedagogy, which reflects whole social interaction and the transformation process through educational environments. Sterling (1996), further describe the six underlying principles of social critical pedagogy as follows.

- Learning is active and experiential.
- Classroom dialogue introduces elements of critical theory and encourages learners to think critically.
- Learners begin to see themselves, their histories and futures in new ways. They develop a sense of their own power to shape their lives.
- Education develops comprehension of the sources of beliefs and values, how they are transmitted and the interests they support.
- Learners reflect on the structural and ideological forces that influence and restrict their lives and on democratic alternatives.
- Learners are taught how to act democratically with others to build a new social order (Sterling, 1996, p. 106).

UNESCO (2012), emphasizes that quality education involves teaching strategies that aim at whole individual learner development using a learner-centred approach, acknowledging the learner's prior knowledge and experience, drawing from learner's immediate environment, and using diverse teaching and learning techniques. These strategies enhance learners' active participation, which enhances knowledge and skills development and appreciation of sociocultural values. Natural science and Technology education should look beyond traditional teaching methods which may result in rote learning. "Meeting the learning needs of all learners in the classroom is a form of social equity, which is a core concept of sustainability" (UNESCO, 2012, p. 15). Appropriate teaching methodologies in a Natural Sciences and Technology classroom must be used to stimulate learners' inquiry, critical thinking, analytical and decision-making skills. ESD classroom activities should have an impact on the cognitive, affective and psychomotor domains of learning (Bloom, 1956). Additionally, UNESCO (2012), propose that teaching and learning activities to arouse creativity, social critique and critical thinking should be drawn from learners' immediate contexts and should also be problem-based. Activities that can be integrated in teaching techniques included stimulation, class discussion, analysis of issues and storytelling (UNESCO, 2012). Lastly, teaching of ESD involves developing and fostering skills, values and attitudes that support sustainable development (Armstrong, 2011).

2.6. LEARNING OF ESD

Human beings learn in different ways as they understand and make sense of concepts and construct knowledge (Armstrong, 2011). Arguably, learning in ESD is founded in constructivist learning theory, which promotes learner-centered pedagogy, even at higher educational levels (Kostoulas-Makrakis, 2010; Armstrong, 2011). In this regard, a learner-centred approach allows students autonomy in their learning and active development of knowledge, rather than providing passive learning experiences (UNESCO, 2017). The learners' prior knowledge, experiences and social interaction influence construction of knowledge; hence they are the starting point of the learning process (UNESCO, 2017). ESD learning requires approaches which facilitate active engagement of learner through experience and application of procedural knowledge which eventually lead to holistic transformation of the individual learner (Armstrong, 2011). Reid (2002) cited by Armstrong (2011) asserts that many scholars suggest that all ways of ESD learning, seemingly point to fundamental ideas such as meaningful social interaction, personal reflection on attitudes, real-life problem-solving and self-consciousness. Therefore, teaching strategies in ESD classroom

must be diverse to account for diverse learning styles. UNESCO (2016a; 2017) suggests that effective learning strategies in ESD include approaches such as experiential learning, enquiry-based learning, learning through problem-solving and learning outside the classroom. These are discussed next.

2.6.1. Experiential learning

Kolb (1984) describe learning as “a process, in which knowledge is created through transformation of experience” (p. 2). Kolb (1984) recommends a four-stage cycle of the experiential learning process which includes (1) concrete experience (2) observation and reflection (3) abstract conceptualization and (4) application and experimentation. ESD embraces experiential learning by engaging students through practical experience, lived experiences and use of local knowledge (Armstrong, 2011). Studies have shown that real-life experiences facilitate ESD by dealing directly with related issues (Johnston, 2007; Hopkinson, Hughes and Layer, 2008 cited by Armstrong, 2011). Moreover, learning towards sustainability occurs by doing, active participation in classroom discussion, group work, hands-on minds-on tasks, direct feel of a phenomenon with senses, reflection and application of knowledge and skills (Armstrong 2011; Sharlanova, 2004; UNESCO, 2017). Experiential action-oriented learning can be facilitated by school projects, internship, workshops and awareness programs (UNESCO, 2017). “The role of the educator is to create a learning environment that prompts learners’ experiences and reflexive thought processes” (UNESCO, 2017, p. 55).

2.6.2. Enquiry-based Learning

Hutchings (2006) expresses enquiry as “the action of seeking especially for truth, knowledge, or information concerning something; or a search, research, investigation, examination” (p. 9). Enquiry-based learning involves any learning process driven by curiosity, hence it supports development of higher-order thinking skills (Madhuri et al., 2012 cited by Pretorius, Lombard and Khotoo, 2016). Enquiry-based learning is related to problem-based learning. It involves activities which are presented as problems to promote critical thinking skill in students as they “pursue their own lines of enquiry, draw on their existing knowledge and identify the consequent learning needs” (Kahn and O’Rourke, 2005, p. 1). In enquiry-based learning the teacher acts as a facilitator of the learning process, directing and supporting the students to make decisions about their own learning (Kahn and O’Rourke, 2005). Students learn new knowledge through inquiry and by a process of active learning; in other words, by a more natural method than is traditionally offered (Hutchings, 2006). UNESCO (2017)

highlights enquiry-based learning as a useful measure of teaching sustainable development goals through developing projects to investigate various phenomena. Furthermore, Pretorius et al. (2016) state that enquiry-based approaches “can potentially enrich sustainability learning in any educational context, and in regions of educational need (such as the Global South, of which Africa forms part)” (p. 167).

2.6.3. Learning through Problem-solving

Students should be equipped with skills for analyzing societal problems that may arise in the future. ESD knowledge equips learners with analytical reasoning skill as they engage with current global problems. According to Tilbury (2011), problem-solving learning involves a six-step process, which aids decision making. The six steps as outlined by Tilbury (2011), include identifying possible causes and effects of a problem, identifying the underlying problem, brainstorming potential solutions, developing criteria for evaluating solutions, evaluating all solutions to determine the best one and developing an action plan. Hence, each of these six steps provide the learners with learning opportunities. Dale and Newman (2005) cited by Armstrong (2011) suggest that facts-based learning (that is, research-based learning) supports problem-solving learning by directing learners to investigate and question unsustainable practices, thereby developing solutions to sociocultural, environmental and economic problems. The advantage of this approach is that it remains relevant in lifelong-learning, which promotes an adaptive “quality that makes the learner more flexible in a time when most societies are experiencing dramatic social, environmental, and economic transformation” (Armstrong, 2011, p. 1).

2.6.4. Learning outside the Classroom

Milne (2017) states that “learning outside the classroom has the potential to extend a child’s technological knowledge and promote design solutions to real-world problems” (p. 146). Learning outside the classroom brings reality to the learning process. The idea is to allow students to make sense of the world in a more realistic way and “to appreciate their first-hand experiences from a variety of different perspectives” (UNESCO, 2012). Learning outside the classroom is suitable for most topics in the Natural Sciences and Technology (UNESCO, 2012). The learning process can take place on an excursion away from the school locality such as a visit to the school gardens, parks and nature reserves, museums, theatres, galleries, mechanical workshops, libraries, or cityscapes (UNESCO, 2012). This method would facilitate various aspects of ESD such as understanding environmental pollution and water

resource management. This method of leaning provokes creativity and aesthetical appreciation, especially among younger learners (Milne, 2017).

2.7. ESD AND PRE-SERVICE TEACHERS IN SOUTH AFRICA

Several studies suggest that, to ensure implementation of ESD through formal education systems, educators need to embrace, and be committed to, the recent ESD paradigm (e.g. UNESCO, 2009 a; 2012; 2014; Burns, 2012; Du Plessis, 2012; Tilbury, 2011; Pavlova, 2011; Armstrong, 2011). In South Africa, the education sector emphasizes quality teacher education programs as a step towards empowering teachers as agents of transformation and true democracy (DBE, 2011; Lotz-Sisitka, 2011). Notably, the quality sought echoes the corresponding need to embrace the idea of sustainable development in the South African Education system. Implementing sustainable development as policies and definitions of teachers' roles is not a new issue. For instance, in 1995, the Department of Education white paper on education and training indicates that "the expansion of the education and training system must meet the test of sustainability" (DoE, 1995). Lotz-Sisitka (2011) reports more recently that there has been valuable progress and positive awareness of teachers' roles towards implementation of ESD in the South African schooling system. With a curriculum that is constantly being reviewed, in-service teachers struggle with the numerous paradigm shifts required of them (Vandeyar and Killen, 2007; Spaull, 2013). Therefore, pre-service teachers are in a critical position of present-day curriculum implementation. This is reflected in the, studies on teachers' role on ESD in South Africa, which have evolved from a focus on in-service teachers' roles to the place of pre-service teachers in the emancipatory process. McKeown and Hopkins (2005) report that UNESCO, likewise, suggests that sustainability in science and technology education can be achieved by making pre-service teachers a major target audience of ESD. Consequently, pre-service Natural Science and Technology teachers need to acquire appropriate pedagogical content knowledge in order to implement the proposed action plans of ESD outlined in the CAPS curriculum. A priority is the expansion of the "scope of environment and sustainability topics in the CAPS, for all phases of the schooling system" (Lotz-Sisitka, 2011, p. 60). Scott (2009) cited by Armstrong (2011) recommends that learning outcomes of related ESD topics in school curricula can be used to measure the effectiveness of a curriculum in ESD implementation. Similarly, Armstrong (2011) states that "the ESD educator must practice what they preach, encouraging values development by example, a position more compelling to the learner" (p. 5). This implies that pre-service teachers in Natural Sciences and Technology learning areas must be ready to

learn, and be equipped with knowledge and values that are directly transferable to their learners through their attitudes.

2.8. ESD and Teaching and Learning in Higher Education

Mohamedbhai (2015a, p. 1) states that “the recognition that education, at all levels, can be a powerful tool in promoting sustainable development, led to the concept of Education for Sustainable Development”. Education for Sustainable Development has been discussed extensively in curricula across various levels of education. However, Armstrong (2011) argues integration of ESD has not been prioritized in the higher education system, especially in developing nations such as South Africa. This contrasts with the situation in developed nations such as Australia and the United States of America, where the evidences of ESD is demonstrated through green research and initiatives. Nevertheless, developing appropriate pedagogical practices has remained sluggish in these countries (Armstrong, 2011). In this regard, Winter et al. (2015) hold the position that promoting ESD in the higher education sector requires radical measures, which involve more than simply teaching about environmental issues. That being said, higher education organizations, such as the Association of African Universities, the Global University Network for Innovation and the International Association of Universities have expressed commitment towards the promotion of sustainable development by higher education institutions in sub-Saharan Africa, through joint partnership projects (Mohamedbhai, 2015 b). If true ESD can be achieved in higher education institutions this will have a positive influence when it projects onto teaching and learning at other lower levels (primary and secondary) of education (Laurie et al, 2016). Therefore, universities and other institutions of higher learning could play a major role in integrating ESD into teaching and learning, by strengthening partnership with other sectors and influencing society through research and education (Armstrong, 2011; Mohamedbhai, 2015a & b; Otte, 2016). Corcoran, Calder and Clugston (2002) suggest that ESD can be actualized, not only through professional education and training, but through the universities’ attitude towards inculcating sustainability culture among students. Students should have become responsible citizens and future decision and policy makers by the time they graduate from university. UNESCO (2017) acknowledges that ESD can be tackled through “whole-institution approaches” (p. 54). This addresses an individual institutions’ ethos, teaching and learning contents and resources, as they reflect awareness about sustainable development issues (UNESCO, 2017). Universities and colleges of higher learning should imbibe the culture of sustainability, showing exemplary ethos to the communities (Winter et al., 2015).

Regarding implementation of ESD in higher education institutions, scholars have suggested a ‘whole institution approach’, which assigns all facets of higher institutions with the responsibility of demonstrating consciousness amount the three pillars of sustainability. Studies have revealed the gap in implementing ESD in higher education institutions (HEIs) as it is still only being discussed rhetorically in this context. UNESCO (2017) agrees that implementation of ESD is crucial in HEIs with several reasons and “the higher the percentage of tertiary education students in the total population, the higher the air pollution index” (UNESCO, 2017, p. 10). Consequently, the first major step towards achieving this goal is to “develop curricula and pedagogy that will give students the skills and knowledge to live and work sustainably” (Winter et al., 2015, p. 1). Johnston (2007), in the same accord, outlines a framework for implementation of ESD in higher education institutions by developing useful practice-oriented activities. This framework was based of several action research case studies, carried out in fifteen HEIs across Europe, Asia, North America and Australasia. The framework embraces contributions of sustainable development in communities in respect of environmental, social and economic factors. It also traces barriers to implementing ESD and gives effective policy suggestions (Johnston, 2007). Johnston’s (2007) model for implementation of ESD in higher education institutions is analysed in the table below, in accordance with the contributions of other numerous scholars and organizations.

Table 1: Analysing Johnston’s (2007) framework for implementation of ESD in Higher Education institutions

ESD Effective Practices	Measure of Achieving Effective Practices
<ul style="list-style-type: none"> ▪ Efficient resource usage or management 	<ul style="list-style-type: none"> ▪ Teaching the conscious application of the 3Rs (Reduce, Reuse, and Recycle); Reduced energy consumption, wise raw materials usage; wise water, paper and other non-renewable resources harvesting and use, sewage and waste disposal and reduction campaign; students on school environmental management team Emphasis on water resource conservation; Establish low maintenance and drought tolerant green gardens.

<ul style="list-style-type: none"> ▪ Develop new ideas towards the economy 	<ul style="list-style-type: none"> ▪ research-based teaching; business development with low-carbon consideration; creativity and career orientation; Corporate Social Responsibility - using local economic crisis as a reference to teach ideas of socially responsibility, behaviour of individuals, activities of public and private sector organisations and improved stakeholders collaboration; Exploring impact of organizations' activities to the local and regional economy and broader context of the society; Creating a standalone degree programme in sustainable development; Environmental Economics: for instance, in the United states, "Oberlin College, provided a course in Environmental Economics. The college puts this dedication to valuing natural capital into practice in many ways, with the most direct example of this being the colleges' decision to purchase 60% of its electricity from green sources" (Johnston, 2007, p. 16); Reduction in carbon emissions.
<ul style="list-style-type: none"> ▪ Conserving and enhancing the environment 	<ul style="list-style-type: none"> ▪ Subscribe to low-impact travel schemes; cost-effective alternative to driving. "Public transport and other forms of alternative transportation contribute to reductions in air pollution and consumption of resources, and decrease the demand to develop land for parking" (p. 16). Use of bicycles reduce carbon dioxide emission and increase individuals' fitness level; Increase biological mass and diversity (on campus and locally); On-campus gardens "comprises of- important scientific collections, providing research subjects and laboratories for students, and promote knowledge of conservation work through exhibitions, displays and interpretation" (p. 16); Creating natural environment such as ecosystem of sand dunes, lakes and subtropical forests to exemplify biological and geological processes and foster environmental research; Creating "atmosphere that encourages environmental enthusiasts and

	<p>researchers to make use of its facilities and provides resources for field study sites for primary, secondary and tertiary student groups to learn more” (p. 16-17).</p>
<ul style="list-style-type: none"> ▪ Attracting and retaining high caliber staff and students 	<ul style="list-style-type: none"> ▪ Create community of purpose for staff, students, other stakeholders; being values-led organization; ensure healthy working culture and physical environment; be active on diversity; Providing occupational health service, psychosocial advice and medical examination for staff; Providing free medical treatment to all staff. Providing counseling and support for staff and students against drug and alcohol addiction, gender equity/harassment; Prohibiting smoking within the university buildings, prohibiting staff and students from bringing pets within the university buildings. Safety instructions for handling hazardous waste and chemicals should be placed in the laboratories, use of electrical gadgets should be guided by instructions. These measures are taken to ensure safety and ethical practice within the institution.
<ul style="list-style-type: none"> ▪ Providing quality student experience 	<ul style="list-style-type: none"> ▪ Upholding a standard as an organization; ensuring healthy working culture and physical environment; enhance employability of graduates; ensure sustainable literacy for all. For instance, in “Chalmers University of Technology, Sweden all students are required to take one compulsory course in Environment and Sustainable Development. Courses are available in the different disciplines, which allow students choice in how to fill the requirement” (Johnston, 2007, p. 17).
<ul style="list-style-type: none"> ▪ Promoting lifelong learning 	<ul style="list-style-type: none"> ▪ Mixing on/off campus learning experiences to enable student to engage with the local community, primary and secondary schools.
<ul style="list-style-type: none"> ▪ Fostering governance and management 	<ul style="list-style-type: none"> ▪ Ensuring clear and coherent strategic planning, and developing well trained managers, “decision-making systems to ensure transparency and democracy” (p. 17).

<ul style="list-style-type: none"> ▪ Anticipating future markets for graduates 	<ul style="list-style-type: none"> ▪ Acknowledge present-day challenges in teaching, research, knowledge transfer in order to “promote a vision of the future that engages new generations; prepare graduates for multi-disciplinary approaches to problem solving” (p.17); Multidisciplinary research to link the environment and the people.
<ul style="list-style-type: none"> ▪ Responding to other policy agendas 	<ul style="list-style-type: none"> ▪ Ensuring equity, justice and human rights; aligning with national constitution and policies; being sensitive to employers demands for future needs; creating a worthwhile purpose for Higher Education Institutions (HEIs); providing leadership structures in the ever-changing society, active participation in community service especially in rural and underdeveloped communities; applying national policies as tools for transformation towards socially, environmentally and economically sustainable society, “thus enabling individuals to contribute to and feel responsible for their communities” (p. 18).
<ul style="list-style-type: none"> ▪ Demonstrating best values in the use of estates 	<ul style="list-style-type: none"> ▪ Ensure sustainable building designs, refurbishment; paying attention to renewable energy sources as well as reducing carbon dioxide emission; renovations of existing “facilities to better meet their evolving requirements, for up-to-date ventilation, improved air quality, and modernized heating” (p. 18).
<ul style="list-style-type: none"> ▪ Fostering excellence in research and teaching 	<ul style="list-style-type: none"> ▪ “Integrate student learning with campus improvement and community experience; sustainability research/consultancy; encourage innovation for sustainable design solutions” (p. 19);
<ul style="list-style-type: none"> ▪ Promoting community relations and outreach 	<ul style="list-style-type: none"> ▪ “share sports, library, other facilities; build portfolio of joint ventures for student, staff and local residents; sustainable transport partnerships” (p. 19).
<ul style="list-style-type: none"> ▪ Saving money/being efficient 	<ul style="list-style-type: none"> ▪ Wise usage of economic resources; ethical investment, long-term capital investments; use recycled products.
<ul style="list-style-type: none"> ▪ Competing 	<ul style="list-style-type: none"> ▪ “Structure and make relationships to facilitate ideas-

internationally/regionally	innovation implementation process; export models and programmes” (p. 19).
<ul style="list-style-type: none"> ▪ Modernising risk management 	<ul style="list-style-type: none"> ▪ Report on environment and social impacts as well as financial; use procurement strategies to support local markets and ethical trade; sustainable food sourcing, waste management practices; purchasing food from local sources to strengthen and support local economy, to “provide high quality fresh foods, and help preserve the natural environment and landscape by reducing transportation demands” (p. 20). Purchasing organic food would reduce cost of production and facilitate accessibility.

Johnston (2007) concludes that most developed nations’ universities and other institutions of higher learning have shown that HEIs have begun to respond creatively to economic, social and environmental sustainability. The interconnectedness of the 3 spheres (social, environmental, and economic) is imperative in all levels of sustainable development discourse, implementation, strategies and policies (Sterling, 1996; Pavlova, 2011; and Filho, Manolas, and Pace, 2009; Jucker, 2004; Stables and Scott, 2002 all cited by Armstrong, 2011). In this regard, Winter et al. (2015) advocate that higher education institutions develop a clear knowledge and understanding of the principles of sustainability and ESD within a particular university or higher institution context. This ideology supports the statements by Laurie, McKeown and Hopkins (2016) and by Armstrong (2011) that the first step in integrating ESD within HEIs is to create a sustainability ‘lens’, while reviewing traditional content, and then next to infuse sustainable development “throughout the curriculum, to reframe content entirely to support sustainable development” (Armstrong, 2011, p. 3). Armstrong continues: “When students understand the guiding principles of sustainability, this framework can be used to perceive all content”. Winter et al. (2015) further indicate that identifying key sustainability issues within the institution and beyond, are crucial for HEIs in developing sustainability literacy and competencies, enhancing teaching and learning through sustainability pedagogies, using campuses as valuable learning resources, linking the curriculum and informal learning and creating university sustainability initiative are crucial. Winter (2015) adds that practices such as community engagement programs, students’ on-campus sustainability projects, encouraging students to consider their own values and

behaviour can support the implementation of sustainability in a higher education institutions. UNESCO's (2017) Global action programme emphasizes that policy-makers, institutional leaders, educators, youth, local authorities, and civil society organizations are the stakeholders of ESD, and must therefore create close partnerships with one another for effective and transformative knowledge promotion and capacity building.

2.9. ENVIRONMENTAL CRISES IMMINENT IN SOUTH AFRICA

As in many other developing nations, environmental crises arising from inappropriate behaviours and practices in society are imminent in South Africa. These challenges will make the environment unfit for living, thereby presenting related issues such as health problems, poor sanitation and deteriorating water resource (Angus and Butler, 2011). The most important environmental crises affecting the human society in South Africa are elaborated upon below.

2.9.1. Water Scarcity

Water is indispensable for life. It is also indispensable for economic activities. According to Bhargava (2006) population explosion in societies around the globe has aggravated demand for and "use of fresh water for human consumption, agriculture, and other activities. Some rivers that formerly reached the sea no longer do so, all of the water is diverted to human use before it reaches the river's mouth" (p. 12). Water supply in South Africa is limited, unevenly distributed. It is negatively affected by changes in climate (Blignaut, 2009), by environmental degradation and lack of infrastructure (Kumar, 2013) and by the prevalence and spread of invasive alien plant species (Van Wilgen, et al., 2012; Blignaut, 2009). The demand for water increasing beyond supply constraints leads to an untenable situation. It implies that not only would water conservation measures have to be applied, but also that considerable effort would have to be made in redistribution of water. This situation was recognised by both Grobler and Ntsaba (2004) in the Department of Water Affairs and Forestry, who stated that given the demographic trends the whole of South Africa is likely to have a water deficit of approximately 1.7% by 2025. The surplus water available for any kind of use is, therefore, fast declining; implying that water will be a very scarce resource, or even the factor limiting development. In describing water as "a climate regulator, a carrier of energy, and cooling and heating agent" Bogardi et al. (2012, p. 36) concluded that for the world to have sustainable water supply, creative commitments are required by all stakeholders.

2.9.2. Loss of Biodiversity

The alteration of species distribution and ecosystems due to human reliance on and increasing demand for energy results in the loss of unique gene pools (UNEP, 2007). Biodiversity has also been lost due to invasion by alien species and poor forest maintenance (Butchart et al., 2010). According to both Egoh et al. (2010) and Butchart et al. (2010) such loss of biodiversity must be prevented. Biodiversity makes livelihood more secure and enables the use of genetic resources to harness other ecosystem services (UNEP, 2007). Nonetheless, the world's biodiversity is being lost at an increasing rate since 2002, with less movement between species populations, interactions and interdependence within the environment.

2.9.3. Climate Change

According to Bryan, Deressa, Gbetibouo, and Ringler (2009), the greatest threat confronting the world is the release of greenhouse gases such as carbon dioxide into the atmosphere through industrial activities and burning fossil fuels. The resultant greenhouse effect causes increasing temperature on Earth (Dincer, 2000). The negative impact of this, according to Caldeira (2012), is bizarre weather patterns such as life-threatening rainfall, hotter winters and melting ice and snow at the poles. These changes could result in ill health and natural disasters of unimaginable magnitude causing millions of people to be displaced.

The National Climate Change Response White paper of South Africa (Republic of South Africa, 2011, p. 9.), states that “climate change is a global problem requiring a global solution through the concerted and cooperative efforts of all countries. Should multi-lateral international action not effectively limit the average global temperature increase to below 2°C above pre-industrial levels, the potential impacts on South Africa in the medium to long-term are significant and potentially catastrophic”. This statement reinforces the need for awareness and education among the citizens about the scourge that is being created by world climate change, to which no nation is immune.

2.9.4. Land Degradation

Natural disasters contribute to land degradation, but this is exacerbated by human activities such as mining, overgrazing, deforestation, poor soil and water management and improper agricultural practices (UNEP, 2003). As described by the Food and Agriculture Organization (FAO, 2008 cited by Adebayo, 2014), the resultant effect of land degradation is reduced ecosystem functions and productivity. The FAO (2008) further notes that land degradation

has visibly increased globally, with above 20 percent of all agricultural lands, 30 percent of forests and 10 percent of grasslands affected.

2.9.5. Implication of Environmental Crises

It is essential to offset the environmental crises about to strike South Africa through ESD. Furthermore, as explained earlier in Section 2.7.1, teachers and higher education institutions are ideally placed to put ESD into effect. Thus, exploring the experiences pre-service Natural Sciences and Technology teachers (PSNSTTs) have in learning ESD will contribute to the promotion of sustainability awareness and knowledge. PSNSTTs are perceived as curriculum implementers. They can contribute to improving science and technology education by being aware of and understanding global challenges as well as ways to address these. The teachers can thereby contribute to ESD in South Africa. The knowledge about sustainability imparted to learners could be taken back to communities. In this way, ESD consciousness will be nurtured and the sustainable development goals can be realised.

2.10. Conceptual Framework

The conceptual framework used for this study is based on and developed from the UNESCO's (2005) basic three sphere model of sustainability. These are related to the United Nation (2015) seventeen key sustainable development goals, which are intended to be met by the year 2030 through the Global Action Programme. The model tries to understand the aspects of the sustainable development goals which speak to either environment, social and economic aspects of sustainability. By implication, ESD is a multidisciplinary concept that should be addressed through all subject specializations in both the formal and informal teaching and learning environments. Nonetheless, the focus of the study is on the sustainable development goals, which can be addressed through science and technology education. The model thus includes Natural Sciences and Technology education, which is integrated at the Intermediate Phase of the South African curriculum, as a tool for achieving ESD in the three spheres of sustainability. The pre-service Natural Sciences and Technology teachers who participated in this study are trainee Intermediate Phase teachers.

As defined by UNESCO (2009 b), "Education for Sustainable Development (ESD) is a learning process (or approach to teaching) based on the ideals and principles that underlie sustainability and is concerned with all levels and types of learning to provide quality education and foster sustainable human development – learning to know, learning to be,

learning to live together, learning to do and learning to transform oneself and society” (UNESCO 2009 b, p. 26). Consequently, ESD in this study is analysed using the table below to describe the roles of education in foregrounding sustainable development. The table below analyses the UNESCO (2015) agenda 2030 sustainable development goals.

Table 2: A breakdown of the sustainable development goals and role of ESD

UNESCO (2015) Sustainable Development Goals	ESD through Intermediate Phase Natural Sciences and Technology
Goal 1: End poverty in all its forms everywhere.	<ul style="list-style-type: none"> ▪ Career orientation for better income jobs and self-reliance; employability skill; food production; agricultural income programs; Reduce – living according to income, Reuse – economize by using already acquired resources multiple times, and Recycle – recycling used resources to avoid buying new product by creating them (3Rs).
Goal 2: Ending hunger, achieve food security and improved nutrition and promote sustainable agriculture.	<ul style="list-style-type: none"> ▪ Improve nutrition; healthy diets; knowledge of essential vitamins and micronutrients; water and environmental sanitation to improve hygiene practices and avoiding food contamination. ▪ Food production as it relates to the environment; the concept of photosynthesis.
Goal 3: Ensure healthy lives and promote well-being for all at all ages	<ul style="list-style-type: none"> ▪ Educate on hygiene and disease control in children; seek health care services; teaching importance of vaccination; prevention of diseases such as pneumonia and malaria; HIV and AIDS education. ▪ Effects of pollution and contamination of air, water and soil on human health. ▪ Healthy diets, consequence of unhealthy diets; Overweight and obesity, physical activity.
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	<ul style="list-style-type: none"> ▪ Government policies to ensure provision of equal education opportunities for all learners; parents should make education a priority for their children ▪ Degendered science and technology career (Martin and Barnard, 2013).
Goal 5: Achieve gender equality and empower all	<ul style="list-style-type: none"> ▪ Inclusive and degendered science and technology career orientation to empower both male and female children economically and

women and girls	attitudinally.
Goal 6: Ensure availability and sustainable management of water and sanitation for all	<ul style="list-style-type: none"> ▪ Water resource management and environmental sanitation; Rain water harvesting and management; irrigation technology for farmers; water, recycling, purification methods such as boiling and filtering. ▪ Water cycle and water distribution; effects of water depletion; drought, death of crops; water and human health, waterborne diseases. ▪ “Impacts of pollution, dumping and release of hazardous chemicals and materials on water quality, importance of water-related ecosystems” (UNESCO, 2017, p. 23).
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.	<ul style="list-style-type: none"> ▪ Sources of energy; renewable energies such as solar, wind, water, geothermal, tidal energy: production, supply, demand and usage of different countries. ▪ Renewable energy vs Non-renewable energy. ▪ Sustainable energy – use of reliable and affordable solar energy; uses of energy such as solar energy in photosynthesis; learning about energy and its impact on the environment; Economies in household energy consumption such as electricity; energy affordability; alternative energy creation. ▪ Energy efficiency and sufficiency in energy usage strategies: Centralized versus decentralized energy production; energy self-sufficiency, e.g. through local energy supply companies ▪ Political, economic and social dimensions of energy and their link to power constellations, e.g. in mega energy projects such as large scale solar farms or dam projects – potential conflict of interests (political and economic power, across borders, rights of especially indigenous people) ▪ Environmental impacts and issues of energy production, supply and usage (e.g. climate change, grey energy) ▪ The role of the public and private sectors in ensuring the development of low carbon energy solutions.
Goal 8: Promote sustained, inclusive and sustainable	<ul style="list-style-type: none"> ▪ Advocacy for career orientation to economic empowerment of both male and female children.

economic growth, full and productive employment and decent work for all.	<ul style="list-style-type: none"> Production which increases trade and improves small and medium scale enterprise.
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	<ul style="list-style-type: none"> Eco-design, Design process model, innovative architecture and engineering; Information and communication technology; “Waste disposal and recycling, the relation of quality infrastructure and the achievement of social, economic and political goals; The need for basic infrastructure like roads, sanitation, electrical power and water; sustainable electricity: expanding sustainable renewable sources, Ecological footprint” (UNESCO, 2017, p. 29).
Goal 10: Reduce inequality within and among countries	<ul style="list-style-type: none"> Equitable educational and social service delivery; Social justice education; Peace education; “Expanding education, ensuring that most people have completed secondary schooling” (UNESCO, 2017, p. 9); Agricultural boost; Reduce income inequality through education.
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.	<ul style="list-style-type: none"> Access to greater social infrastructure and income opportunities; through learning science and technology, provision of social facilities to rural communities; improving environmental, social and economic wellbeing; appreciation of aesthetics; Industrial productivity and distribution; “Equitable education service delivery is critical to tackle the roots of discontent in cities” (UNESCO, 2017, p. 10). Natural resources management sustainable energy use (residential energy use, renewable energies, community energy schemes) and transportation; sustainable food distribution through agriculture; ecology and wildlife preservation, protection of endangered species. Sustainable resilient buildings and spatial planning (building materials, energy saving, planning processes) Waste generation and management (prevention, reduction, recycling, reuse). “Communities and their dynamics (decision-making, governance, planning, conflict resolution, alternative communities, healthy communities, inclusive communities, ecovillages, transition towns,

	<ul style="list-style-type: none"> ▪ Water cycle and restoring ground water through urban design (Green roofs, rainwater harvesting, sustainable urban drainage) ▪ Disaster preparedness and resilience, resilience to weather problems and in the future and a culture of prevention and preparedness” (UNESCO, 2017, p. 33).
Goal 12: Ensure sustainable consumption and production patterns	<ul style="list-style-type: none"> ▪ Reduce: living according to income, Reuse: economize by using already acquiring resources multiple times, and Recycle: remodeling used resources to avoid buying new product by creating them – considering affordability (3Rs). Environmental and social impacts of production and consumption; energy production and consumption (transport, commercial and residential energy use, renewable energies). ▪ Food production and consumption (agriculture, food processing, dietary choices and habits, waste generation, deforestation, overconsumption of food and hunger).
Goal 13: Take urgent action to combat climate change and its impacts	<ul style="list-style-type: none"> ▪ Effects of greenhouse gases and their emission on the environment, crops and human health ▪ Climate change-related hazards, effects of and impact on big eco-systems leading to disasters such as drought, loss of biodiversity weather extremes., Social and economic impact within households, communities and countries ▪ Lifestyle (such as smoking), useful ethics of the environment, health, affordability of health care systems ▪ Local, national and global institutions addressing issues of climate change ▪ Local, national and global policy strategies to protect the climate. ▪ Government’s policies to combat climate change (such as emission policies). ▪ Green designs.
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.	<ul style="list-style-type: none"> ▪ The water cycle, cloud formation, water as the great climate regulator ▪ Management and use of marine resources (renewables and non-renewables): global commons and overfishing, quotas and how they

	<p>are negotiated, aquaculture, seaweed, mineral resources</p> <ul style="list-style-type: none"> ▪ Sustainable Marine Energy (renewable energies, wind turbines and their controversy) ▪ Marine ecology – the food web, predators and prey, competition, collapse ▪ Coral reefs, coasts, mangroves and their ecological importance ▪ Sea level rise and countries that will experience total or partial loss of land; climate refugees and what a loss of sovereignty will mean ▪ The oceans and international law: international waters, territory disputes, flags of convenience and their related issues ▪ Ocean pollutants: plastics, microbeads, sewage, nutrients and chemicals ▪ The deep ocean and deep-sea creatures ▪ Cultural relationships to the sea – the sea as a source of cultural ecosystem services such as recreation, inspiration and building of cultural identity.
<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<ul style="list-style-type: none"> ▪ Ecology: competition, predator-prey, community dynamics, energy flow through food webs, dispersal and ranges; Specific ecosystems – natural and human-made, e.g. managed forestry plantations. ▪ Threats to biodiversity: habitat loss, effects of deforestation, fragmentation, invasive species and ▪ Consequences of unsustainability practices ▪ Protection and preservation of endangered species; restoration of wildlife; climate change and biodiversity, ecosystems, Soil desertification, effects of deforestation to the ecosystem. ▪ Evolution and genetics.
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</p>	<ul style="list-style-type: none"> ▪ “Definitions of justice: retributive and rehabilitative, Crime and punishment, comparing laws and punishments across the globe ▪ Climate Justice; Trade Justice; Child labour and exploitation of children ▪ Global treaties and agreements related to war, peace and refugees; Corruption and how to measure it; the illegal weapons trade ▪ Drug abuse and its trade

	<ul style="list-style-type: none"> ▪ The international criminal court and its role” (UNESCO, 2017, p. 43).
Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development (United Nations, 2015, p. 14).	<ul style="list-style-type: none"> ▪ “Global partnerships between governments, the private sector such as SMEs, and civil society for sustainable development. ▪ Global policies attending SD issues. ▪ Global citizenship and citizens as change agents for SD. ▪ Cooperation on and access to science, technology and innovation, and knowledge sharing ▪ Global distribution of access to the internet ▪ Development cooperation, development assistance, and additional financial resources for developing countries from multiple source ▪ Capacity-building to support national plans to implement all the sustainable development goals ▪ Measurements of progress on sustainable development” (UNESCO, 2017, p. 45).

The UNESCO (2005) three pillar model is represented diagrammatically below in Figure 2, followed by the conceptual framework which is specifically developed for this study.

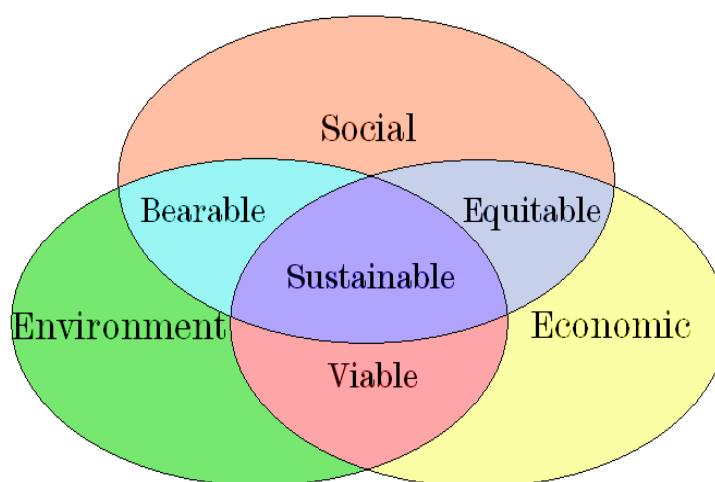


Figure 2: The interdependency of the 3 spheres of sustainability.

Adapted from UNESCO (2005) DESD 2005-2014 International Implementation Scheme.

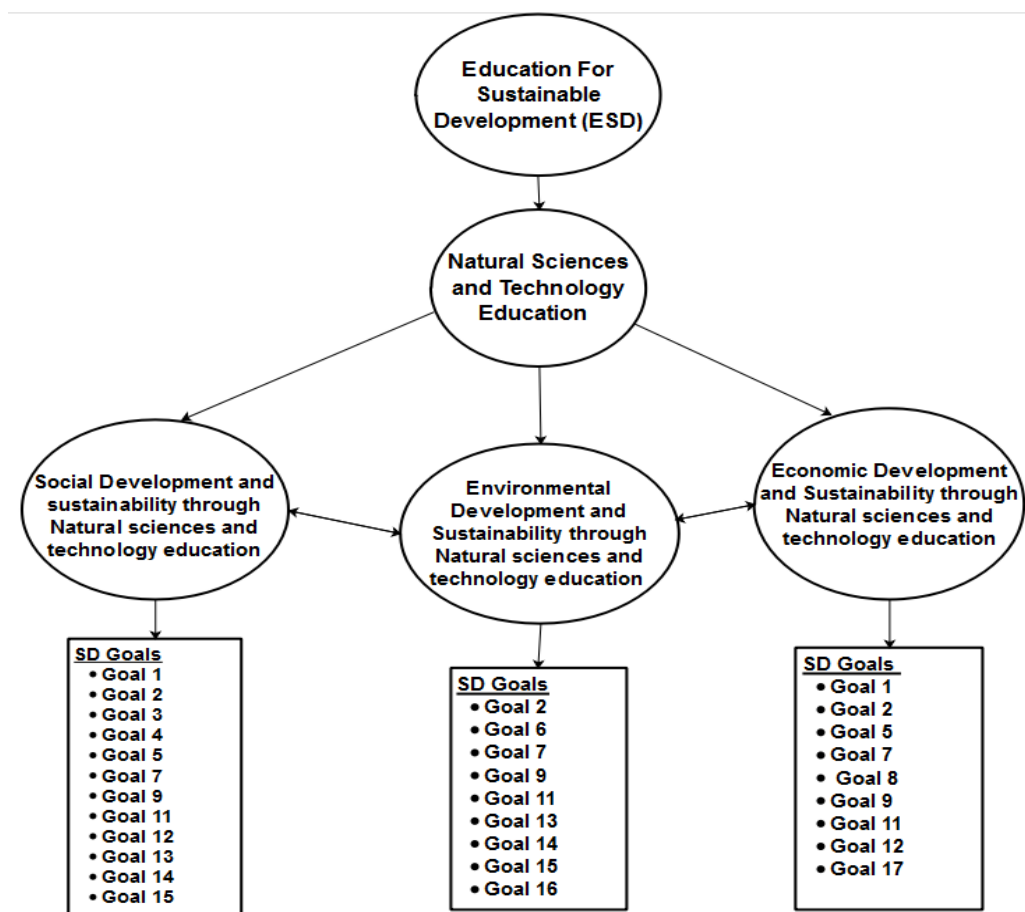


Figure 3: Conceptual framework of ESD in Natural Science and Technology Education.

The interdependence of the three spheres of sustainability (Society, Environment and Economy) and the possibility of reaching the various UNESCO (2015) sustainable development goals through Natural Sciences and Technology education, are represented in Figure 3 above. The spherical representation is an indication that science and technology education in an integrated learning area that has a major role to play in ESD, especially at the Intermediate Phase. According to the diagram in Figure 3 ESD in natural sciences and technology education provides a proper link to the sustainable development goals that cut across social, environmental and economic sustainability. The above framework will be used during the analysis of data. The three pillars will be used when examining PSNSTTs conceptions of ESD and the sustainable development goals will be used to illuminate which goals are embraced in their actions.

2.11. Conclusion

This chapter highlighted discussion around Education for Sustainable Development (ESD) by examining published literature and scholarly contributions from previous studies. The chapter

thus reveals that the important idea of ESD can be examined from different perspectives. ESD has been broadly conceptualised and discussed by numerous researchers and scholars, yet there are still many issues still to be addressed. It is also obvious that ESD is a multidisciplinary concept, but it is evident that ESD should be integrated, especially in higher education institutions. A cross-examination of practice-based implementation strategies in teaching and learning settings ought to be conducted. This places science and technology education teachers and curriculum developers at the pivot of implementation through the sustainable development goals.

The conceptual framework used to underpin this study is framed from the UNESCO (2015) sustainable development goals. Notably, most developing and ambitious nations such as South Africa have realised the global concerns of sustainability, and have taken promising steps to actualize sustainability in all aspects of the society through education. Numerous scholars have suggested innovative teaching methods by which ESD can be addressed in formal education systems; particularly within natural sciences and technology, hence assigning the responsibility of effective incorporation of ESD into the hands of educators. Regarding implementation of ESD in higher education institutions, scholars have suggested a 'whole institution approach', which assigns all facets of higher institutions with the responsibility of demonstrating consciousness around the three pillars of sustainability. Studies have revealed the gap in implementing ESD in higher education institutions (HEIs) as it is still only being discussed rhetorically in this context. UNESCO (2017) agrees that implementation of ESD is crucial in HEIs with several reasons and "the higher the percentage of tertiary education students in the total population, the higher the air pollution index" (UNESCO, 2017, p. 10).

The next chapter of this dissertation will discuss the research methodology used in the study.

CHAPTER 3.

RESEARCH METHODOLOGY

“Not everything that can be counted counts, and not everything that counts can be counted” - Albert Einstein.

3.1. INTRODUCTION

This chapter presents, the research design and methodology used in this study. First, I discuss the research paradigm that guided this study, followed by a justification for adopting a qualitative case study research approach. Subsequently the research design is outlined with reasons for particular choices. The method of data generation, sampling, location of the study, research instruments and data analysis used in this study are highlighted. Attention is also paid to ethical issues, research vigour, strategies used to ensure trustworthiness in the study and finally the limitations encountered in the study.

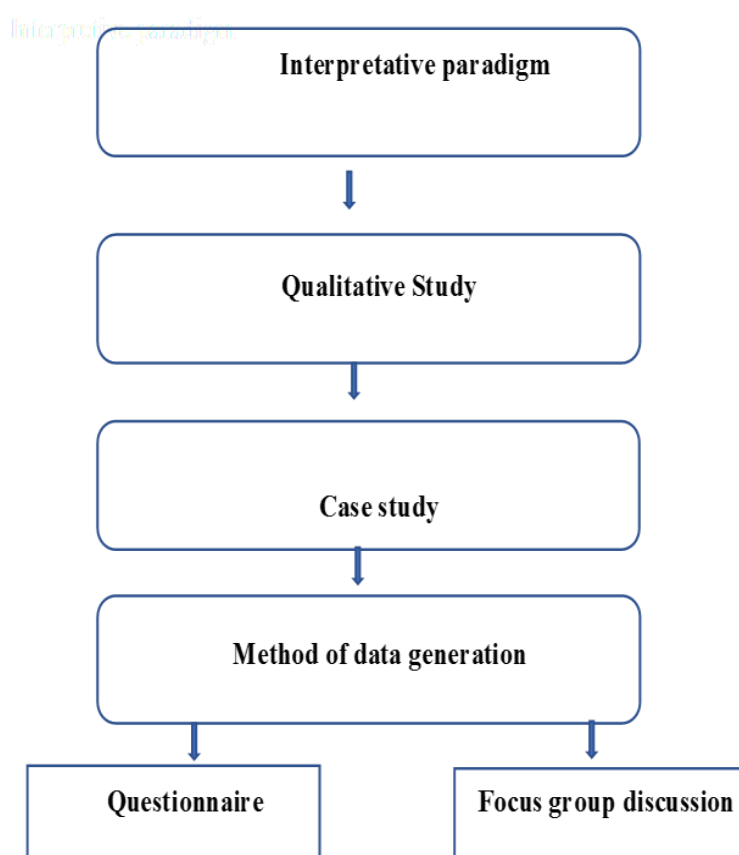


Figure 4 Diagrammatic representation of research methods and approach to this study

3.2. CONTEXT OF THE STUDY

For this research, the sample was drawn from intermediate phase pre-service Natural Sciences and Technology teachers, enrolled in a B.Ed. programme. The B.Ed. is a 4-year

programme in which teachers can specialize in the Further Education and Training phase, Senior Phase, Intermediate phase and Foundation phase. In primary schools within the South African context, in the intermediate phase (Grades 4 to 6) Natural Sciences and technology are integrated into a single learning area, in order to ensure learners are both scientific and technological literate. Consequently, the context of this study is the Technology Processing (EDTE 220) and Natural Science Method 2 (NSM 2) modules within the Science and Technology Education cluster, at Richmond University. These are, respectively, a content module and a methods module. These two modules were chosen for this study because the goal of this research was to explore the experiences of PSNSTTs in learning about ESD, they modules speak directly to my research question. They thus covered both learning about ESD and learning how to teach. The EDTE 220 and NSM 2 module.

The Technology Processing EDTE 220 module is a content module, which emphasizes the subject matter of the discipline. The module is offered in the first semester of the year. The module outcomes are to:

- Increase awareness in Pre-service Natural Sciences and Technology Teachers (PSNSTT) of the need for sustainable use of resources, waste reduction, management and recycling in communities.
- Engage PSNSTTs in problem-based learning.
- Enhance PSNSTTs' learning by joining theory with experience and thought with action in a community setting.
- Enable PSNSTTs to help and enter into caring relationships with others and their community.
- Increase the civic and citizenship skills of PSNSTTs.
- Assist communities to benefit from engagement with PSNSTTs.
- Enable PSNSTTs to engage in reflective practice whilst learning.

The plastics section of the EDTE 220 module focuses on the chemistry related to plastics, It covers the production and processing of plastics from its initial building block of crude oil (a non-renewable resource), the properties of plastics, and their advantages and disadvantages. An ESD lens is used to examine the disposal of plastics and their impact on the environment and human health.

Teaching methods courses are judged to be the most appropriate was of incorporating ESD into pre-service teacher education, according to Heimlich, Braus, Olivolo, McKeown-Ice and

Barringer-Smith (2004). These authors contend that ESD requires many resources and integrating it with method modules will enhance knowledge through the content embedded in such modules. The Natural Sciences Methods module, NSM 2, is a teaching methods module and, as such, emphasizes approaches to teaching and “how to teach”, in other words the relevant PCK for Natural Sciences. Besides, intermediate phase teachers learn these modules different at university level while implementing the integration in field. NSM 2 is a first semester module in the second year of study in the B.Ed. programme. The module aim is “to prepare students to teach Natural Sciences at the intermediate and senior phases” of the South African schooling system. The content of the module includes “Learning Theories, Practical Work and Investigations, Demonstrations, Improvisations, Laboratory Safety, Problem Solving, Concept Mapping and Indigenous Knowledge Systems” as they relate to Natural Sciences (University Handbook, 2017).

3.3. RESEARCH PARADIGM

A paradigm is regarded as one of the frames of references we use to organise our observations and reasoning (Babbie, 2011). This study is underpinned by an interpretive paradigm. According to Cohen, Manion and Morrison (2011) the main concern of the interpretivist paradigm’s is to understand the subjective world of human experience, in order to derive meaning from shared experience. Similarly, Bertram and Christiansen (2014) state that the purpose of an interpretivist paradigm’s is to develop a better understanding of how people make sense of contexts in which they live, work and learn. This means that researchers employing an interpretive paradigm aim to describe and make sense of social phenomena, such as peoples opinion and experiences, in order to develop a greater understanding of how people make sense of the contexts in which they live and work. The interpretivist paradigm has the following characteristics as given by Cohen et al. (2011). It focuses on the individual, is small- scale research, acknowledges subjectivity, is qualitative in nature, has multiple directions of causality, seeks understanding of actions or reasons rather than cause and effect. Researchers using this paradigm thus focus on the specific context in which people live and work (Creswell, 2013). This study is concerned with understanding the interpretations of experiences of learning about ESD among intermediate phase pre-service Natural Sciences and Technology teachers’ (PSNSTTs) at Richmond University.

The ontological assumptions of the interpretative paradigm required me to take into consideration that multiple realities exist. I understood the multifaceted reality of how PSNSTTs experience learning about ESD, and that I could only understand this reality from

the meaning the participants attach to it. Cohen, Manion and Morrison (2007) state that the role of the researcher in the interpretive paradigm is to understand, explain, and demystify social reality through the eyes of the participants (p.16). For that reason, as the data for this study, I will use the descriptions given by the participants of their experiences and opinions of learning about ESD.

3.4. QUALITATIVE RESEARCH APPROACH

This study uses a qualitative research approach because I sought to explore PSNSTTs experiences of learning about ESD at university. In this choice, I was guided by the ontological position of the interpretative paradigm. The notion of constructing multiple social realities is fundamental in a qualitative approach and it is recommended by Johnson and Onwuegbuzie (2004, p.20) for furnishing comprehensive descriptions of human experiences of a phenomenon. Qualitative research offers suitable approaches when seeking to know or interpret in-depth understanding of a real-life phenomenon, such as human subjective experiences, contexts or conditions of living, social behaviors, understanding or conceptions, views and perspectives on social issues (Yin, 2011). Creswell (2013) and Rosnow and Rosenthal (2008) all agree that qualitative research is concerned with understanding participants' views, experiences, beliefs, ideals, thoughts and actions of social or human problems.

Qualitative research is an advantage when investigating a completely unknown or unpredictable situation Creswell, (2013). It allows participants to express their opinions without bias, thereby providing uncut data for the researcher. Furthermore, qualitative research involving human subjects makes use of audio, visual or textual data which enable the research to deduce meaning from active social context (Henning, Van Rensburg, and Smit, 2004). Accordingly, qualitative data analysis involves the researcher being able to develop a pattern or theme which best describes the phenomenon observed (Creswell, 2012). In this study, intermediate phase pre-service Natural Science and technology teachers' experiences of learning about ESD were explored with a view of gaining in-depth knowledge of their individual and group learning experiences with respect to ESD.

3.5. CASE STUDY RESEARCH DESIGN

A case study design was embraced to explore qualitatively intermediate phase pre-service Natural Sciences and Technology teachers' experiences of learning ESD in a university. According to Yin (2009), a case study is an approach to research that facilitates exploring a

phenomenon within its context using a variety of data sources. Resonating with Yin's (2009) idea of case study, Creswell (2012) defined a case study as "an in-depth exploration of a bound system which could be an activity, event, process or individuals" (p. 462). In describing the underlying philosophies of case study research, Njie and Asimiran (2014) suggests that case study research is often grounded by time (in which data is generated or intended to be generated), phenomenon and context. A case cannot be considered without its context. The context binds the case. In this study, the case explored is PSNSTTs' experiences of learning about ESD. The context is bounded to intermediated phase natural science and technology at a particular university.

The hallmark of the case study approach, according to Lapan et al. (2011, p. 245) and Cohen et al. (2013), is that the methodology provides thick descriptions of participants' lived experiences of, or thoughts about and feelings for, a situation, using multiple data sources. These authors further contend that the strength of the case study approach lies firstly in its being concerned with rich and explicit descriptions of events relevant to the case; its focus on individual actors or groups of actors, seeking deep understanding of their views; and secondly that the researcher is involved in the case, because the case study may be linked to the researcher on a personal or professional level.

Case studies may be categorized with regards to their outcomes, which include exploratory, descriptive and explanatory case studies (Yin, 1994). An exploratory case study is a suitable means of eliciting information in order to seek new insights and clarify ones understanding of a process or problem. The exploratory approach provides new and detailed information or insight about a phenomenon through the research findings, which could inform policy or serve as the background for further research. Descriptive case studies focus on providing narrative accounts, while an explanatory case study would deal with hypothesis testing. Bearing Yin's classification in mind, this study embraces an exploratory case study approach based on the purpose of the study; to explore PSNSTTs experiences about of learning about ESD at a chosen university.

Case study design both sets the parameters for sampling and suggests the methods of generating data. These two aspects are discussed in the next sections.

3.6. SAMPLING AND SAMPLING METHOD

Sampling involves making decisions about which people, settings, events or behavior to include in the study (Bertram and Christiansen, 2014). Flick (2009) asserts that the process

of sampling is important for data collection, interpretation and presentation of findings. It is important because it enables researchers to choose participants and data collection methods rationally. For this study, selection of participants was guided by my research design. The specified criteria of the case and the context required that participants had to be intermediate phase pre-service Natural Sciences and Technology teachers learning about ESD within the context of the natural sciences content and method module as well as technology processing module and technology method module. They were purposively selected. Purposive sampling is described by Rule and John (2011) as the “sampling where the people selected, as research participants, are deliberately chosen because of their suitability in advancing the purpose of the research” (p. 64). Intermediate phase pre-service Natural Sciences and technology teachers were thus purposively targeted as participants in the study. I made judgments about which participants to choose using snowball sampling to select participants for the study. In this sampling method, potential participants were referred to by their acquaintances (Cohen et al., 2011). I already knew one of the PSNSTTs, who lived at the university residence. I also live in the same university residence. The other PSNSTTs were then approached to volunteer to participate in this study. There is a total of twenty pre-service enrolled in the relevant modules to train as intermediate phase natural science and technology teachers, of which 20 were selected as participants in the study.

3.7. LOCATION OF THE STUDY

This study is located within the Science and Technology education cluster at the Marian Ridge campus of Richmond University. Marian Ridge campus and Richmond University are both pseudonyms used in this study to protect the identity of the institution. Richmond University is located within the KwaZulu-Natal province of South Africa. The Marian Ridge campus specializes in the training of pre-service teachers in various disciplines and phases as part of a B.Ed. programme. The pre-service teachers training at the Marian Ridge campus represent South Africa's rainbow or multi-cultural population.

3.8. RESEARCH INSTRUMENTS

In order to answer the research questions given in chapter one Section 1.5, two instruments were used to capture data; a questionnaire and focus group interviews. These instruments were chosen as they were suitable for collecting the qualitative data needed in this case study.

3.8.1. Questionnaires

Questionnaires have several advantages over other research instruments. Firstly, they are relatively economical in terms of both time and money (McMillan & Schumacher, 2006). Perhaps more importantly, questionnaires provide identical questions to a sample of participants, unlike other techniques such as interviews or observations where these may vary. Finally, they allow adequate time for the participants to think about their responses.

The rationale for using the questionnaire as the first instrument of data capture was twofold. First, it allowed participants the opportunity to answer the questions privately, with the information written down by the participants in their own words. These aspects reduce the possibility of the researcher misunderstanding information and then misrepresenting it in field notes.

A questionnaire was therefore designed with the assistance of university researchers. It comprised both closed and open-ended questions (see appendix F for ESD questionnaire). Using a questionnaire with both closed and open-ended items to collect data for this study was deemed suitable in order to capture the specificity of a particular situation (Cohen et al., 2011); which in this study is an exploration of intermediate phase PSNSTTs' experiences on learning about ESD. Closed questions were used as they facilitate easy collection of data for an overall picture on PSNSTTs' attitudes and behavior towards ESD. Open-ended questions, according to Cohen et al. (2011), make it possible and easy for the respondents to answer without any restrictions on what they wish to say. This makes it suitable for enquiring into complex issues, which demand more than just simple answers.

In as much as the questionnaires have advantages, Yin (2011) also gives a critique of their disadvantages. For example, questionnaires are standardized, so it is not possible to explain any points in the questions that participants might misinterpret. To overcome the above-mentioned disadvantage the questionnaire was piloted with senior Further Education and Training phase pre-service Natural Sciences and Technology teachers. The questionnaire was piloted to check the clarity of the questionnaire items, and to eliminate ambiguities or difficult wording. According to Cohen et al. (2011) a pilot study serves to increase the reliability, validity and practicability of the questionnaire. The outcome of the piloting was that the questionnaire items had good construct validity. Changes were made to two questions to avoid ambiguity.

Further disadvantages of questionnaires, according to Yin (2011), are that participants might not wish to reveal the information required, or they might think that their responses are incorrect. To overcome the preceding disadvantages participants were assured about the confidentiality of answers. They were also assured that there were no right or wrong answers and were urged to respond honestly.

The questionnaire for this study was design to answer all the research questions through both closed and open-ended questions. The first section of the questionnaire targeted biographical data in order to establish the topography of the intermediate phase PSNSTTs. The second section of the questionnaire focused on multiple-choice questions, designed to explore the PSNSTTs basic understanding and awareness of the concept of ESD, their attitudes towards ESD and their behavioral actions associated with ESD. Thereafter, the questionnaire offered open-ended questions where the participants filled-in their own responses, which were used to explore their conceptual understating of ESD.

Copies of the questionnaire were delivered personally to 20 intermediate phase PSNSTTs within the Science and Technology cluster at Marian Ridge campus. Participants were given one week in which to complete the questionnaire, before it could be collected from them. As a follow-up measure, telephone calls were made to participants after four days to remind them to complete the questionnaire in time (Kerruish, Settle, Campbell-Stokes and Taylor, 2005). Contrary to expectation, it took two weeks to retrieve the distributed questionnaires. The return rate of the questionnaire was 85%. The returned questionnaires were coded from P1 up to P16 (P1 up to P16) to represent the seventeen respondents who completed and returned the questionnaires.

3.8.2. Focus Group Interview

Focus groups are a qualitative method that offer unstructured discussion between researcher and participants (Cohen et al.,2011). They usually involve between four and twelve people “exploring a specific set of issues” (Tong, Sainsbury, and Craig, 2007, p. 351). Yin (2011) also emphasizes that “the groups are ‘focused’ because you have gathered individuals who previously have had some common experience or presumably share some common views” (p. 141). According to Kvale and Brinkmann (2009) the intention of a focus group interview is not to arrive at a unanimous decision but rather to articulate different points of views.

Before the focus group interviews, I had prepared a protocol that involved a schedule of questions designed to provide answers to my research questions, but still allow the participants to engage freely and give their insights as they related to the phenomenon under research (see Appendix G for focus group interview schedule). The interview questions thus related to the experiences of intermediate phase pre-service natural sciences and technology teachers about learning ESD within these learning areas. The interview protocol was semi-structured and open-ended so as to allow the participants to provide details of their experiences in order to reveal the way they perceived their reality.

Check and Schutt (2012, p. 205) affirm that “focus groups generate qualitative data using open-ended questions posed by the researcher or group leader”. Krueger and Casey (2009, p. 7) agree that “the data in the focus group are solicited through open-ended questions”. Some of the participants were prompted to speak while listening to their peers’ contributions. This corroborates Patton’s (2002) view that in focus group interviews, participants can provide more perceptiveness as they pay attention to their peers’ opinions”. Similarly, Cohen et al. (2011, p. 436) are of the view that “it is from the interaction of the group that the data emerge”.

There are several merits attached in using focus group interviews as posited by Fahad (as cited in Ngunjiri, 2013, p 108), which are shown below in Table 3

Table 3: Merits of Focus group interviews

S/N	Merit	Merits explained.
1	Synergism	Combined effect of the group produces a wider range of information, ideas, among others.
2	Snowballing	When a member of the group raises a comment, the comment often triggers a chain of responses from other participants in the group.
3	Motivation	Participants tend to respond quicker after the first course and are more likely to express their attitudes and feelings as the overall level of enthusiasm increases.
4	Security	Most participants find comfort in a group that shares their feelings and beliefs
5	Spontaneity	Since a participant is not meant to answer specific questions, their responses are likely to be more spontaneous and less conventional.
6	Serendipity	The ethos of the group is likely to produce wider ideas and often when least expected
7	Specialisation	The content allows a more trained interviewer to be used and

		minimise the possibility of subjectivity.
8	Scientific scrutiny	The nature of the research gives room for scrutiny in the technique by allowing the observers playing back and by analysing recording sessions.
9	Structure	Discussions afford more flexibility in the topics that can be covered and in the depth in which these are treated
10	Speed	Given that several participants are being interviewed at the same time, this speeds up the process of collecting and analysing data.

Two sets of focus group interviews were conducted. Each group had 8 participants, participants self-selected their groups. The focus group interviews were both audio recorded.

3.9. DATA GENERATION PLAN

In qualitative research, the term data generation is preferred rather than data collection as the process entails intellectual, analytical and interpretative activities, rather than measurements. It is necessary to have a data generation plan in order to ensure that all research questions posed were answered. Table 4, below reflects the steps that were undertaken to generate data. Data were generated in two phases. The first phase entailed generating data through the questionnaire (Appendix F) and in the second phase focus group interviews were conducted with intermediate phase PSNSTTs (Appendix G).

Table 4: Data generation plan

Research Question	Phase	Data source	Instrument
1. What are intermediate phase pre-service Natural Sciences and Technology teachers' understanding of ESD?	1	20 Volunteers PSNSTTs who are registered for Natural Sciences and Technology method modules.	Questionnaire
2. How does learning about ESD affect the attitudes and behavioral actions of intermediates phase pre-service Natural Sciences and Technology teachers?		20 Volunteers PSNSTTs who are registered for Natural Sciences and Technology method modules.	Questionnaire

3. What are the views of intermediate phase pre-service Natural Sciences and technology teachers on the ESD content included in the Natural Sciences and Technology modules?	2	6 PSNSTTs	Focus group interview
4. What challenges or enables intermediate phase pre-service Natural Sciences and technology teachers to learn about ESD in science and technology modules?	2		Focus group Interview

3.10. METHOD OF DATA ANALYSIS

“Qualitative data analysis involves organizing, accounting for and explaining the data; in short, making sense of data in terms of the participants’ definitions of the situation, noting patterns, themes, categories and regularities” (Cohen et al., 2011, p. 537). Scholars such as Creswell (2013), Mouton (2001) and Cohen et al. (2013) consider that data analysis consists of the following tasks:

- Preparing and organizing the data,
- Reducing the data into themes, and
- Representing the data in figures, tables or discussions.

Whilst these three tasks were all undertaken in this study when answering the research questions, I was always aware that data analysis is not a linear, process. Instead, it is, as Creswell (2013, p.228) says “inductive”, “iterative”, “eclectic” and “interpretive”. Data analysis entails working from specific sets of data to develop general codes and patterns. The unit of analysis in this study is intermediate phase PSNSTTs experiences of learning about ESD. Data were analyzed in each phase of the study.

Phase 1.

The returned questionnaires were numbered P1 to P16. The responses to each question were read and re-read to note the content of the responses and to begin the coding process.

Phase 2.

All focus group interviews were transcribed verbatim and sent to participants for member checking, as explained later in Section 3.13. The interview transcripts were read several times and coded in response to the constructs of my conceptual framework (Social, Environmental and Economic sustainability respectively, through Natural Sciences and Technology education). Coding refers to relating standardized remarks made in transcripts and grouping them together into sections (Adler and Clark, 2008). I adopted the “open-coding” approach where “concepts” are used to convey the information derived from the data collection methods (Flick, 2006, p. 297). Open-coding was accomplished using the “line-by-line and phrase by phrase” technique (Cohen et al. 2011, p. 561). The participant’s experiences about learning ESD were categorized and coded. Codes were regrouped into themes. Thematic analysis in qualitative research is described by Roulston (2010, p. 150) as “sorting and classifying codes into groupings or clusters”. Braun and Clarke (2006, p.19) also mention that “thematic analysis reports experiences, meaning and the reality of participants”.

The links or interplay between the three dimensions from my conceptual framework were traced across the data from both the questionnaire and interview and then juxtaposed to reveal intermediate phase PSNSTTs experience of learning about ESD.

3.11. ETHICS AND GAINING ACCESS

Ethics entails moral justification for doing the right or wrong thing during interactions among humans, animals or the environment. As such it must be considered carefully at different stages in the research process (Miller and Brewer, 2003). In order to adhere to the ethical standard during this research project the following rights and responsibilities were assumed: the rights of participants taking part in the research, circumventing harm to participants, avoiding undue intrusion, obtaining informed consent, rights to confidentiality and concealment and the rights of participants during data dissemination (Creswell, 2013).

In this study, sensitive information was gathered from intermediate phase PSNSTTs concerning their experiences of learning about ESD within the science and technology modules. As a result, the identities of both the PSNSTTs and the university needed to be protected. I ensured their anonymity and confidentiality by the use of pseudonyms. Ensuring that the ethical considerations mentioned above were adhered to, gave the participants the confidence to share their views and experiences of learning about ESD without fear of

exposure. Moreover, this assurance contributed to a trustworthy environment, which allowed high levels of participation and openness during the focus group interviews. As a result, participants were quite willing to be involved in the study and saw it as an opportunity to share their experiences of learning about ESD.

The rights of individuals (participants or respondents) taking part in a research study is expressed as informed consent, anonymity, privacy and confidentiality (Cohen et al., 2011). Informed consent entails ensuring that the participants taking part in a study must have the legal and mental capability to accept responsibility of taking part in a study, and also ensures their right to withdraw as and when they wish to, particularly if the purpose of the study was not clearly understood by the participants. To this end, permission to conduct the research was obtained formally from my university's research office. The certificate to this effect is included in this thesis (see appendix B for ethical clearance certificate). Permission was also sought from the registrar of Richmond University, the Dean of the School of Education as well as the cluster leader for science and technology education.

Then permission was also sought from the participants; individual intermediate phase PSNSTTs, who were enrolled for the Natural Science and Technology modules. This involved informing them about the background to and purpose for the study. Participants were assured that they could withdraw from the study at any time they chose to and they would also be guaranteed confidentiality and anonymity. A total of 16 PSNSTTs consented to participate in this study. I have come to realise that gaining access is an iterative process. It entailed dealing with various gatekeepers at each stage of the research.

3.12. ENSURING RIGOR IN THE RESEARCH

Rigor entails all the steps in the study taken to ensure thoroughness or consistency. Therefore, a study is flawed if rigor is not ensured. Krefting (1991) states that the worth of any research study, regardless of the approach taken, is for the study to be critically evaluated by readers. Accordingly, the research report must be presented in a manner that it can be critiqued by readers or researchers. In this study, the use of multiple data generation methods, that is questionnaires and focus group interviews, were measures taken to ensuring research rigour. According to Mays and Pope (1995), issues of trustworthiness and validity inform rigour in qualitative research. Other measures taken in this study include participant's reflection and member checking used during that data generation stage and data transcription processes respectively. Also, audio data generated in the interviews was transcribed verbatim to ensure

accuracy of participants' response before developing themes. Participants' reflection and member checking are discussed next in Section 3.13.

3.13. TRUSTWORTHINESS

Trustworthiness is an element of rigor; it is a measure of whether the findings of a research study can be relied on by readers. It speaks to the processes followed in gathering data or information. Shenton (2004) suggest that trustworthiness in qualitative research can be ensured if appropriate research methodology is applied. As this study is a qualitative study, I had considered the entire research design to ensure fitness of purpose. Using participants' personal reflections at the data generation stages (especially during the interview) was an important means of ensuring trustworthiness. In the focus group interview, my participants were given a chance to restate what they had previously stated, just to be sure that they had meant what they said. The interview questions were open ended question in order not to impose opinions on the participants.

One of the key steps taken to ensure trustworthiness is known as 'member checking'. Creswell and Miller (2000) suggest that member checking is related to participant reflection, and "consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and narrative account. A popular strategy is to convene a focus group of participants to review the findings, or have the participants view the raw data and comment on their accuracy" (p. 127). For this study, member checking was applied at the first stage of data generation (use of questionnaires). Participants who returned their fully completed questionnaires were asked to confirm that what their answers in the questionnaire were what they had meant. In some cases, those who felt they had made errors in the questionnaire, or who were unsure of what they wrote, were given new questionnaires to fill in. The essence of member checking is to make sure that participants can express their views accurately on the phenomenon being explored, and to avoid misinterpretation by the researcher. Interview transcripts were also subject to member checking. For interviews member checking is really important, because of the possibility of mishearing what was said and to ensure their views are accurately captured.

3.14. ENSURING VALIDITY OF THE RESEARCH

Validity in qualitative research refers the overall authenticity of the research. Unlike rigor, validity speaks to the entire research report rather than merely the process of gathering

information in the research. Creswell and Miller (2000) propose that one of the measures of ensuring validity is to include thick or rich descriptions.

Thick description, as described by Creswell and Miller (2000), is a procedure used to describe the setting, the participants, and the themes in a qualitative research. Furthermore, Denzin (1989) as cited in Creswell and Miller (2000) says that “thick descriptions are deep, dense, detailed accounts” (p. 128). Creswell and Miller (2000) further add that thick description speaks to the confidence with which the readers feel as if they had “experienced, or could experience, the events being described in a study. The process of writing using thick description is to provide as much detail as possible” (p. 129). In other words, thick description is the ability of the research to connect with every reader of the research report in the simplest and most comprehensible language. This procedure influenced my study at each step I took in describing the entire study.

3.15. CONCLUSION

In this chapter, I have discussed the methodology and process followed in the research. This included a description of the research design (case study) and data generation procedure (questionnaire with closed and open-ended responses and semi-structured focus group interviews) and considered the fitness of data instruments for the purpose of the research. In the next chapter I will show the process of analyzing the generated data, to provide answers to the research questions.

CHAPTER 4.

PRESENTATION OF ANALYSIS AND FINDINGS

4.1. INTRODUCTION

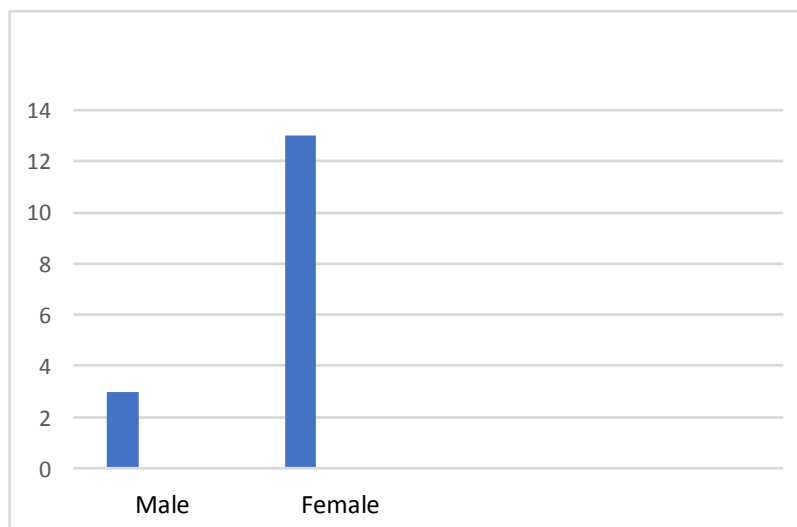
This chapter aims to answer the four research questions posed, specifically: (1) *“What are intermediate phase Natural Sciences and technology pre-service teachers’ understanding of ESD?”* (2) *How does learning about ESD affect the attitudes and behavioral actions of intermediates phase Natural Sciences and Technology pre-service teachers?* (3) *What are the views of intermediate phase Natural Sciences and technology pre-service teachers on the ESD content included in the Natural Sciences and Technology modules?* (4). *What challenges or enables intermediate phase Natural Sciences and technology pre-service teachers to learn about ESD in Natural Sciences and Technology modules?*

As mentioned in Chapter 3, data were generated using a questionnaire and focus group interviews. This chapter is divided into 6 parts. In part A, the biographical responses from the questionnaire were used to create the topology of the PSNSTTs. In parts B to E an attempt is made to answer the four research questions in sequence. Finally, the chapter summary is given.

4.2. PART A: BIOGRAPHICAL RESPONSES

The data acquired from the biographical section of the questionnaire was used to create a context for the PSNSTTs. In order gain an insight into who the PSNSTTs are, as well as the context that serves as their frame of reference, this section of the questionnaire focused on gender, location of family home, where PSNSTTs live as students, and their familiarity with the concept ESD

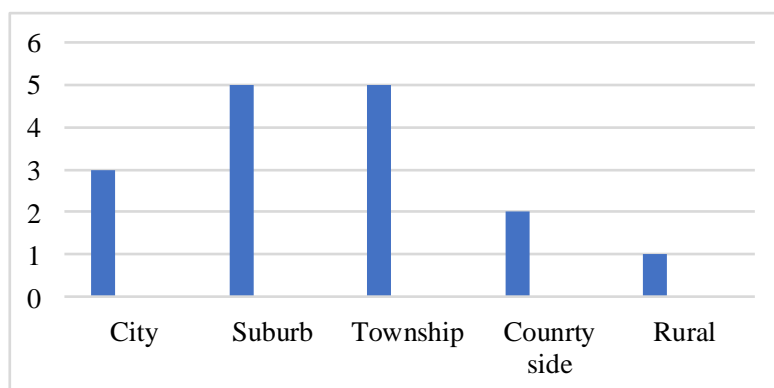
The gender distribution of PSNSTTs who responded to the questionnaire is shown below in Graph 1.



Graph 1: Depicting gender distribution of PSNSTTs

The data in Graph 1 reveals that there are many more female than male participants, almost a 4:1 ratio, which means that many more females are enrolled to train as teachers of Natural Sciences and Technology than are males. The skewed representation in favour of female teachers is in keeping with the gender distribution of enrolments for teaching at this particular university. It also aligns with trends observed in the literature (Dee, 2007; Petersen, 2014; Khattak, 2014; Chant, 2012). The gender distribution of participants does raise further questions concerning gender and its impact on behaviour and actions in terms of sustainability. In this regard, Kilinc and Aydin (2013) conducted a study to discover Turkish prospective teachers' understanding of the concept of sustainable development. They found that the female teachers were more aware of sustainable development than were male students.

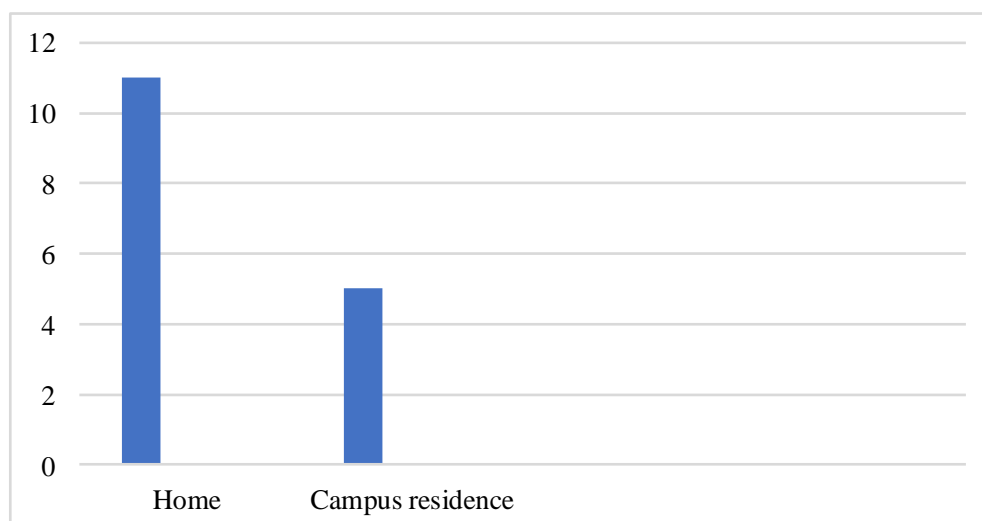
I considered the location of the family home to be important as it could influence how PSNSTTs understand ESD. The location in which PSNSTTs grew up is and according to Didonet (2008) and Samuelsson and Kaga (2008), it is where an individual's views and attitudes towards anything begin to take shape in early childhood. Thus, home background plays an important role in adopting a sustainable way of life in the coming years. Home background is a key factor in achieving the sustainable behavior of individuals (Hemingway and MacLagan, 2004; Tuziak, 2010; Michalos, 2009; Bernat, 2012). Graph 2 below indicates the location of the family home.



Graph 2: Home location of PSNSTTs

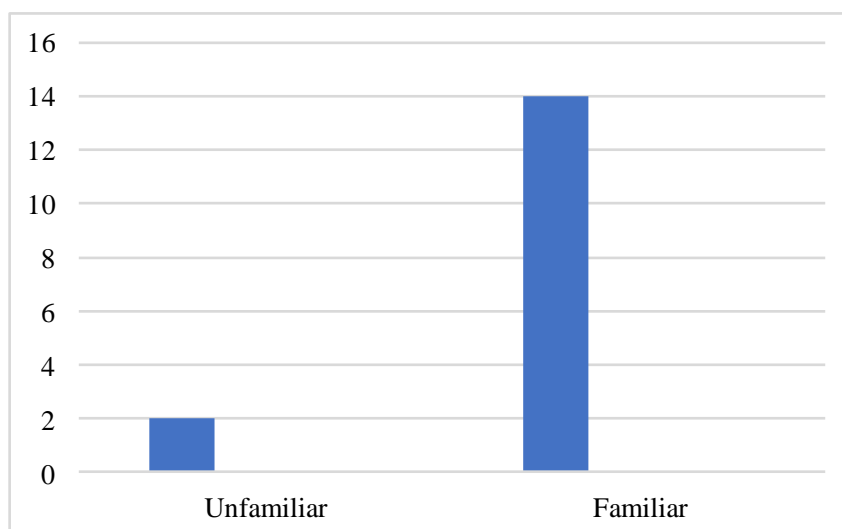
The data above reveals that the majority (10 out of 16) PSNSTTs reside in suburbs or townships.

The third factor which I considered as relevant is whether PSNSTTs travelled to campus (i.e. they lived at home) or lived in residence. I regarded this information as pertinent as it could influence behaviour and attitude towards issues of sustainability. Graph 3 below reflects where PSNSTTs live as students.



Graph 3 represents where PSNSTTs live as students

The data indicates that 11 out of 16 PSNSTTs travel daily to campus while 5 out of 16 PSNSTTs live on campus residence. It means that almost one third of the PSNSTTs encounter a different environment at university, that has its own set of living conditions, norms, values and acceptable standards of behaviour.



Graph 4 reflects PSNSTTs familiarity with the concept ESD

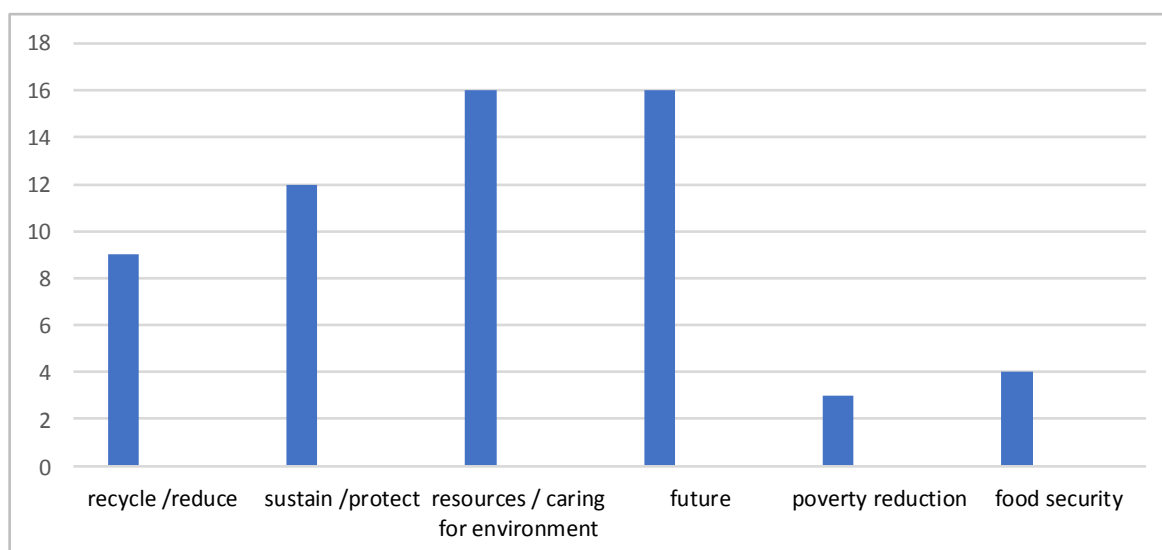
The data reveals that nearly all the PSNSTTs (14 of the 16) claimed to be familiar with the concept ESD. Studies conducted in Germany by Seybold and Rieß (2006) and Rieß and Mischo (2008) revealed that 787 primary school and 1865 secondary school teachers revealed a lack of knowledge, in the field of ESD, yet all teachers displayed positive behavioural actions towards the environment and wise use of resources. This raises questions regarding whether PSNSTTs familiarity with the concept ESD affects their attitudes and behavioural actions.

4.3. PART B: RESEARCH QUESTION ONE

Data from the questionnaire and focus group interviews were used to answer the first research question: *“What are intermediate phase Natural Sciences and Technology pre-service teachers’ understanding of ESD?”* In addressing the first research question, particular attention was paid to the concepts PSNSTTs associate with ESD and their definition of ESD.

4.3.1. Concepts PSNSTTs associate with ESD

Six concepts were associated by PSNSTTs with ESD as reflected in Graph 5 below.



Graph 5: Concepts PSNSTTs associated with ESD

These PSNSTTs foreground recycle and reduce, sustain and protect, resources and caring for the environment, the future, poverty reduction and food security as key concepts associated with ESD. A closer examination of the meaning behind the terms reveals that they focus on environmental issues (global warming, pollution, or fossil fuel usage), some type of action connected to sustainability (reduce/reuse recycle), temporal factors within sustainability (sustain resources for the future) and human-related factors (food security and poverty reduction). All 16 PSNSTTs think of ESD as intrinsically connected with caring for the environment, resources (both human and physical) and the future. Nine PSNSTTs think of waste management (reduce/recycle) as a way of reducing the volume of waste, protecting the environment and reducing the use of valuable non-renewable resources (e.g. crude oil which is a monomer for plastics). Besides their high awareness of those concepts, 3 PSNSTTs also associate ESD with poverty reduction while 4 of them also link it to food security. This is heartening as it shows that some PSNSTTs think beyond ESD as a vision of a better environment or the wise use of resource; they also see it as a tool to address very real and complex challenges facing South Africa. Every day hundreds of South Africans encounter poverty, lack of food and similar challenges. ESD is seen by these future teachers as a means of addressing inequalities and poverty amongst households with low purchasing power and poor nutritional status, as is evident in the excerpt below:

“If they are taught to have indigenous gardens/farms – they will have food, be healthy, have energy to work on their farms they could trade their crops – so they won’t be poor” (Participant 9: Questionnaire)

The above excerpt makes explicit the direct link between ESD, food security and poverty reduction (*they could trade these – they won’t be poor*). Emphasis is placed on the local cultural aspect (*indigenous farming*) and farming is linked to better health (*be healthy, have energy to work*) and economy (*won’t be poor*). Awareness among PSNSTTs that many South African households experience food insecurity, malnutrition and unemployment comes to the fore. PSNSTTs are discreetly mindful of the powerful position they hold as teacher-agents of change as well as their civic responsibility to address these issues through teaching and learning (*if they are taught... they won’t be poor*). In associating the above terms with ESD, a new vision for ESD becomes visible. The vision helps to understand the world as an integrated or interconnected system between human actions (reduce/recycle, sustain/protect, poverty reduction /food security) and provides for the future of the environment and its resources.

A closer examination of the concepts associated with ESD reveals that in thinking about ESD PSNSTTs link ESD to the three spheres of sustainability, namely social (poverty reduction, food security), economic (resources/future/ reduce/reuse) and environmental (caring for the environment).

4.3.2. PSNSTTs’ Understanding of ESD

The Natural Sciences and Technology curriculum as a vehicle for promoting ESD is seen to exemplify PSNSTTs’ understanding of ESD. This means that ESD is invariably linked to teaching and learning and it is construed to be an avenue through which environmental, economic and social needs of people could be addressed. Two key themes emerged from the pre-service teachers’ understanding of ESD:

- Education about the environment, ecology and environmental issues
- Education for the future – wise use of resources

4.3.2.1. Education about the Environment, Ecology and Environmental Issues (Environmental/Social).

This theme comprises of three sub-themes, namely, education about the environment, conserving resources and reduce/reuse/recycle. Each sub-theme is discussed below.

- **Education about the environment**

PSNSTTs defined ESD as education about the environment. This definition of ESD is aligned to Huckle's (1983) definition of ESD, as is visible in the excerpts below:

"...we learnt about caring for the environment, biodiversity and how much pollution ...we cause as men and women that it destroys that biodiversity of our animals, of our plants and it causes great damage" (Participant 7: Focus group 1)

The notion of ESD as education about the environment is based on the assumption that teaching facts, concepts and generalisations about environmental patterns, processes and problems leads people to willingly and independently take actions to mitigate adverse ecological deterioration (Fien, 2004; Huckle, 1983). Pre-service teachers in this category focused mostly on teaching about ecological systems, biodiversity, and environmental issues on the assumption that increased levels of knowledge will stimulate appropriate pro-environmental action. They see ESD as a means to contribute effectively to biodiversity and the sustainability of the Earth. PSNSTTs emphasized the need to protect and conserve indigenous plants and animals. The excerpts below reveal PSNSTTs awareness of indigenous practices that continue in South Africa:

"...in Natural Sciences, we learn about biodiversity....and need to conserve plants. So, we have to reduce cutting our indigenous plants and planting more....some are used for muti (medicine)... so we always have... also we have to stop poaching like South Africa is facing a major issue on poaching of rhinos of their horns, so teaching the learners about that, I think it's also education for sustainable development". (Participant 16: Focus group 2).

"We learnt about the plant called hoodia. So, there was a case study on hoodia showing the effects, the uses of hoodia and ...biodiversity over the years... the case studies are mostly used in these parts..." (Participant 12: Focus group 2).

The above excerpts show an awareness of the need to prevent over-harvesting of plants that are endemic to South Africa (not found elsewhere in the world). Within South Africa, 80% of the population use traditional medicines for primary health care needs (Wiersum et al., 2006). This means that indigenous plants make a significant contribution to primary health care in South Africa. Intensive harvesting of indigenous medicinal plants due to their increasing use would result in overexploitation and consequently pose a serious threat to biodiversity. Put

differently, this means that ESD is visualised as a special platform to sensitize and create awareness of the need to appreciate and protect indigenous fauna and flora through teaching and learning. ESD is interpreted as a way to conscientise communities to promote the active cultivation of indigenous plant (Cunningham, 1993). The cultivation of indigenous medicinal plants may also contribute to a growing economy and job creation. In the above excerpts, even though the focus is on the environment, emphasis is placed on the human aspect (overharvesting of indigenous plants for medicines), issues of poverty, access and equity (UNESCO, 2006).

- **Education about Conserving Resources**

The scarcity of water and disrupted electricity supply in South Africa were identified by PSNSTTs as unsustainable phenomena in South Africa. Many PSNSTTs considered ESD as the conserving of resources, which were natural, renewable and non-renewable. PSNSTTs are of the opinion that sustainable consumption is expected to minimise environmental damage, as it allows every individual to consume only what is needed as can be seen in the excerpts below:

“Education for sustainable development is about educating people to conserve what they have e.g. water, electricity, food, keep the environment clean by recycling and ensure the sustainability of mineral resources e.g. coal, fuel” (Participant 1: Questionnaire).

ESD is “teaching kids how to save electricity and water, implementation of recycling programs, encourage community participation in environmental restoration, planting of trees – it’s to teach them to prevent wasteful consumption (participant 3: Questionnaire).

“even my parents at home.....they just take it for granted, like um our house is small, so all the lights are on... like every light is on and I’m like why are you leaving the light on? Put it off. There is nobody in the bathroom, put it off...there is no point wasting it... there is nobody there... so put the light off. You educate the elders as well the elderly people...” (Participant 8: Focus group 1).

The above excerpts emphasise the teachers’ view on the need to conserve resources such as water, food and electricity in order to promote wise consumerism. South Africa is a water-

stressed country and millions of people lack access to safe clean water (Mukheibir and Sparks, 2005). ESD is envisioned as leverage to educating people about these valuable resources (Peattie and Collins, 2009). This is to say that PSNSTTs consider people to be trustees of these invaluable resources (O’Riordan, 2004). The definition of ESD as conserving resources embraces the three pillars of sustainability, namely the environment (resources), society (people) and economy (consumerism).

- **Education about Reducing, Reusing and Recycling**

PSNSTTs (having been exposed during their technology studies to the processing of polymers) considered ESD as education about reducing, reusing and recycling being an integral part of sustainable living and protecting resources. The excerpts below bear testimony to PSNSTTs definition of ESD as education about reducing, reusing and recycling:

“...we learnt about plastics, as it’s made from crude oil therefore we must recycle and upcycle the plastics, we must reduce our use of plastics by reusing it – we can also reuse all materials do not just throw it all around, maybe accumulate it, do something, have a program to accumulate it so you can use it in a beneficial way.... our lecturer told us that it must be recycled because if it thrown into like um... the sea and maybe animals have to consume it will go into their tummy and they will die because they will think that its food but they are not food...” (Participant 7: Focus group 1)

“...they learn about recycling, how to recycle and um the ways in which you can recycle and the benefits of recycling, so I think that's an education for sustainable development... if I use the can now, this can be still useful, I cannot just throw it away, I can use it for another purpose...” (Participant 16: Focus group 2).

The excerpts reveal that PSNSTTs through their learning have become informed about the environmental impact of product such as plastics. For these PSNSTTs reducing, reusing and recycling is a way to save resources and raw materials, and reduce the amount of waste created.

4.3.2.2. *Education for the Future*

This theme is composed of three sub-themes, namely, education for economic sustainability, education for food security, and education about gender equity. Each sub-theme is elaborated below.

- **Education for economic sustainability**

PSNSTTS consider ESD as education for economic sustainability. The excerpts below illustrate this notion of ESD:

“Sustainable Development deals with preserving the environment, having food, conserving resources all of which is linked to the economy” (Participant 5: Focus group 1).

“Green economy, green growth, low carbon development, healthy natural environment” (Participant 9: Questionnaire).

From the above statements, it is evident that the participants see the intertwined interdependent relationship between the sustainability and the economy.

- **Education for Food Security (via Indigenous Gardens)**

The idea of food production and stability only came to the fore during the second focus group interview. PSNSTTs emphasised the need to learn about food production through indigenous gardens as reflected in the excerpts below:

“.... we can maybe talk about food processing in technology, indigenous food production in science to educate people so that everyone has food, there is no starving children, everyone has good health, everyone does some job or farming so there is no poverty...” (Participant 11: Focus group 2).

“...about various ways of processing food...we have to process that food...we have to also make it practical so that we can have more understanding of what is being taught...I think what you do to the environment to benefit yourself, you must do it in such a way that the environment will benefit also” (Participant 16: Focus group 2).

The above conception of ESD convey the idea of promoting social justice and equity between all people (Oskamp, 2002) and embraced UNESCO's (2015) first two sustainable development goals. The first sustainable development goal focuses on ending poverty whilst

the second goal pays attention to ending hunger. In other words, PSNSTTs see ESD as a means of perpetuating altruistic values (caring for others). The PSNSTTs support the view that ESD must involve practical education towards sustainable food production (Johnston, 2007).

- **Education for Gender Equity**

As mentioned in the previous section, the demographic data (see Graph 1) shows that more female than male PSNSTTs participated in the study (13 of 16). The participants' views as drawn from both focus group interviews suggest gender power in relation to actualizing sustainability. For example, as quoted by participants below:

“it’s like aa... I don’t know, sometimes boys think only girls must clean the environment, but it’s not so. Everybody must be involved in ESD regardless of gender” (Participant 8: [Female] Focus group 1).

“.....sustainable development shouldn’t only be in the subjects of Natural Sciences and Technology because every module aa with relation to the subjects... every individual has an impact on the environment including male and female. There is so much issues in the society, wars destroying the environment, racism, gender violence like rape, we aamm... just need peace in society aamm for our future kids, so even if it’s not necessarily recycling, every module should have something you know that creates awareness about, SD not only NS and Tech,” (Participant 5: [Female] Focus group 2).

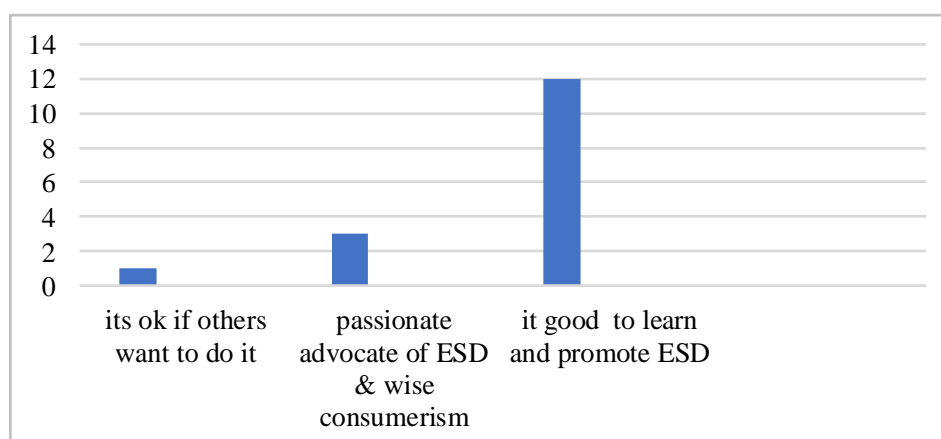
The above responses from the participants bring to the fore the social construction of gender roles-namely, females should be nurturing towards the environment (*boys think only girls must clean the environment*). This leads me to question why it is difficult for people to see that development that delivers unequal advantages and disadvantages to men and women is not sustainable. Female participants are conspicuously calling for a change in the stereotypical gendered norm role in education for sustainable development (*Everybody must be involved in ESD regardless of gender*). Additionally, the responses suggest the need to integrate peace education and gender education. The above finding resonates with those from Vaughan’s (2016) study, which highlights that educational activities still show massive inequality between men and women across different sectors. Hence “as part of sustainable

development goal⁴, there needs to be discussion around links between substantive gender equality in education and other education goals” (Vaughan, 2016, p. 28).

4.4. PART C RESEARCH QUESTION TWO

In answering the second research question it is important to note that beliefs and attitudes can act as filters through which new knowledge and experiences are screened for meaning. They also affect how knowledge and intentions are operationalized in class (Nespor, 1987; Pajares, 1992).

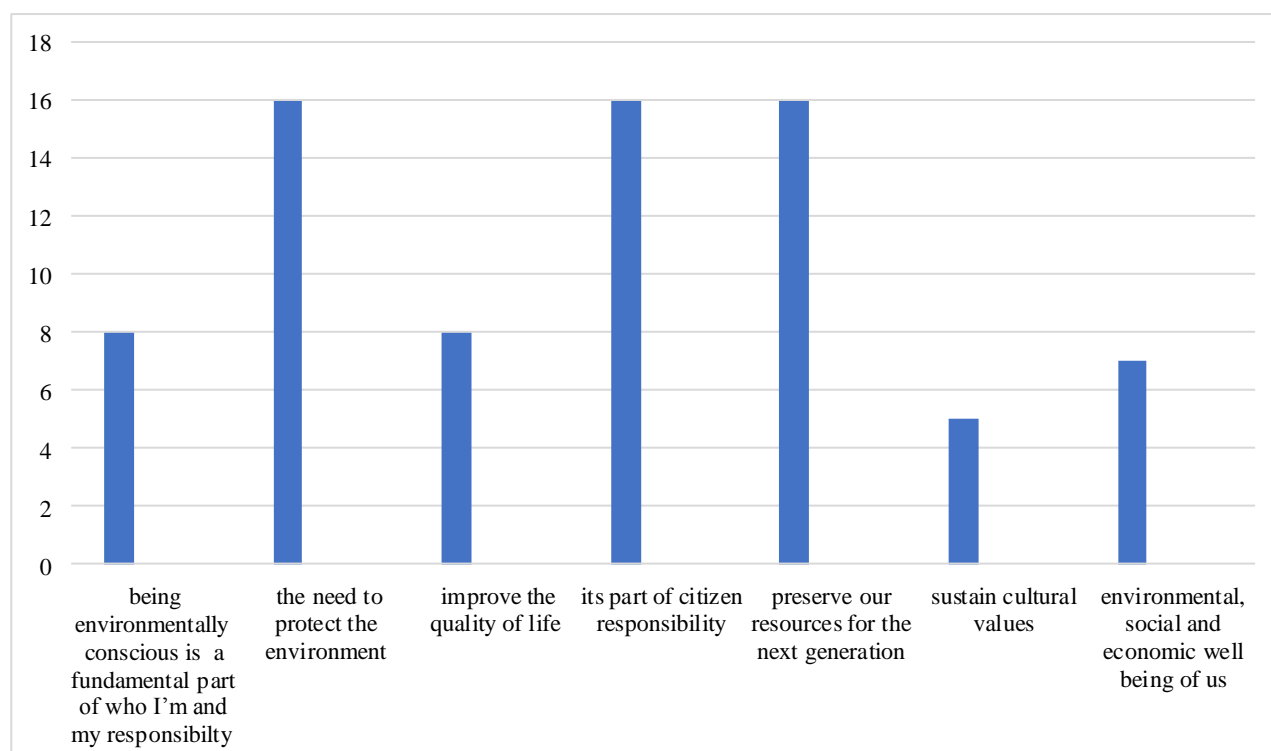
I draw on data from the questionnaire (see appendix F), which focuses on the importance of learning about ESD, motivation to learn about ESD, attitude to ESD and behavioural actions, as well as data from the focus group interviews to answer research question two: *How does learning about ESD affect the attitudes and behavioural actions of intermediate phase PSNSTTs?* It is important to note that attitude and behavioural actions were self-reported by the pre-service teachers. Graph 6 below shows data from the questionnaire.



Graph 6: Attitude of PSNSTTs towards ESD

From Graph 6 it can be seen that the three quarters of the PSNSTTs (12 out of 16) reportedly consider it important and good to learn about sustainable development and display a willingness to promote ESD in their teaching. Three PSNSTTs claim to be passionate advocates of ESD and wise consumerism. This means that PSNSTTs perceived the value of learning and teaching about ESD. Kagawa (2007) found similar results in an online survey of 1865 students from all subject areas, including educational subjects, at the University of Plymouth.

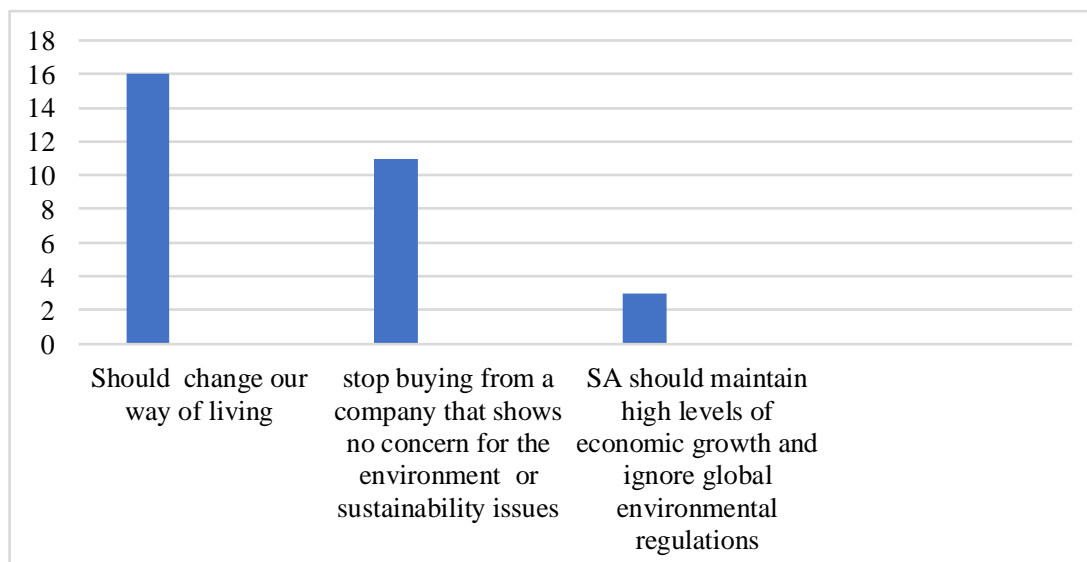
A closer examination at what motivates PSNSTTs to learn about ESD will expose how connected they feel to nature and their level of sustainability concern. In other words, it will expose how they value the connection between humans and sustainability attitudes (Stern and Dietz, 1994). Accordingly, Graph 7 below shows the results from the questionnaire which indicates the PSNSTTs self-reported reasons for being motivated to learn about ESD.



Graph 7: Motivation to embrace ESD

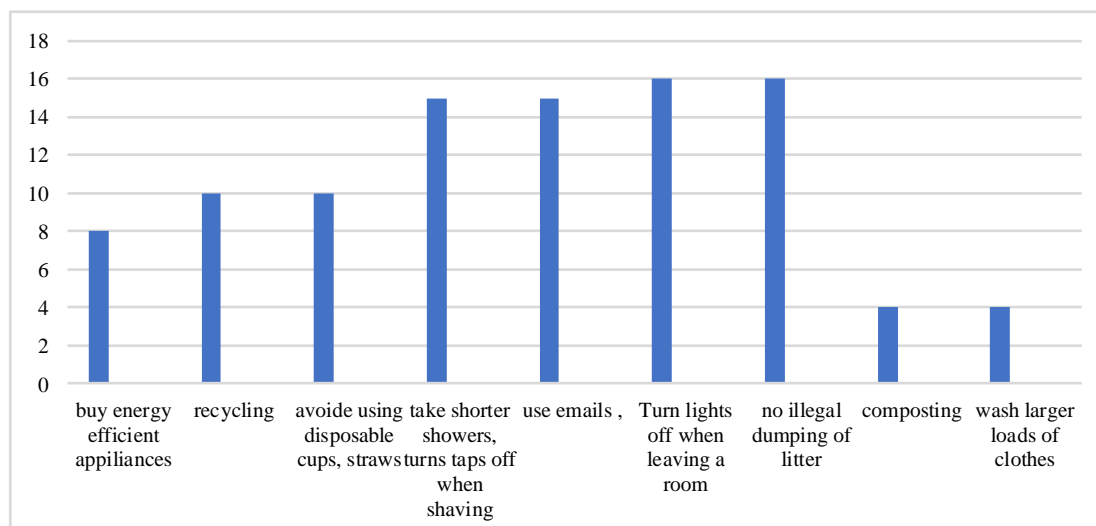
From Graph 7 above it can be seen that there are seven main motivations reported by PSNSTTs for studying ESD, which can be regrouped into three categories of pro-environmental behavior. The categories are self (responses 1 and 3), others or altruistic (3 and 6) and biospheric or nature (2, 5 and 7). When the responses are regrouped, it can be seen that in relation to themselves, half the PSNSTTs consider being environmentally conscious as a fundamental part of who they are, while all of them see learning about ESD as part of their citizen responsibility. Altruistic concerns motivate half the PSNSTTs to improve the quality of human life and about one third of them see learning about ESD as a way to retain culture. All the PSNSTTs consider it important to learn about ESD in order to protect the environment and preserve resources. The results indicate that a range of sustainable

development issues motivate the pre-service teachers in learning about ESD. More so, Graph 8 below reflects the results from the questionnaire, which indicates the PSNSTTs self-reported attitude towards sustainable development issues.



Graph 8: Attitude towards SD issues

The results in Graph 8 show positive attitudes toward the environment a high degree of concern about environmental problems. All of the PSNSTTs indicated they would be willing to *change our way of living* and well over half would *stop buying from a company that shows no concern for the environment*. PSNSTTs thus recognized the centrality of the environment as a focus for sustainable development, and their responsibility towards it. This mirrors the previous set of results which indicates they accept their responsibility as citizens. This finding is heartening because Tuncer et al. (2009) argue that teachers will only produce learners who are literate about issues of sustainability, if they themselves are knowledgeable and have positive attitudes towards ESD. There is, however of concern to note the dissonances of 3 PSNSTTs asserting that South Africa should maintain high levels of economic growth and disregard global environmental regulations. This negative attitude towards the environment conflicts with the pre-service teachers' self-reported positive attitude towards the environment. It suggests further investigation is needed. Graph 9 foregrounds the results from the questionnaire which indicates the PSNSTTs self-reported behavioural actions in terms of sustainable development.



Graph 9: Resultant Behavioral Actions of PSNSTTs

The pro-environmental behaviours shown in Graph 9 can be placed into the following three categories, namely Energy consumption (responses 1, 4, 6 and 9), recycling (2, 3, 7 and 8) and wise use of resources (1, 3, 4, 5, 6, 8, 9). These self-reported behaviors align with the positive attitude PSNSTTs also display towards learning about ESD and the environment as reported in Graph 8. When the responses are regrouped, it can be seen that the 3 categories of behavioural actions are intrinsically intertwined. These behavioural actions elucidate that PSNSTTs are environmentally conscious of their actions and its impact on the environment.

4.5. PART D: RESEARCH QUESTION THREE

This section shows the analysis of data to provide answers to the third research question: *What are the views of intermediate phase Natural Sciences and Technology pre-service teachers on the ESD content included in the Natural Sciences and Technology modules?*

Data from the focus group interviews are used to answer this research question. Three categories emerged from the data, namely, place of ESD in the curriculum, natural science content and technology content.

- **Place of ESD in the university curriculum.**

A common view expressed in the focus groups was that that ESD should be incorporated into the curriculum at higher education institutions. Some participants even though it should be compulsory for all future teachers. The excerpts below illustrate typical views:

“it should be a compulsory module, you should not have a choice it needs to be compulsory so you have to take it to learn,” (Participant 15: Focus group 1).

“Yes, because some people might not be interested, it should be compulsory module on its own or every course should include it” (Participant 7: Focus group 1)

From the above excerpts, it is evident that the PSNSTTs realise the value of learning about EDS and are making an appeal for ESD to be a separate module (*on its own*) or to be included into every module (*every course should include it*). Put simply, this means that ESD should not be relegated only to the science and technology curricula (*compulsory module*) but it should be a module for which all pre-service teachers must enroll (*compulsory module*). The implication is that everyone is responsible for promoting ESD in the school curriculum and not only those teaching Natural Sciences and Technology. In these opinions, PSNSTTs recognise that universities can be key players delivering skills for ESD (UNESCO, 2015). That being said, it is also encouraging to note that they want to learn even more about sustainable development, as is visible in the excerpts below:

“We need more time to learn about it” (Participant 8: Focus group 1).

“We are just getting a bit here in tech and a bit there in NS, more time needs to be devoted to ESD if we are serious about it” (Participant 11: Focus group 2)

“We must have organised activities, excursions, site visits that lets us get first-hand experience in ESD” (Participant 12: Focus group 2).

PSNSTTs are vociferous about the need to create and provide extra-curricular activities (*hands on experience*) that will allow for more excursions, field trips, community engagement projects.

- **Natural Sciences content**

In Natural Sciences, biodiversity is closely linked to ESD, as it visible in the excerpts below:

“Conservation of plants, so we have to reduce cutting our indigenous plants...stop poaching” (Participant 16: Focus group 2).

“...there is a little information about the ecosystems and biodiversity as a whole more should be done to teach sustainability” (Participant 11: Focus group 2).

“Preventing all types of pollution” (Participant 2: Focus group1).

The above excerpts provide a glimpse of the natural sciences content that focuses on biodiversity, conservation of indigenous plant and prevention of pollution. The stated curriculum correspondingly focuses not only on content, but also on values, attitudes and beliefs to facilitate sustainable behavior and environmental justice. In this regard, amongst pre-service teachers, Özsoy, Ertepinar, and Sağlam (2012) support the idea that

valuing the protection of the environment fosters positive feelings about environmentally sensitive activities, which facilitate demonstration of environmentally sensitive behaviours.

- **Technology content**

In Technology education, the processing of polymers is closely intertwined with ESD issues, as can be seen in the excerpts below:

“Dr. S-P goes on and on about us as agents of change... how we can make a difference via our teaching as local curriculum developers to be reflective... how we need to respond to contextual issues... that’s real learning” (Participant 8: Focus group 1).

“she demonstrates how we can link what we teach to local issues... like using discarded plastics to make artifacts ... that can be sold... so in a way the environment is clean and we teach skills to address social issues like poverty, improve the quality of life, prevent lack of food ... (Participant 7: Focus group 1).

“We learnt about the properties of plastics ... then as a follow up application activity we had to design with specifications, a waterproof and fire resistant informal dwelling... using recyclable plastics.... I did not think it possible we also learnt to work as a team” (Participant 5: Focus group 1).

We used ... the design process to design useful resources that many schools lack like pen and pencil holders, classroom bins, mats, brooms, dustpans ... we learnt how to innovate in our teaching (Participant 11: Focus group 2)

“Dr S-P via the plastics content, empowered us about energy from waste, clean incineration, social equity, how to overcome the lack of resources by innovating, be local curriculum developers, we did a plastic audit in class, at home and res. I wish other tech modules could adopt an ESD approach” (Participant 12: Focus group 2).

What comes to the fore in these excerpts is how the content pertaining to plastics was used to teach PSNSTTs some core values pertaining to sustainable development, such as respect for resources, the environment, and others in order to facilitate sustainable behavior and environmental justice. It is evident that the content had been used to make PSNSTTs aware about their citizen and social responsibility as teachers (*on about us as agents of change... how we can make a difference via our teaching*), to be reflective practitioners (*reflective*), to respond to local contextual issue (*local curriculum developers*). In other words, the content in the plastics section had been used to demonstrate to PSNSTTs that they are not simply technicians who deliver the published curriculum, but that they have to respond to contextual issues, such as lack of resources or poverty. The content in the plastics module was thus used to engage PSNSTTs in projects (*follow up application activity... informal home*) and problem based learning (*use discarded plastic*). Problem and project based learning as the appropriate methodology for teaching ESD (Steinemann, 2003). This means that the content in the plastics module had been used to develop awareness among teachers about the pedagogies and practices that could promote ESD in schools. In the plastics module content, certain key competencies are being developed amongst pre-service teachers, such as how to introduce ESD across the curriculum, the ability to design situations for learners in which they can understand ESD, and the ability to present examples for application of ESD in daily life. The teaching strategies used in the plastics module supports student centered, transformative pedagogies that encourage active participatory learning for sustainable development, as advocated by Scott (2015). Traditional lectures provide limited opportunities for involving pre-service teachers in such pedagogies (Evans, Tomas, and Woods, 2016).

4.6. PART E RESEARCH QUESTION FOUR

This section shows the analysis of data to provide answers to the fourth research question:

What challenges or enables intermediate phase Natural Sciences and technology pre-service teachers to learn about ESD in Natural Sciences and technology modules? Data from the focus group interviews are used to answer this research question.

This research identifies three challenges and one enabling action/activity/pedagogy that PSNSTTs encounter in their learning to teach about sustainable development.

- **Challenges**

The three challenges are subject matter, teaching strategy and time

Subject matter

The first challenge expressed by PSNSTTs relates to understanding the complexity of the subject matter on sustainable development issues, the nature and inter-connectedness of its sub-concepts, and its value-laden nature, as reflected in contested meanings and differing aims. The excerpts below indicate how the subject matter is seen to be complex:

“I want to make a difference. Do a proper job .. but what do I focus on environment or technology issues. The definition of SD does not help as it focuses on three pillars. These pillars are in conflict with each other- do I emphasise sustainability or development- it’s confusing” (Participant 15: Focus group 1)

“There are so many definitions of SD, it’s confusing –which one is right? The terms are so closely related, the SD goals have so many aims – which do I focus on? How would I know what to focus on?” (Participant 12: Focus group 2).

The excerpts above reveal that the respondents felt that integrating sustainable development into teaching and learning was very important (*make a difference*) and they reported a willingness to be adept at it (*do a proper job*). They are, however, also overwhelmed or confused or both by the apparent complexity of sustainable development (*These pillars are in conflict with each other- do I emphasise sustainability or development- it’s confusing*) and in turn draw on images of sustainability that are often infused with an environmental focus. This finding aligns with previous research studies (Curtner-Smith, 2007; Evans, Penney and Bryant, 1993; Laws and Aldridge, 1995 cited by Curtner-Smith, 2007). In particular, it resonates with the views of Dymont, Hill and Emery (2015), who also note confusion over the definition of sustainable development and that students’ understanding would be positioned more in the environmental dimension of sustainability.

Teaching Strategies

The excerpts below clarify some of the dilemmas that the pre-service teachers encounter when they think about how to incorporate sustainable development into their teaching.

“It looks easy when Dr. S-P does it, she refers to hands on, minds on, hearts on and the activities we do match this, but I’m not sure I can do this – we don’t know the strategies to use to teach it – our methods lectures do not focus on ESD. We really need to teach about SD” (Participant 12: Focus group 2)

In schools, NS and tech are integrated into one subject, we study these two subjects separately, it’s obvious that each lecturer is doing things on the own...we are not

taught how to integrate ESD into any topic. I'm not confident." (Participant 2: Focus group 1).

It can be inferred from the excerpts above that PSNSTTs are being challenged to think in critical ways so as to integrate sustainable development into their teaching of Natural Science and Technology. The excerpts also indicate the gap between the two aspects (natural science and technology) in the university curriculum (*we study these two subjects separately*). The two aspects are not taught in an integrated manner. How can pre-service teachers teach Natural Science and Technology as an integrated subject if they do not first experience it as one integrated learning area at university? Consequently, it appears that PSNSTTs are not taught how to teach ESD within this integrated learning areas (*we don't know the strategies to use to teach it – our methods lectures do not focus on ESD*). This infers that the content module (EDTE 220) focus on the sustainable development content to be included, and demonstrates the teaching strategies relevant to ESD, however the method module (NSM2) which ought to foreground teaching strategies does not pay attention to the teaching of ESD. In the absence of PSNSTTs learning how to teach ESD via the method modules the lecturers of the content module (*it's obvious that each lecturer is doing things on the own*) tries to introduce PSNSTTs to teaching strategies for ESD.

Time

Participants talked about challenges that had arisen when they tried to incorporate teaching sustainable development during their teaching practice. Existing schemes of work at the schools in which they had been placed did not allow sufficient notional time. The excerpts below indicate this perceived lack of time and the consequent lack of confidence that they will be able to incorporate ESD in their own classroom after graduation.

"If you examine the NS/TECH CAPS policy – it's so lengthy – there is so much content, it's not easy to do justice to ESD in a limited time – I tried it during teaching practice and my mentor teacher was not happy with me, she said the syllabus was cast in stone, its rigid – I should not add to it" (Participant 2: Focus Group 1).

"Doing a proper job integrating SD into the curriculum consumes energy and time as a first-year teacher next year I don't know if I will have time to try out new ideas – I'm nervous – about next year" (Participant 12: Focus Group 2).

“...how do you find time for learners to engage in SD project work – then time is fixed and the content is a lot” (Participant 8: Focus group 1)

Thus, lack of teaching time was perceived as challenging (*lengthy ... rigid curriculum*), and the curriculum was noted as *cast in stone*. This means that there was not enough class time for learners to be involved personally with ESD issues. However, the excerpts could reveal that pre-service teachers have poor time management skills. Time cannot be managed like any other resource, it is fixed, everyone has the same time to teach NS/TECH. The national time for the Natural Science and Technology curriculum is calculated nationally. Ideally, pre-service teachers should learn to manage how and what they teach in accordance with this time constraint (McInnis,1992). Undoubtedly, this is a gap in implementing Education for Sustainable Development in formal educational systems that still needs to be addressed at this university.

- **Enabler**

The respondents reported a sense of pride when engaging in sustainable development projects that are community related. Through these they could see how sustainability issues extend from the school into the community, as is visible in the excerpt below:

“I’m really enjoying ESD – I feel so proud to take up issues affecting a community ...it shows me how we are an interconnected system and how schools extend into communities” (Participant 2: Focus group 1)

The learning opportunity provided in the Natural Science and Technology modules included an affective component (*enjoying ESD*) – their sense of pride. They realise the importance of integrating ESD into teaching and learning (*shows me how we are an interconnected system and how schools extend into communities*). This was most encouraging.

4.7. CONCLUSION

This chapter presented qualitative data generated by a questionnaire and two focus group interviews. The presentation of the analysis of the data was guided by the four research questions.

Research question one sought to understand the intermediate phase pre-service Natural Science and Technology teachers’ conception of ESD. From the analysis of data generated by the questionnaire and focus groups it was evident that the participants perceived six

concepts to be fundamental as they learned about ESD; namely, recycle and reduce, sustain and protect, resources and the environment, poverty reduction and food security, and the future. These concepts fell into three major themes, which are education about the environment, ecology and environmental and social issues and education for the future. This suggests that the pre-service teachers understood all three spheres of ESD.

Research question two was concerned with how learning about ESD affects the participants' attitudes and behavioral actions. The results from the focus groups were presented graphically and revealed the importance of learning about ESD. It is evident that the majority of the PSNSTTs deemed learning about ESD as being very interesting and essential. The analysis of various activities with which the PSNSTTs engaged, was used as a measure of how passionate and motivated they were in embracing ESD. It revealed that most of the participants were ideologically inclined towards issues of protecting the environment and resources. Other analyses show positive attitudes towards sustainability and daily activities which would promote sustainable development, thus showing a concrete understanding of the impact of learning about ESD among the pre-service teachers.

Research question three focused on the views of the intermediate phase Natural Sciences and Technology pre-service teachers on the ESD content included in their Natural Sciences and Technology modules. The analysis concerned the place of ESD in the university curriculum, the Natural Sciences content, and the Technology content. The result suggests that all PSNSTTs favoured incorporating ESD as a stand-alone module higher education curricula, not only for Natural Sciences and Technology teachers. Evidence showed that in Technology module processing of polymers or plastics had been used effectively to foreground and give practical ways to incorporate ESD as the 3Rs of Reduce, Reuse and Recycle (the 3R).

Lastly, the fourth research question examined the challenges to and enablers of learning about ESD for intermediate phase Natural Sciences and Technology pre-service teachers. The data revealed, on the one hand, that the three major challenges expressed by the participants were the subject matter itself being perceived as difficult, that they had learned few ESD teaching strategies and that there had not been enough class time for them to develop ESD ideas during teaching practice. On the other hand, the PSNSTTs expressed a sense of pride and fulfilment as they engaged in sustainable development community projects. In other words,

carrying out sustainable development projects affects the community positively, so education was identified as one of the enablers of a community learning about ESD.

This chapter has thus identified some gaps which could be rationales for more extended studies. The next chapter of this dissertation will be the discussion and recommendation chapter, where I will further discuss on the results of the study in relation to literature and conceptual framework and finally giving recommendation for further studies.

CHAPTER 5.

DISCUSSION OF FINDINGS AND RECOMMENDATIONS

5.1. INTRODUCTION

The focus of the study in this dissertation study was to gain insights into how Intermediate Phase Natural Sciences and Technology pre-service teachers experience learning about ESD, in the Natural Sciences (NSM 2) and Technology processing (EDTE 220) modules. A case study design was used. Twenty PSNSTTs were purposively selected to participate in this study; however, only 16 consented to participate. Qualitative data were generated by a questionnaire and two focus group interviews, which were used to answer the following four research questions:

- (1) What are intermediate phase Natural Sciences and Technology pre-service teachers' understanding of ESD?*
- (2) How does learning about ESD affect the attitudes and behavioral actions of intermediates phase Natural Sciences and Technology pre-service teachers?*
- (3) What are the views of intermediate phase Natural Sciences and Technology pre-service teachers on the ESD content included in the Natural Sciences and Technology modules?*
- (4) What challenges or enables intermediate phase Natural Sciences and Technology pre-service teachers to learn about ESD in Natural Sciences and Technology modules?*

This chapter of the thesis presents an overall discussion of the key findings in answer to the research questions. The themes that emerged from the analysis are used as the basis for the discussion. The chapter is divided into four subsections. The first discusses positive experiences of learning about ESD for PSNSTTs, taking into consideration the context of this study. The second subsection discusses the negative experiences while learning about ESD. The third subsection gives recommendations, while the fourth and final subsection is the conclusion of this dissertation.

5.2. POSITIVE EXPERIENCES OF LEARNING ABOUT ESD WITHIN NATURAL SCIENCES AND TECHNOLOGY

Analysis of data revealed that the pre-service Natural Science and Technology teachers had, as they learned about ESD, developed an obvious interest in caring for the environment. As this study sought to understand experiences of PSNSTTs learning about ESD, the data revealed that amid the challenges highlighted by the participants, there were positive learning

experiences. Furthermore, pedagogical approaches they had experienced in the Natural Sciences and Technology modules had contributed to positive learning experiences. These positive experiences eventually lead to positive behavioral attitudes, such as conservation of water and electricity and proper waste disposal. The participants recounted the positive experiences through their engagement with a major technology project which focused on plastic waste management as part of their project assessment. The positive experiences and visible learned behaviors are discussed, in subsections 5.1.1 to 5.1.3 below.

5.2.1. Reducing, Reusing, Recycling (3Rs)

From Chapter 2 the conceptual framework of ESD showing the interplay between Natural Sciences and Technology education and the sustainable development goals, at various points, indicated that one or more of the three spheres of sustainability (social, environmental and economic) could be targeted through Natural Sciences and Technology education. Consequently, various concepts taught within Natural Sciences and Technology foreground many of the sustainable development goals, goals 1,2,3,4 and 5 in particular (UNESOC 2015). Key findings of this study include that the 3Rs of reducing, reusing and recycling had been well emphasised in the technology (EDTE 220) module. This finding upholds the United Nations' Environment Programme (UNEP, 2007) recommendation for plastic waste management, to avoid the way plastics contribute to environmental degradation in South Africa. The participants expressed positive attitudes and values towards sustainability, is in accordance with UNESCO recommendations that ESD should equip individuals with knowledge, skills and values (UNESCO, 2009 a, 2009 b, 2012, 2013, 2015, 2017). For instance, a statement from participant 16 says a lot about how immersed he is with the attitude of 'reusing' of materials in his daily life.

"...whenever, I use something that is disposable, before I dispose of it or throw it away, I ask myself, can this be usefully again? so asking that question can make you eee.. come up with another idea of of of.... using that product again instead of throwing it and littering the environment. so like if aaa... I buy the drink eee with a plastic bottle, I finish the drink and then I decide to throw it away, before throwing it away, I ask myself, can I use this again? then maybe the idea will come that you are going to use water, so for you to get water you have to use this container, so every time before eeee.. Considering throwing something away, eeee.. I ask myself if I can use it over and over again..."

By engaging with these practices (the 3Rs), individuals are empowered towards sustainable practices such as creativity and problem solving. Indeed, the 3Rs concept targets multiple sustainable development goals. My observation of the project presentation by the PSNSTTs shows that the 3Rs plastic project had empowered and equipped them with the skill of creativity through recycling of plastics. For example, the pictures in Figures 5 to 8 below show examples of high quality products made by PSNSTTs from waste plastics.



Figure 5: A plastic handbag made from recycled plastics



Figure 6: 'Environbins'- A waste disposal bin made by PSNSTTs from recycled plastic



Figure 7: Plastic- door mat –made from recycled plastics bags



Figure 8: Prom dress designed from different types of plastic

By reducing plastic waste and making useful objects, the pre-service teachers are caring for and saving the environment, which is a positive value. This value speaks directly to:

1. Sustainable development goal1- *Ending poverty*: Creativity, making plastic objects are could increase financial earnings, or make a livelihood, since they are of high quality and marketable.
2. Sustainable development goal5- *Achieve gender equality and empower all women and girls*: Through creativity and problem-solving skill in schools, boy are girls are all empowered thereby displacing the notion that ‘doing science and technology is only for girls’.
3. Sustainable development goal 6 -*Ensure sustainable management of water and sanitation for all*: Attaining a clean and green decent environment sanitation is a key for equity in South Africa as million of people do not have access to clean water and sanitation.
4. Sustainable development goal8- *Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all*: This implies that individuals can be self-employed and productive if they are empowered and creatively skilled.
5. Sustainable development goal14- *Conserve and sustainably use the oceans, seas and marine resources for sustainable development*: This goal one of those foregrounded, because plastic waste could otherwise contaminate the oceans and rivers.

Waste plastic accumulation in on the South African coast is a serious concern. The picture below (Figure 5.5) shows a small view of the challenge that plastic waste presents on the shoreline near Durban. Therefore, if most of the population were aware of the need for sustainability consciousness and sanitation, there would be reduced littering. Instead people would practice the use and reuse of resources “*over and over again*” with a more positive attitude towards recycling of plastics and other non-biodegradable materials.



Figure 9: Durban Sea shore from eThekwin Municipality (Adapted from www.sapeople.com)

Economically, if people upheld the 3Rs philosophy in respect of plastics waste, the waste could be turned into sellable and useable goods, which earns the makers money, thereby empowering them economically. Environmentally, it would also promote a sense of decency, environmental consciousness, and healthy living while people empower themselves economically. Socially, both boys and girls are empowered through creativity and product making.

5.2.2. Natural Sciences and Technology Modules Create Environmental Awareness

One focus of inquiry (research question one) in this study was to explore the level of awareness of Sustainable development and its goals through ESD amongst PSNSTTs. The analysis of data from both instruments used in the study revealed a key finding to be the positive experience gained by the research participants (PSNSTTs) of awareness about sustainable development and the environment. This assertion is based on several instances where, on the one hand, most of the participants declared that they had been completely unaware of ESD prior to enrolling for the Natural Sciences and Technology modules at the higher institution (*P8: "...modules teach us to be aware..."*, *P15: "... not everybody is aware..."*, *P5: "...I wasn't aware..."*, *P16: "...I'm now aware..."* etc.). On the other hand, the acquired knowledge or awareness could also be viewed as having led to an interest in the topic,

This finding supports Mensah and Castro's (2004) conclusion that the main agenda of the initial phases of the sustainability movement, had been to promote greater public awareness and advocacy for a united global community, and to create well defined frameworks among institutions to promote Sustainable Development. In addition, Wyness and Sterling (2015)

support the view that ESD within a higher education curriculum should be geared towards “increasing awareness of sustainability issues by students and employers” (p. 1).

Investigating the level of awareness of Sustainable Development is the first step, as very notably, challenges facing developing nations in Africa in that regard include the lack of the basic awareness. The South African CAPS curriculum through its vision proposes actualizing quality and sustainable formal education aimed at ensuring that learners acquire and apply knowledge and skills in ways that are meaningful to their own lives. By implication, the curriculum promotes knowledge within local contexts, while being sensitive to global imperatives (DBE, 2011, p. 4). Broader global issues such global warming and climate change are concepts that are still relatively unknown in local education settings in South Africa. Consequently, achieving a holistic development of learners through education should start from basic awareness of such concepts. This enables more prognostic type of learning. In other words, there is need to start teaching preparedness for facing global challenges.

The findings of this study are quite convincing about the possible roles expected of PSNSTTs as they move into formal teaching and learning settings, where they will need to teach sustainability concepts. It can be deduced that at least they are going to promote awareness about environmental and global issues of sustainability, even though they are expected to do much more than create awareness. Although teachers are key to curriculum implementation, there is still a need for shared responsibility pointing to partnership between educators and other formal and informal institutions.

5.2.3. Promotion of Knowledge of Biodiversity

The result of this study shows that both Natural Sciences and Technology method modules promote knowledge of biodiversity of South Africa flora and fauna, and by so doing the foreground sustainable development goal 15 (*“Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss”*). Studies have shown that South Africa has an incredibly rich heritage of biodiversity of plants and animals (Department of Environmental Affairs and Tourism [DEAT], 2008). The biodiversity includes medicinal plants such as the hoodia plant mentioned by the participants, and endangered species of wild animals such the rhinoceros mentioned earlier. Accordingly, on the one hand, the richness of South African biodiversity contributes to making the country a world heritage site and tourist destination. On the other hand, it is disturbing to know that South Africa faces a massive

challenge of loss of biodiversity due to humans' irrational actions such as poaching, bush burning, deforestation and overharvesting of medicinal plants.

5.3. NEGATIVE EXPERIENCES OF LEARNING ABOUT ESD

Despite the participants having highlighted the benefits of learning about ESD, there are some concerns about pedagogical approaches used in learning ESD within Natural Science and Technology modules. This led to a lack of applicability of the content of the modules or to unrealistic (mere theoretical) application of ESD (*"more theoretical than practical, P16; "they don't relate it or link it to real-life", P8; "some of the plants that we learn about, some of us have never even seen it, and we can't identify it", P11; "what is being taught is not being practiced", P14*).

This finding supports Jasper's (2008) argument that students or learners would feel more motivated learning about ESD outdoors through their love for nature, and feeling of connection to nature as they respond to environmental stimuli. By Implication, Jasper's (2008) findings emphasise the value of humans' social interaction with the environment during the learning process. The present ideology behind the current modules appears to be tacitly aligned with behaviorist theory, which assumes that learning is passive and teachers merely transmit knowledge through reinforcement, feedback and correction or discouragement of undesirable behaviours. Behaviourist theory conflicts with Bloom's (1956) active cognitive learning approach, which assumes that learning occurs as a cognitive, affective and psychomotor processes (mental processing, attitude or self, and manual or physical skills). In accordance with Bloom, learning ESD can be understood to be multifaceted. Therefore, Natural Sciences and Technology teaching requires innovative and exploratory teaching strategies that make students 'think outside the boxes', while at the same time enhancing a multidisciplinary perception of ESD. The findings of this study also challenge teachers and lecturers' practices, institutional ethos of sustainability, and institutional policies on implementing ESD. To this end, ways to improve learning of ESD will be recommended in the next section.

5.4. RECOMMENDATIONS

The findings of this study identified that PSNSTTs have mixed experiences of learning about ESD, thereby pointing to a gap in harmonious implementation of ESD in teacher education programmes. Therefore, the findings from study lead to advocating a more streamlined implementation of ESD in Natural Sciences and Technology education, within institutions of

higher learning. This is especially pertinent for teacher education programmes because implementation in primary and secondary education settings hinges on the teachers. The following recommendations are directed at institutions of higher learning, policy makers, educators and other researchers.

5.4.1. Recommendations for Institutions of Higher Learning

5.4.1.1. *Whole Institution Involvement*

The concept of ESD applies to universities and other institutions of higher learning in that it reflects what they teach through their sustainability cultures. In other words, the whole institution initiative advocates action focused on ESD, wherein the institutions, through activities such as green gardens, or environmental sanitation demonstrate a genuine cultural shift towards sustainability practices. For instance, it was observed that at the university where this study was conducted, waste management and disposal remained a huge challenge. The university was yet to adopt a variety of waste disposal bins, as can be seen in some universities in more developed nations. For example, the picture in Figure 10 below shows refuse disposals bins seen at the university of Siauliai, Lithuania. The bins are differently coloured according to the type of refuse materials to be placed in in each for proper disposal. Instead at Richmond University all refuse is still dumped in a single type of bin regardless of the material involved, or even worse, simply littered around the environment.



Figure 10: University of Siauliai, Lithuania refuse bins. (Stiklas - Glass, Plastiklas - Plastics, Popierius -Papers) Picture taken by researcher 13th June 2017.

5.4.1.2. *Institution and Community Partnership*

From this study, it is recommended that educational institutions should work with government and non-government entities, both cooperate and non-cooperate organisations, in order to actualize sustainable development goals. For instance, they could provide critical teaching and learning resources, especially for local or rural communities. It is recommended that education institutions should partner with government agencies and media agencies in order to strategies that promote awareness of sustainable development, especially in local communities. Understanding the sustainable development goals is crucial; the sustainable development goals assign roles to each sector of the human society, thereby addressing inequalities between different levels of the society. Additionally, knowing that schools are an integral part of the local communities, they should partner with United Nations organisations to create programs and strategies that target local communities to end challenges such as poverty and hunger

5.4.1.3. *“Doing ESD rather than Talking ESD” (Action Focused ESD)*

The result from this study revealed that the PSNSTTs mostly perceive ESD as action(s) taken by individuals (whether teachers or not) on a collection of key actions. For instance, *recycling or reusing, sustaining and protecting the environment, caring for the environment and natural resources, saving for the future, poverty reduction and food security* were foregrounded. This implies that ESD can be actualized through any form of teaching and learning. However, formal education systems as at universities and colleges of education have greater prospects for facilitating ESD, since there are well-structured curricula allowing for specific plans of action. Contrarily, in South African society at present, the topic of ESD seems to be theoretically and policy oriented rather than being practical. Little has been done practically in comparison to other developed societies. Therefore, this study recommends that educators at all levels embrace a paradigm shift to put policies and politics into practice rather than romanticise the concept or ECD with ‘buzzwords’.

5.4.1.4. *Emphasis on ‘Normative and Self-awareness’ Competencies*

Competencies are described by Strebler, Thompson and Heron (1997) as the ability of an individual to perform activities within an occupation to a prescribed standard (p. 21). In this regard, bearing in mind that ESD should develop learners who think in appropriate ways, the UNESCO (2017, p. 10) outlines 8 key competencies for sustainability, as follows;

1. Systems thinking
2. Anticipatory

3. Normative
4. Strategic
5. Collaboration
6. Critical thinking
7. Self-awareness
8. Integrated problem-solving.

This study leads to recommending emphasis on being placed on normative and self-awareness competencies, in a bid to inculcate and foster positive environmental behaviours in students. In the UNESCO document, normative competency is described as “the abilities to understand and reflect on the norms and values that underlie one’s actions” and self-awareness competency as “the ability to reflect on one’s own role in the local community and global society and to deal with one’s feelings and desires” (p. 10). In this regard, an easily visible sustainability challenge facing the university environment where this study was conducted is the lack of proper waste disposal as mentioned in Section 5.3.1. above. One reason for this unsustainable behavior could be that most students are still “ignorant” of the impact of their actions on the environment, despite some provision being made to address that issue. For instance, a visit to the university library shows that most individuals are still insensitive to the issue, as illustrated in **Figure 11**. It is evident from the picture that students ignore boldly written instructions and the refuse bin provided, and litter without remorse.



Figure 11: “No Eating or Drinking, Help Keep the Library Clean!!”

Picture taken by the researcher on a meeting with participants of the study.

Although ESD involves addressing all competencies, focusing on normative and self-awareness competencies offers ideal opportunities to address the consciousness and consciences of people to do what is right within the environment. This includes respect of rules and laws of the society. For instance, people must be able to make good judgments and take responsibility for their actions, even when they are alone. Flouting instruction is a personal decision, hence ESD involves teaching obedience and making individuals drawn on their consciences to demonstrate sound moral judgment.

5.4.2. Recommendations for Policy Makers

It is evident from the findings of this study that ESD should involve a multidisciplinary approach. Nevertheless, it can be seen for the curriculum both at the university where this research was conducted and in the South African CAPS curriculum, there is no well-structured module for ESD, and so the concept of sustainable development has not been fully incorporated. In other words, SD concepts can only be identified in specific topics of biodiversity, energy and change, life and living etc. Hence, from this study I recommend that university and higher education policy makers should consider creating a separate ESD compulsory module within the university curriculum. Similarly, for primary and secondary schools, I recommend that the Department of Basic Education should consider including sustainable development as a key learning strand in both the primary and secondary school curricula. This will certainly give more focus to the learning area. Additionally, policy makers and departments of education should include in-service training for all teachers in order to facilitate knowledge and implementation of ESD.

5.4.3. Recommendations for Educators

Through the findings of this study, it is recommended that, to realise sustainable development goals, educators should not wait for curriculum or policy reforms before they start practicing ESD. In this regard, ESD entails educational action that specifically aims to achieve the sustainable development goals. UNESCO (2017) supports radical steps for stakeholders to undertake global action programme activities, involving plans for concrete activities that support the priority action areas, which are the sustainable development goals. This idea points to educators seeing ESD as agents for social transformation. Thus, I recommend that teachers should employ the following pedagogical approaches to facilitate teaching and learning ESD:

- Integrated teaching and learning of Natural Sciences, Technology and Social studies

- Integrated ESD and Indigenous Knowledge teaching
- Real-life teaching approach
- Research based teaching and learning
- Community awareness and programs within schools
- Field trips or learning outside the classroom
- Video or media teaching
- Group work and discussions, as teaching approaches

5.4.4. Recommendation for Further Research

This study revealed that two major challenges to effective ESD are pedagogical (teaching and learning) strategies and poor understanding of the concept. It is therefore recommended that further studies be conducted on instructional strategies in intermediate phase Natural Sciences and Technology teaching of ESD, especially focusing on primary schools. The reasoning behind this recommendation is the need to uncover and understand the challenges presented to teachers in school settings. Through such research, research institutes can create and evaluate strategies that would assist teachers and enable positive implementation of ESD.

5.5. LIMITATIONS OF THE STUDY

This study was limited in three ways. Firstly, by using a questionnaire as the data generation method. Participants were hesitant about filling in and returning the questionnaires. Studies have shown that questionnaire respondents are sometimes not serious about filling in research questionnaires (Cohen et. al., 2000). Hence this affected the return rate, so ultimately only 65% of the questionnaires had been filled in correctly and returned. Some of the respondents, who were students, alluded to being so busy with their studies that they did not prioritise filling in and returning the questionnaires, despite follow-up phone calls and emails to remind them to do so.

A second limitation to the study was the use of focus groups, although they were useful in generating rich data. It was difficult to gather all the participants selected for the focus groups interviews at a particular time due to individuals' programme differences. Also, transcribing the audio-recorded focus group interview was a challenge as for the purposes of qualitative data the transcription had to be verbatim. Because, the participants' voices echoed at the same time, it was difficult to separate different voices. Thus it was difficult to code and summarize the data.

A third limitation was the use of a case study method. According to Hodkinson and Hodkinson (2001), although case studies are limited to only a single data source, so much data can be generated from that source, which makes data analysis rich and in-depth. Consequently, the results of this study are limited; they should not be generalized beyond the group of pre-service teachers in the study. Nevertheless, as an exploratory study, the results are useful in highlighting the issues encountered by the students, which may be relevant at other HEIs.

5.6. CONCLUSION

This study explored pre-service Natural Sciences and Technology teachers' experiences of learning about ESD in a selected university college of education in KwaZulu-Natal province of South Africa. Chapter 1 of this thesis introduced the research landscape, and highlighted the rational of this dissertation while describing the aims, objectives, focus and significance of the research.

Chapter 2 was a review of literature and presented the conceptual framework that supported this study. Chapter 2 also analysed the definition and historical developments of concepts relating to ESD, by examining previous literature. It showed the 3-spheres model of sustainability.

The third chapter discussed the methodology. This included a description of the context of study, research paradigm and sampling method. Chapter 3 also described the data generation plan and described the data instruments used to generate the qualitative data.

The data was analyzed in Chapter 4. The focus was on answering the four research question by presenting the findings inferred from the data. Lastly in this chapter (Chapter 5) were found the discussions and recommendations of this study.

Notably, this study from its findings revealed that the way PSNSTTs experienced learning about ESD suggested that there is a poor implementation of it in the context of the chosen university. Additionally, the findings of the study indicate is a poor awareness of ESD among students prior to enrolling for their tertiary Natural Sciences and Technology studies. This finding points to a lack of proper implementation of ESD at primary and secondary school levels, which in turn suggests a shortfall of policies, a lack of resources and a lack of awareness or negligence among teachers. Hence causing over-expectation amongst PSNSTTs in terms of ESD.

As the study results indicated both positive and negative learning experiences, recommendations are given so that stakeholders might work together with higher education institutions, or beyond, in implementing ESD.

REFERENCES

- Adebayo, O. A. (2014). *Exploring the Views of Pre-service Science Teachers about how They Learn to Teach Environmental Education*. Unpublished Masters dissertation, University of KwaZulu-Natal, Durban, South Africa.
- Adler, E. S. & Clark, R. (2008). Questionnaires and structured interviews. *How it's done: An invitation to social research*, 215-253.
- Angus, I., & Butler, S. (2011). *Too many people? population, immigration, and the environmental crisis*. Haymarket Books.
- Armstrong, C. M. (2011). Implementing education for sustainable development: The potential use of time-honored pedagogical practice from the progressive era of education. *Journal of Sustainability Education*, 2(2), 2011.
- Babbie, E. R. (2011). *Introduction to social research*. Belmont CA: Wadsworth Cengage Learning.
- Bernat, P. (2012): Sustainable Development and the Values We Share Sustainability as the Confluence of Islamic and Western Frameworks, *Problemy Ekorozwoju*, 7 (1), 33-41.
- Bertram, C. & Christiansen, I. (2014). *Understanding research: An introduction to reading research*. Van Schaik Publishers. Pretoria.
- Bhargava, V. K. (Ed.). (2006). *Global issues for global citizens: An introduction to key development challenges*. World Bank Publications. Retrieved from <https://openknowledge.worldbank.org/bitstream/handle/10986/7194/374520Global010R00FFICIAL0USE0ONLY.pdf?sequence=1&isAllowed=y>
- Blignaut, P. (2009). A bilateral perspective on the digital divide in South Africa. *Perspectives on Global Development and Technology*, 8(4), 581-601.
- Bloom, B. S. (1956). *Taxonomy of educational objectives. Vol. 1: Cognitive domain*. New York: McKay, 20-24.
- Bogardi, J. J., Dudgeon, D., Lawford, R., Flinkerbusch, E., Meyn, A., Pahl-Wostl, C., ... & Vörösmarty, C. (2012). Water security for a planet under pressure: interconnected challenges of a changing world call for sustainable solutions. *Current Opinion in Environmental Sustainability*, 4(1), 35-43.
- Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Bryan, E., Deressa, T. T., Gbetibouo, G. A. & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science & Policy*, 12(4), 413-426.

- Burns, T.R (2012). The sustainability revolution: A societal paradigm shift. *Journal of Sustainability*, 4, 1118-1134. doi:10.3390/su4061118
- Butchart, S. H., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P., Almond, R. E., & Carpenter, K. E. (2010). Global biodiversity: indicators of recent declines. *Science*, 328(5982), 1164-1168
- Caldeira, K. (2012). The great climate experiments. *Scientific American*, 307(3), 78-83.
- Chant, S. (2012). The disappearing of 'smart economics'? The World Development Report 2012 on gender equality: Some concerns about the preparatory process and the prospects for paradigm change. *Global Social Policy*, 12(2), 198-218.
- Check, J. & Schutt, R. K. (2012). *Research methods in education*. Los Angeles: Sage Publications
- Cohen, L. M. & Manion, L. L. & Morrison, K. (2007) Research methods in education 6th edition. London: *Routledge*.
- Cohen, L. M. & Manion, L. L. & Morrison, K. (2011) Research methods in education 7th edition. London: *Routledge*.
- Cohen, L. M. & Manion, L. L. & Morrison, K. (2013) Research methods in education 8th edition. London: *Routledge*.
- Constitution, S. A. (1996).—"In terms of Article 32(1) of the Constitution of South Africa, section 28 (1996).
- Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand oaks: Sage publications.
- Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand oaks: Sage publications.
- Creswell, J. W. & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, 39(3), 124-130.
- Cunningham, A. B. (1993). African medicinal plants. *United Nations Educational, Scientific and Cultural Organization: Paris, France*.
- Curtner-Smith, M. D. (2007). The impact of a critically oriented physical education teacher education course on preservice classroom teachers. *Journal of Teaching in Physical Education*, 26(1), 35-56.
- Dee, T. S. (2007). Teachers and the gender gaps in student achievement. *Journal of Human Resources*, 42(3), 528-554.
- Department of Basic Education (2011). *National Curriculum Statement; Curriculum and Assessments Policy Statement*. Natural Sciences, Senior Phase, Grades 7-9. Pretoria; South Africa.

- Department of Education. (1995). The white paper on Education and Training *Government Gazette* (23), Pretoria: Republic of South Africa
- Department of Education. (2000). Norms and standards for educators. *Government Gazette*, 415. Pretoria: Republic of South Africa
- Department of Environmental Affairs and Tourism (2008). *National Strategy for Sustainable Development and Action Plan*: South Africa. NSSD1 2011–2014. Retrieved from https://www.environment.gov.za/sites/default/files/docs/sustainabledevelopment_actionplan_strategy.pdf
- Department of Public Service and Administration. (1995). *White paper on public service training and education*. Department of Public Service and Administration. Pretoria
- Department of Science and Technology (2010). *Annual report*. Retrieved from <http://www.dst.gov.za/images/pdfs/DST%20Annual%20Report%20LR.pdf>
- Didonet, V. (2008). Early childhood education for a sustainable society. *The contribution of early childhood education to a sustainable society*, 25-31.
- Dincer, I. (2000). Renewable energy and sustainable development: A crucial review. *Renewable and Sustainable Energy Reviews*, 4(2), 157-175.
- Du Plessis, C. (2012). Towards a regenerative paradigm for the built environment. *Building Research & Information*, 40(1), 7-22.
- Dymont, J., Hill, A. & Emery, S. (2014). Sustainability as a cross-curricular priority in the Australian curriculum: A Tasmanian investigation. *Environmental Education Research*, 21(8), 1105-1126.
- Egoh, B. N., Reyers, B., Carwardine, J., Bode, M., O'Farrell, P. J., Wilson, K. A., & Cowling, R. M. (2010). Safeguarding biodiversity and ecosystem services in the Little Karoo, South Africa. *Conservation Biology*, 24(4), 1021-1030.
- Eriksen, C. (2007). Why do they burn the 'bush'? Fire, rural livelihoods, and conservation in Zambia. *The Geographical Journal*, 173(3), 242-256.
- Evans, J., Penney, D. & Bryant, A. (1993). Improving the quality of physical education? The Education Reform Act, 1988, and physical education in England and Wales. *Quest*, 45(3), 321-338.
- Evans, J., & D. Penney. 1993. "Physical Education after ERA?" *British Journal of Physical Education Research Supplement* 13: 2–5
- Evans, N., Tomas, L. & Woods, C. (2016). Impact of Sustainability Pedagogies on Pre-service Teachers' Self-efficacy. *Journal of Education for Sustainable Development*, 10(2), 243-261.
- Farley, J. & Daly, H. (2006). Natural capital: The limiting factor: A reply to Aronson, Blignaut, Milton and Clewell, *Ecological Engineering*, 28(1), 6-10.

- Fien, J. (2004). 11 Education for sustainability. In R. Gilbert (Ed) *Studying society and environment: A guide for teachers* 3rd edition, 184-200, Melbourne: Thompson Social Sciences Press
- Flick, U. (2006). Coding and categorizing. In U. Flick (ed.), *An introduction to qualitative research* (3rd edn., pp. 295–319). London: Sage. Florencio.
- Flick, U. (2009). *An introduction to qualitative research*. Thousand oaks: Sage publications.
- Food and Agriculture Organization of the United Nations (FAO). (2008). *Land degradation on the rise*. retrieved from <http://www.fao.org/newsroom/en/news/2008/1000874/index.html>
- Grobler, D. C., Ntsaba, M. (2004). Strategic Framework for National Water Resource Quality Monitoring Programmes. Report No. N/0000/REQ0204. ISBN 0- 621-35069-9. Pretoria: Resource Quality Services, Department of Water Affairs and Forestry. Retrieved from http://www.dwaf.gov.za/IWQS/wrmais/National_Water_Resource_Quality_strategy_ed01_dr05_final.pdf
- Grubb, M. (1993). *The Earth Summit agreements: a guide and assessment; an analysis of the Rio'92 UN Conference on Environment and Development*. London: Earthscan and the Energy and Environmental Programme of the Royal Institute of International Affairs.
- Heimlich, J. E., Braus, J., Olivolo, B., McKeown-Ice, R. & Barringer-Smith, L. (2004). Environmental education and preservice teacher preparation: A national study. *Journal of Environmental Education*, 35(2), 17-21.
- Hemingway, C. A. & MacLagan, P. W. (2004). Managers' personal values as drivers of corporate social responsibility. *Journal of Business Ethics*, 50(1), 33-44.
- Henning, E., Van Rensburg, W. & Smit, B. (2004). *Finding your way in qualitative research* (pp. 19-22). Pretoria: Van Schaik.
- Hodkinson, P. & Hodkinson, H. (2001). The strengths and limitations of case study research. In *Learning and Skills Development Agency conference, Cambridge 1*(1), 5-7.
- Hopkins, C. & McKeown, R. (2002). Education for sustainable development: an international perspective. In Tilbury, D. R. B. Stevenson, J. Fien, & D. Schreuder (Eds.), *Education and sustainability: Responding to a global challenge* (pp. 13–24)
- Huckle, J. (Ed.). (1983). *Geographical Education: reflection and action*. London: Oxford University Press.
- Huckle, J. (1996). Realizing sustainability in changing times' in John Huckle and Stephen Sterling (eds.) *Education for Sustainability*. London: Earthscan.
- Human Sciences Research Council (HSRC) (2010). *Annual report 2010/2011*. Retrieved from <http://www.hsrc.ac.za/uploads/pageContent/622/HSRC%20Annual%20Report%202010%202011.pdf>

- Hutchings, B. (2006). *Principles of enquiry-based learning*. Centre for Excellence in Enquiry-Based Learning, University of Manchester.
- Jasper, J. C. (2008). Teaching for sustainable development: Teachers' perceptions. *Unpublished Master of Education Thesis, University of Saskatchewan, Saskatoon, Saskatchewan*. Available at http://library2.usask.ca/theses/available/etd-02042009-212522/unrestricted/J_Jasper_Thesis.pdf.
- Johnson, R. B. & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26.
- Johnston, A. (2007). Higher Education for Sustainable Development. Final Report of International Action Research Project. In *Forum for the Future Action for a Sustainable World*. Organisation for Economic Co-operation and Development. Retrieved from <https://www.oecd.org/education/innovation-education/centreforeffectivelearningenvironmentscele/45575516.pdf>
- Kagawa, F. (2007). Dissonance in students' perceptions of sustainable development and sustainability: Implications for curriculum change. *International Journal of Sustainability in Higher Education*, 8(3), 317-338.
- Kahn, P. & O'Rourke, K. (2005). Understanding enquiry-based learning. In Barrett, T., Mac Labhrainn, I., Fallon, H. (Eds). *Handbook of Enquiry and problem-based learning—Irish case studies and international perspectives*. Galway, Ireland: Centre for Excellence in Learning and Teaching. Retrieved from <https://pdfs.semanticscholar.org/cdea/6b262e99d92df058044485c76a815eaa1c47.pdf>
- Kerruish, N. J., Settle, K., Campbell- Stokes, P. & Taylor, B. J. (2005). Vulnerable baby scale: Development and piloting of a questionnaire to measure maternal perceptions of their baby's vulnerability. *Journal of Paediatrics and Child Health*, 41(8), 419-423.
- Khattak, S. S. G. (2014). Teaching professionalism and the feminisation debate in Pakistan. *American Journal of Educational Research*, 2(12A), 45-53.
- Kilinc, A. & Aydin, A. (2013). Turkish student science teachers' conceptions of sustainable development: A phenomenography. *International Journal of Science Education*, 35(5), 731-752.
- Kolb, D.A. (1984) *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.
- Kostoulas-Makrakis, N. (2010). Developing and applying a critical and transformative model to address ESD in teacher education. *Journal of Teacher Education for Sustainability*, 12(2), 17-26.
- Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *American journal of occupational therapy*, 45(3), 214-222.
- Krueger, R. A. & Casey, J. (2009). *Successful focus groups: practical guidelines for research*. New Delhi: Sage Publications.

- Kumar, S. (2013). The looming threat of water scarcity. In *Vital signs* (pp. 96-100). Island Press/Center for Resource Economics
- Kvale, S. & Brinkmann, S. (2009). *Learning the craft of qualitative research interviewing*. Thousand Oaks: Sage Publications.
- Lapan, S. D., Quartaroli, M. T. & Riemer, F. J. (Eds.). (2011). *Qualitative research: An introduction to methods and designs* 37(3-18). Arizona: John Wiley & Sons
- Laurie, R., Nonoyama-Tarumi, Y., McKeown, R. & Hopkins, C. (2016). Contributions of Education for Sustainable Development (ESD) to quality education: A synthesis of research. *Journal of Education for Sustainable Development*, 10(2), 226-242.
- Lotz-Sisitka, H. (2011). Teacher professional development with an Education for Sustainable Development focus in South Africa: Development of a network, curriculum framework and resources for teacher education. *Southern African Journal of Environmental Education*, 28, 30-71.
- McMillan, J & Schumacher, S., (2006). Research in Education Evidence-Based Inquiry. *Boston: Pearson Education*.
- Martin, P. & Barnard, A. (2013). The experience of women in male-dominated occupations: A constructivist grounded theory inquiry. *South African Journal of Industrial Psychology*, 39(2), 01-12.
- Mays, N. & Pope, C. (1995). Rigour and qualitative research. *BMJ: British Medical Journal*, 311(6997), 109.
- McInnis, C. (1992). Changes in the Nature of Academic Work. *Australian Universities' Review*, 35(2), 9-12
- McKeown, R. & Hopkins, C. (2005). *Guidelines and Recommendations for Reorienting Teacher Education to Address Sustainability*. UNESCO education for sustainable development in action, Technical paper no.2
- McKeown, R., Hopkins, C. A., Rizi, R. & Chrystalbridge, M. (2002). *Education for sustainable development toolkit*. Knoxville: Energy, Environment and Resources Center, University of Tennessee.
- Mensah, A. M. & Castro, L. C. (2004). Sustainable resource use & sustainable development: a contradiction. *Center for Development Research, University of Bonn*.
- Michalos, A. C. (2009). Index of Behaviors Favorable Toward Sustainable Development. *Encyclopedia of Quality of Life and Well-Being Research*, 3154-3155.
- Miller, R. L. & Brewer, J. D. (Eds.). (2003). *The AZ of social research: A dictionary of key social science research concepts*. London: Sage publications.
- Milne, L. (2017). Children learning outside the classroom. . In C. Benson & S. Lawson (Eds.), *Teaching Design and Technology Creatively* (pp. 146–158). New York, USA: Routledge.

- Mochizuki, Y. (2016). Educating for transforming our world: Revisiting international debates surrounding Education for Sustainable Development. *Current Issues in Comparative Education*, 19(1), 109-125.
- Mohamedbhai, G. (2015a). What role for higher education in sustainable development. *University World News*, 09 January 2015, 349. Retrieved from <http://www.universityworldnews.com/article.php?story=20150108194231213>
- Mohamedbhai, G. (2015b). Higher education in Africa: facing the challenges in the 21st century. *International Higher Education*, 63(Spring), 20-21.
- Mouton, J. (2001). *How to succeed in your master's and doctoral studies: A South African guide and resource book*. Pretoria: Van Schaik.
- Mukheibir, P. & Sparks, D. (2005). Climate variability, climate change and water resource strategies for small municipalities. Retrieved from <http://open.uct.ac.za/handle/11427/17141>
- National Aeronautics and Space Administration (NASA) (2016). Global Climate Change: Vital signs of the planet. Retrieved from <http://climate.nasa.gov/vital-signs/carbon-dioxide/>
- National Oceanic and Atmospheric Administration (2007) Climate Change. Retrieved from <http://www.nws.noaa.gov/os/brochures/climate/Climatechange.pdf>
- Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, 19(4), 317-328.
- Ngure, S. W. (2013). Stakeholders' perceptions of technical, vocational education and training: the case of Kenyan micro and small enterprises in the motor vehicle service and repair industry. Thesis PhD Edith Cowan University Perth Australia. Retrieved from <http://ro.ecu.edu.au/theses/597/>
- Njie, B. & Asimiran, S. (2014). Case study as a choice in qualitative methodology. *Journal of Research & Method in Education*, 3(1), 35-40.
- O'Riordan, T. (2004). Environmental science, sustainability and politics. *Transactions of the Institute of British Geographers*, 29(2), 234-247.
- Oskamp, S. (2002). Summarizing sustainability issues and research approaches. In *Psychology of sustainable development* (pp. 301-324). Springer US.
- Otte, P. P. (2016). Integrating Sustainable Development in Higher Education through experience-based learning: Insights from Experts in Team (EiT) for developing a combined theoretical framework. *Journal of Education for Sustainable Development*, 10(1), 131-159.
- Özsoy, S., Ertepinar, H. & Sağlam, N. (2012). Can eco-schools improve elementary school students' environmental literacy? Retrieved from https://www.eduhk.hk/apfs/lt/download/v13_issue2_files/ozsoy.pdf

- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332.
- Patton, M. Q. (2002). Qualitative interviewing. *Qualitative research and evaluation methods*, 3, 344-347.
- Pavlova, M. (2011). Environmental education and/or education for sustainable development: What role for technology education. *PATT 25: CRIPT8*, 333. Retrieved from https://research-repository.griffith.edu.au/bitstream/handle/10072/46566/74769_1.pdf?sequence=1
- Peattie, K. & Collins, A. (2009). Guest editorial: perspectives on sustainable consumption. *International Journal of Consumer Studies*, 33(2), 107-112.
- Petersen, N. (2014). The 'good', the 'bad' and the 'ugly'? Views on male teachers in foundation phase education. *South African Journal of Education*, 34(1), 1-13.
- Pretorius, R., Lombard, A. & Khotso, A. (2016). Adding value to education for sustainability in Africa with inquiry-based approaches in open and distance learning. *International Journal of Sustainability in Higher Education*, 17(2), 167-187.
- Republic of South Africa. (2011). *National Climate Change Response White Paper*. Pretoria: Government Printer.
- Rieß, W. & Mischo, C. (2008). Development and initial validation of a questionnaire to capture systemic thinking in sustainability-relevant contexts. In *Competences of Education for Sustainable Development* (pp. 215-232). New York: VS Publishing House for Social Sciences.
- Rosenburg, E. (2010). Biodiversity research and conservation: Careers. *Quest*, 6(3), 27-29.
- Rosnow, R. L. & Rosenthal, R. (2008). Assessing the effect size of outcome research. In A. M. Nezu & C. M. Nezu (Eds.), *Evidence-based outcome research: A practical guide to conducting randomized controlled trials for psychosocial interventions* (pp. 379-401). New York: Oxford University Press.
- Roulston, K. (2010). Considering quality in qualitative interviewing. *Qualitative Research*, 10(2), 199-228
- Rule, P. & John, V. (2011). *Your guide to case study research*. Pretoria: Van Schaik.
- Samuelsson, I. P. & Kaga, Y. (Eds.). (2008). *The contribution of early childhood education to a sustainable society* (pp. 1-136). Paris: UNESCO.
- Seybold, H. & Rieß, W. (2006). Research in environmental education and Education for Sustainable Development in Germany: The state of the art. *Environmental Education Research*, 12(1), 47-63.
- Scholes, R. J. (2001). Environmental issues: Panel discussion. *Transactions of the Royal Society of South Africa*, 56(2), 142-143.

- Scott, L. C. (2015). The Futures of Learning 3: What kind of pedagogies for the 21st century? Education Research and Foresight Working Papers. Retrieved from <http://unesdoc.unesco.org/images/0024/002431/243126e.pdf>
- Sharlanova, V. (2004). Experiential learning. *Trakia Journal of Sciences*, 2(4), 36-39.
- Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2), 63-75.
- Shi, W., Wang, S. & Yang, Q. (2010). Climate change and global warming. *Reviews in Environmental Science and Bio/Technology*, 9(2), 99-102.
- Singh-Pillay, A. (2015). Pre-service technology teachers' reflections on their learning during service-learning: A Promising Marriage for 'Pedagogy'. *Alternation Special Edition No 16 (2015) 166 - 188*
- Siraj-Blatchford, J., Smith, K. C. & Samuelsson, I. P. (2010). *Education for sustainable development in the early years*. Gothenburg: World Organization for Early Childhood Education.
- Spaull, N. (2013). South Africa's education crisis: The quality of education in South Africa 1994-2011. *Johannesburg: Centre for Development and Enterprise*.
- Steinemann, A. (2003). Implementing sustainable development through problem-based learning: Pedagogy and practice. *Journal of Professional Issues in Engineering Education and Practice*, 129(4), 216-224.
- Sterling, S. & Huckle, J. (Eds.). (2014). *Education for sustainability*. New York: Routledge.
- Stern, P. C. & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues*, 50(3), 65-84.
- Strebler, M., Thompson, M. & Heron, P. (1997). Skills. *Competencies and Gender: Issues for Pay and Training*, Report, 333. *Report*, 333. Brighton: Institute for Employment Studies
- Tacoli, C., McGranahan, G. & Satterthwaite, D. (2015). *Urbanisation, rural-urban migration and urban poverty*. London: IIED.
- Thomas, I (2014), Special Issue – Pedagogy for Education for Sustainability in Higher Education 23(2) 9-29
- Tilbury, D. (2011). Education for sustainable development: An expert review of processes and learning. *Paris, France: UNESCO*. <http://unesdoc.unesco.org/images/0019/001914/191442e.pdf>.
- Tilbury, D. & Mulà, I. (2009). Review of Education for Sustainable Development Policies from a Cultural Diversity and Intercultural Dialogue: Gaps and Opportunities for Future Action. Paris: UNESCO

- Tong, A., Sainsbury, P. & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, 19(6), 349-357.
- Tuncer, G., Tekkaya, C., Sungur, S., Cakiroglu, J., Ertepinar, H. & Kaplowitz, M. (2009). Assessing pre-service teachers' environmental literacy in Turkey as a mean to develop teacher education programs. *International Journal of Educational Development*, 29(4), 426-436.
- Tuziak, A. (2010). Socio-economic aspects of sustainable development on global and local level. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1638879
- United Nations (1987). *Brundtland Report of the World Commission on environment and development: "our common future."*. Paris: United Nations.
- United Nations (2005). *United Nations Decade of Education for Sustainable Development (2005-2014): International Implementation Scheme*. Paris: United Nations Educational, Scientific and Cultural Organization
- United Nations (2013). *World Economic and Social Survey Sustainable Development Challenges*. United Nations Department of Economic and Social Affairs
- United Nations (2015). *Transforming Our World: the 2030 Agenda for Unstainable development*.
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2005) *UN Decade of Education for Sustainable Development: DESD 2005 – 2014. DESD at a glance*. Retrieved from <http://unesdoc.unesco.org/images/0014/001416/141629e.pdf>
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2007). *The UN Decade of Education for Sustainable Development: DESD 2005-2014. The First Two Years*. Retrieved from <http://unesdoc.unesco.org/images/0015/001540/154093e.pdf>
- United Nations Environment Programme (UNEP). (2009). *Converting Waste Plastics into a Resource-Assessment Guidelines*. Retrieved from
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2009a). *A review of education for sustainable development policies from a cultural diversity and intercultural dialogue perspective identifying opportunities for future action*. Retrieved from <http://unesdoc.unesco.org/images/0021/002117/211750e.pdf>
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2009b) *Decade of Education for Sustainable Development (DESD, 2005-2014) Review of Contexts and Structures for Education for Sustainable Development, Learning for a sustainable world*. Retrieved from http://www.unesco.org/education/justpublished_desd2009.pdf
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2012) *Education for Sustainable Development in Action. Sourcebook*. Retrieved from <http://unesdoc.unesco.org/images/0021/002163/216383e.pdf>

- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2013). *National Journeys towards Education for Sustainable Development: reviewing national ESD experiences from Costa Rica, Morocco, South Africa, Sweden, Viet Nam*. Paris:
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2015). *Sustainable development post-2015 begins with education: How education can contribute to the proposed post-2015 goals*. Retrieved from <http://unesdoc.unesco.org/images/0023/002305/230508e.pdf>
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2016a). *Global action programme on education for sustainable development information folder*.
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2016b). *Schools in action, global citizens for sustainable development: A guide for teachers*.
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2017). *Education for Sustainable Development Goals Learning Objectives*. Paris:
- United Nations Educational, Scientific and Cultural Organization Institute for Statistics (UNESCO IS). (2006). *Teachers and educational quality: monitoring global needs for 2015*. Montreal: UNESCO Institute for Statistics.
- United Nations Environment Programme (UNEP). (2003). *Land degradation*. Retrieved from <http://www.unep.org/dgef/LandDegradation/tabid/1702/Default.aspx>
- United Nations Environment Programme (UNEP). (2007). *Global Environment Outlook (GEO 4): Environment for development*. Valetta: United Nations Environment Programme
- United Nations Environment Programme (UNEP). (2009). *Converting Waste Plastics into a Resource: Assessment Guidelines*. United Nations Environment Programme: Osaka Retrieved from http://www.unep.or.jp/ietc/Publications/spc/WastePlasticsEST_AssessmentGuidelines.pdf
- Vandeyar, S. & Killen, R. (2007). Educators' conceptions and practice of classroom assessment in post-apartheid South Africa. *South African Journal of Education*, 27(1), 101-115.
- Van Wilgen, B. W., Cowling, R. M., Marais, C., Esler, K. J., McConnachie, M. & Sharp, D. (2012). Challenges in invasive alien plant control in South Africa. *South African Journal of Science*, 108(11-12), 8-11.
- Vaughan, R. P. (2016). *Gender equality and education in the Sustainable Development Goals*. Background paper prepared for the 2016 Global Education Monitoring Report. Education for people and planet. UNESCO. Retrieved from <http://unesdoc.unesco.org/images/0024/002455/245574e.pdf>

- Wals, A. E. (2014). Sustainability in higher education in the context of the UN DESD: a review of learning and institutionalization processes. *Journal of Cleaner Production*, 62, 8-15.
- Wiersum, K. F., Dold, A. P., Husselman, M. & Cocks, M. (2006). Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation in the Amatola region, South Africa. *Frontis*, 17, 43-57.
- Winter, J. (2015) *Taking an institutional approach to learning about sustainability*. Educational Development, Plymouth University
- Winter, J., Sterling, S. & Cotton, D. (2015). *Steps to embedding sustainability into student learning*. Educational Development. Plymouth University.
- Wyness, L. & Sterling, S. (2015). Reviewing the incidence and status of sustainability in degree programmes at Plymouth University. *International Journal of Sustainability in Higher Education*, 16(2), 237-250.
- Yin, R. (1994). *Case study research: Design and methods*. (2nd edition) Beverly Hills: Sage Publishing
- Yin, R. K. (2009). *Case study research: Design and methods* (4th edition). Los Angeles: Sage Publishing.
- Yin, R. K. (2011). *Qualitative research from start to finish*. New York & London: Guilford Press.

APPENDIX A

LETTER OF PERMISSION TO CONDUCT RESEARCH



26 April 2017

Alvin Uchenna Ugwu (SN 213569937)
 School of Education
 College of Humanities
 Edgewood Campus
 UKZN
 Email: Pillaya5@ukzn.ac.za

Dear Dr Pillay

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 degree, provided Ethical clearance has been obtained. We note the title of your research project is:

"An Exploration of Intermediate Phase Science and Technology pre-service teachers experiences of learning about education for sustainable development: A case study of a particular University".

It is noted that you will be constituting your sample by handing out questionnaires, and/or conducting interviews with students 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. 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

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APPENDIX B

ETHICAL CLEARANCE



05 June 2017

Mr Alvin Uchenna Ugwu (213569937)
School of Education
Edgewood Campus

Dear Mr Ugwu,

Protocol reference number: HSS/0583/017M

Project title: An exploration of Intermediate Phase Science and Technology Preservice teachers' experiences of learning about Education for Sustainable Development: A case study

Approval Notification – Expedited Application

In response to your application received on 17 May 2017, 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



.....
Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Dr Asheena Singh-Pillay
 Cc Academic Leader Research: Dr SB Khoza
 Cc School Administrator: Ms Tyzer Khumalo

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



Founding Campuses: ■ Edgewood ■ Howard College ■ Medical School ■ Pietermaritzburg ■ Westville

APPENDIX C

LETTER TO THE DEAN COLLEGE OF EDUCATION RICHMOND UNIVERSITY



University of KwaZulu-
Natal Edgewood Campus,

School of Education

Private Bag X03

Ashwood, 3605

The Dean College of Education

Richmond University Kwazulu-Natal

Dear Sir/Madam,

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR INSTITUTION

My name is Alvin Uchenna Ugwu a student studying for a master's degree in Science Education at the University of KwaZulu-Natal, South Africa.

Student No: 213569937

My research is '**An Exploration of Intermediate Phase Natural science and Technology Preservice Teachers' Experiences of Learning About Education for Sustainable Development: A Case study of a Particular University**'. My data generation method involves using questionnaires and focus group interviews with Preservice Natural Sciences and Technology students.

I hereby seek your permission to conduct my research in your college. I expect to get 20 students willing to volunteer as my participants for the particular class I'm choosing my participants. The research data will be generated through questionnaires and focus group interviews. The students-

participants will be issued with a well-structured questionnaire which they will fill-in and return to me or my supervisor (Dr. Asheena Singh- Pillay). I wish to also seek permission from the lecturer taking the modules of interest as well.

More importantly, the students' participation in this study will be completely voluntary. The volunteering students will be issued with consent letters which they will sign and send back to me.

Please Sir/Madam, I humbly request you to kindly fill out the attached declaration and consent form which acknowledges the permission granted to undertake my research in your college.

I guarantee that the information generated from the participants will be used for the research only.

Also, I can assure you that the study will not in any way interfere with the teaching and learning activities in your institution. For more information regarding this research you may contact myself:

Alvin Uchenna Ugwu (cell: 0628657287) or my supervisor Dr. Asheena Singh Pillay (Tel: +27 31 2603 672)

Your cooperation will be greatly appreciated.

Your Faithfully

Alvin U. Ugwu

I.....Dean/Deputy dean of
Richmond University Kwa-Zulu Natal hereby grant permission for the research to be conducted in
my college.

.....

Official Stamp

Signature of Dean/ Deputy Dean

Date.....

APPENDIX D

LETTER TO NATURAL SCIENCES AND TECHNOLOGY MODULE LECTURER



School of Education, College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus, Durban,
South Africa.

www.ukzn.ac.za

Student No; 213569937

Dear Sir/Madam,

A REQUEST OF PERMISSION TO CONDUCT RESEARCH IN YOUR CLASS

My name is, Alvin Uchenna Ugwu. I am a Masters student here at UKZN, Edgewood campus.

Student No: 213569937

My research is '**An Exploration of Intermediate Phase Natural Sciences and Technology Pre-service Teachers' Experiences of Learning About Education for Sustainable Development: A Case study of a Particular University**'. My data generation method involves using questionnaires and focus group interviews with Pre-service Natural Sciences and Technology students.

I hereby seek your permission to conduct my research with the registered students in your class. I expect to get 20 students willing to volunteer as my participants. The research data will be generated through questionnaires and focus group interviews. The students-participants will be issued with a well-structured questionnaire which they will fill-in and return to me or my supervisor (Dr. Asheena Singh- Pillay).

More importantly, the students' participation in this study will be completely voluntary. The volunteering students will be issued with consent (see appendix E for informed consent letter) which they will sign and send back to me.

Please Sir/Madam, I humbly request you to kindly fill out the attached declaration and consent form which acknowledges the permission granted to undertake my research in your class.

I guarantee that the information generated from the participants will be used for the research only. Also, I can assure you that the study will not in any way interfere with the teaching and learning

activities in your class. For more information regarding this research you may contact myself: Alvin Uchenna Ugwu (cell: 0628657287) or my supervisor Dr. Asheena Singh Pillay (Tel: +27 31 2603 672)

Your cooperation will be greatly appreciated.

Your Faithfully

Alvin U. Ugwu

I.....Lecturer/coordinator for
Natural Science Method2 at the Richmond University KwaZulu-Natal hereby grant permission for
the research to be conducted in my class.

.....
Signature of Lecturer/Module Coordinator

Official Stamp

Date.....

APPENDIX E

INFORMED CONSENT LETTER



Dear Participant

INFORMED CONSENT LETTER

My name is, Mr. Alvin Uchenna Ugwu. I am a Masters student studying at the University of KwaZulu-Natal, Edgewood campus, South Africa.

My research is 'An Exploration of Intermediate Phase Science and Technology Pre-service Teachers' Experiences of Learning About Education for Sustainable Development: A Case study of a Particular University'. My data generation method involves using questionnaires and focus group interviews. Hence your participation in this study will be greatly appreciated. On the questionnaire, you would need to fill-in the questions in all honesty and to the best of your ability and return it to me or my supervisor (Dr. Asheena Singh- Pillay). The questionnaire is designed to capture the ideas which will lead to answering the research questions in this study.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- I will not use your identity in this study in a way that it contravenes your privacy and self-esteem. I will be using pseudonyms to represent the identity of all participants.
- The focus group interview may last for about 40 minutes and may be split depending on your preference.
- Any information given by you will not be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.

- You have a choice to participate, not participate or stop participating in the research at any time. You will not be penalized for taking such an action.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	Willing	Not willing
Audio equipment		
Photographic equipment		
Video equipment		

I can be contacted at:

Email: vinyjnr@gmail.com or 213569937@stu.ukzn.ac.za

Cell: 0628657283,

My supervisor is Dr. A. Singh- Pillay who is located at the School of Education, Science and Technology cluster, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: pillaya5@ukzn.ac.za Phone number: 031-26053672

You may also contact the Research Office through:

P. Mohun

HSSREC Research Office,

Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

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

APPENDIX F

ESD Questionnaire

Education for Sustainable Development (ESD) Questionnaire

Dear participant, please note that this study does not intend to undermine your personality in any way. Hence you would be required to answer the questions in this questionnaire to the best of your ability, even if your interest level or knowledge of Education for Sustainable Development is low. All feedback will be valuable in this project. You are not compelled to write your name and student number, but feel free if you wish to do so as your identity will be kept confidential and safe. Your participation in this study is voluntary and anything you submit will be kept anonymous. Your decision to participate will have no effect on your status as a student at the Richmond University Kwa-Zulu Natal. By completing the questionnaire, you consent that you voluntarily agree to participate in the research. If you have further questions and concerns, please contact Mr. Alvin U. Ugwu: email- vinyjnr@gmail.com or Dr. A. Singh Pillay: email- Pillaya5@ukzn.ac.za

Thank You!

A. Demographics

Gender	
Race	
Age	
Year of Study	
Home location (chose one). City, Suburb, Township, Country side, Rural area.	
Residing at residence or home?	

B. Understanding of Education for Sustainable Development.

1. How would you rate your level of familiarity with the term Education for Sustainable Development? Using the scale below, please tick in the open bracket.
 - a. Not familiar at all []
 - b. Unfamiliar []
 - c. Partially familiar []
 - d. Familiar []
 - e. Very familiar []
2. How would you rate your level of awareness of the concept of Education for Sustainable Development? Using the scale below, please tick in the open bracket
 - a. Not aware at all []
 - b. Partially aware []
 - c. Aware []
 - d. More aware []
 - e. Very aware []
3. Consider the term **Education for Sustainable Development**. Please list below any keywords, concepts, ideas, or actions that come to mind when you talk about ESD?

-
-
4. Using the terms/ideas you gathered above, please try to define Education for Sustainable Development to the best of your ability. Please feel free to write whatever comes to your mind.
-
-
-
-
-

5. What are your perception of the Education for Sustainable Development contents included in the science and technology modules you are studying? Please explain your views to the best of your understanding
-
-
-
-
-

6. What challenges or enables your learning of Education for Sustainable Development in the science and technology modules you are enrolled for?
-
-
-
-
-

7. What can be done to enhance your learning in Education for Sustainable Development?
-
-
-
-
-

C. Behavioral practices and motivation in respect of Education for Sustainable Development.

1. Please by means of a tick which of the proposed reasons correspond to your reason for engaging in learning Education for Sustainable Development.

Proposed Reasons	Tick <input type="checkbox"/>
Because I understand the need to teach the younger generation the need to protect the environment.	<input type="checkbox"/>
Sincerely, I don't know	<input type="checkbox"/>
Honestly, I don't know; I have the impression that I'm wasting my time doing things for the environment	<input type="checkbox"/>
For the pleasure I experience when I find new ways to improve the quality of life and	<input type="checkbox"/>

the environment.	
Because it is a reasonable thing to do to help the environment and the society as a whole, and it's part of citizen responsibility	
Because I like the feeling I have when I do things for the environment.	
I think I'd regret not doing something for the environment	
Because it's a sensible thing to do something in order to improve the environment	
Because other people will be upset if I don't	
For the recognition I get from others	
Because I would feel bad if I don't do anything for the environment	
Because taking care of the environment is an integral part of my life and social responsibility	
Because my friends do it	
Because it seems to me that taking care of myself and taking care of the environment are inseparable	
Because I would feel guilty if I don't, because being environmentally -conscious has become a fundamental part of who I'm	
Because it is part of the way I've chosen to live my life	
To preserve our resources for the next generation	
To avoid being criticized	
For the pleasure I experience while mastering new ways of helping our environment	
Because I understand that the environment clings to the social and economic wellbeing of the society.	
To empower myself and other people economically and grow our country's economy	
I don't know, I can't see how my efforts to environmentally conscious are helping the environmental situation	
Because I think ESD would help me to understand how to sustain our cultural values	

2. Kindly place a tick next to the activities you engage in

Activity	Tick <input type="checkbox"/>
Buy energy efficient appliances	
Using a fuel-efficient car	
Recycling (paper, cardboard, cans, phone books, etc.)	
Use permanent plates, silverware and coffee mugs instead of disposables	
Take shorter showers	
Use e-mail system to cut down on paper usage	
Turn lights off when I'm leaving a room	
Double-sided printing	
Turn water off while soaping my hands, shaving, or brushing teeth	
Donate re-usable goods to those in need (food drives, Goodwill, cell phone emergency re-use programs)	
Use CFL (Compact florescent lights) instead of incandescent light bulbs	
Unplug chargers and appliances when not in use	
Walk or bike instead of using car or public transport to near destinations	
Talk to friends, family or associates about environmental issues	
Eat less beef/meat	
Wash and dry larger loads of laundry	
Composting	
Wash clothes in colder water (warm instead of hot, or cold instead of warm)	

Improve home insulation	
Repair all leaking taps	
Do not dump illegally	

D. Attitude towards sustainability and wise consumerism

1. How would you describe your attitude to sustainability and wise consumerism?
Please indicate by ticking which of the proposed responses corresponds to your attitude to sustainability and wise consumerism.

Proposed attitudinal responses	Tick √
A waste of time and effort	
It's ok if other want to do it	
Why bother not everybody is interested	
It's good	
Passionate advocate	
I don't care about sustainability there are bigger issues at hand	

2. As a society, we should change our way of living to offset the danger of global warming, climate change, greenhouse effect, over population, depleting natural resources, and economic crises. Select the most appropriate option provided below by placing a tick next to it.

Options	Tick √
Strongly agree	
Agree	
I don't care	
I do not know	
Disagree	
Strongly Disagree	

3. I avoid buying from a company which shows no concern about the environment.
Select the most appropriate option provided below by placing a tick next to it

Options	Tick √
Strongly agree	
Agree	
I don't care	
I do not know	
Disagree	
Strongly Disagree	

4. South Africa should maintain high levels of economic growth even if it disregards the environment and the global regulations in respect of the environment and sustainability. Please select the most appropriate option provided below by placing a tick next to it:

Options	Tick √
Strongly agree	
Agree	
I don't care	

I do not know	
Disagree	
Strongly Disagree	

5. Please place tick in the appropriate column to indicate if you agree or strongly agree to the following proposed options.

Options	Agree	Strongly agree
Every girl or boy should receive education that teaches the knowledge, perspectives, values, issues and skills for sustainable development in a community.		
The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today or even better.		
Manufacturers should discourage the use of disposables		
Over use of our natural resources is a serious threat to the health and welfare of future generations.		
We need stricter laws and regulations to protect the environment.		
Poverty alleviation is an important topic in education for sustainable development		
Sustainable Development will not be possible until wealthier nations stop exploiting the labor and natural resources of poorer nations.		
Companies that are environmentally sustainable are more likely to be profitable over the long run.		
The teaching of sustainability principles should be integrated into the curriculum in all disciplines and at all levels of schooling.		
Government should encourage greater use of fuel efficient vehicles and should provide safe public transport		
Citizenship education is an important component of Education for Sustainable Development		
Taxes/fines on polluters should be increased to pay for damage to the communities and the environment		
There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.		
We owe a duty to our children and grandchildren to preserve the environment		
I want my child and grandchildren to see and enjoy those things I enjoyed		
We owe a duty to animals and nature; they don't exist just for our enjoyment		
The earth and nature are fragile and we can easily cause irreversible damage.		
We have no choice: we have to protect the environment or we will destroy the human race.		

APPENDIX G

FOCUS GROUP INTERVIEW SCHEDULE

Main RQ 2: What challenges do pre-service Science Teachers experience when they learn how to teach sustainable development?

1. Please could explain in your own opinion what you understand by Sustainable Development (SD)?
 2. Based on your own experience, can you please define for me Education for Sustainable Development?
 3. What are the things that you do in your daily life that pricks your feeling that they are not helping our society in terms of sustainable development?
 4. What are the things that you do in your daily life that you think would help our society now and in the future in terms of sustainable development?
 5. What specific topics do you think reflect ESD development in your natural Science and Technology modules?
 6. How are those topics on ESD being taught on how to teach them as you go into the field?
 7. What are the challenges you face a pre-service teacher when you learn about teaching Education for Sustainable development?
- What do you think is the best part of your learning in Natural Sciences that will help you to teach SD as a pre-service teacher?
8. Do you think that you have been well equipped and ready to teach the concepts of SD in your classroom through what you have learnt in your Natural Sciences and Technology modules?
 9. Explain why you say so?

APPENDIX H:
CERTIFICATE OF EDITING
Sheelagh Halstead
BSc (Natal) HED (UNISA) MSc (UKZN)

Independent Education Consultant

127 11 th Street	tel:	+2710 203 9019
Parkhurst, Johannesburg	cell and Whatsap:	+2782 3717650
South Africa, 2193	email:	halstead@nitrosoft.co.za

EDITING CERTIFICATE

NAME: Alvin U. Ugwu

DISSERTATION TITLE: *An exploration of Intermediate Phase Natural Sciences and Technology Pre-service Teachers' experiences of learning about Education for Sustainable Development: A Case study at a South African university*

AFFILIATION: School of Education, College of Humanities, University of KwaZulu-Natal

I confirm that I have edited this dissertation for grammar, appropriate use of academic language or conventions and flow of the text. I have addressed formatting of pages, headings and references. I have made comments on substantive issues around the flow and internal consistency of the academic argument. I leave the student to institute the suggested changes in consultation with her supervisor.

As an independent educational consultant, one of my specialisations is writing academic learning material and editing academic documents. I am a native English speaker. I obtained a BSc at the University of Natal, with chemistry and applied mathematics majors. After graduation, I was a Research Officer in the Ministry of Roads and Road Traffic in, as was then, Rhodesia. My duties included writing reports and editing those by other authors. Some years later I entered the teaching profession and studied with UNISA for my postgraduate Higher Education Diploma, achieving a distinction for the English language module. After 20 years teaching at high school, I took up an academic position at the University of KwaZulu-Natal, where I completed an MSc in chemistry education and wrote several research articles. Since retirement five years ago, I have edited numerous academic papers and sixteen theses or dissertations, several of which were judged to be *cum laude*, and one of which required no alterations from the examiners.



Sheelagh Edith Halstead 22nd November 2017

APPENDIX I

TURNIT IN REPORT

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<http://www.un.org>
 ✕<1% match (publications)
[G. A. Fahad. "Group discussions: A misunderstood technique", Journal of Marketing Management, 1986](#)
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[ASTE Series in Science Education, 2015.](#)
 ✕<1% match (Internet from 07-Jun-2017)
<http://unesdoc.unesco.org>
 ✕<1% match (publications)
[Lesley Le Grange. "The Environment in the Mathematics, Natural Sciences, and Technology Learning Areas for General Education and Training in South Africa", Canadian Journal of Science Mathematics and Technology Education, 01/2010](#)
 ✕<1% match (Internet from 21-Apr-2015)
<http://Psalud.gob.mx>
 ✕<1% match (Internet from 03-Apr-2015)
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<http://arcworld.org>
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[Iyer, Radha, Suzanne Carrington, Louise Mercer, and Gitta Selva. "Critical service-learning: promoting values orientation and enterprise skills in pre-service teacher programmes", Asia-Pacific Journal of Teacher Education, 2016.](#)
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<http://uir.unisa.ac.za>
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<http://www.unescobkk.org>

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[Sustainability Assessment Tools in Higher Education Institutions, 2013.](#)

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<http://www.iau-hesd.net>

✖<1% match (Internet from 07-May-2015)

<http://d3mcbia3evjswv.cloudfront.net>

✖<1% match (student papers from 10-Mar-2016)

[Submitted to National University of Ireland, Maynooth on 2016-03-10](#)

✖<1% match (publications)

["Sustainable Development Research at Universities in the United Kingdom", Springer Nature, 2017](#)

✖<1% match (publications)

[Jéssica Garcia, Sthefanie Aguiar da Silva, Andréia Simas Carvalho, José Baltazar Salgueirinho Osório de Andrade Guerra. "Chapter 1 Education for Sustainable Development and Its Role in the Promotion of the Sustainable Development Goals", Springer Nature, 2017](#)

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[Submitted to University of KwaZulu-Natal on 2016-05-12](#)

✖<1% match (student papers from 27-Mar-2017)

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APPENDIX J

TABLE OF QUESTIONNAIRE DATA PRESENTATION

Presentation of 16 Completed Questionnaires Data

▪ Understanding of ESD

Question:	Participants' (P1-16) Response				
	a. (Not familiar at all)	b. (Unfamiliar)	c. (Partially familiar)	d. (Familiar)	e. (Very Familiar)
1. Understanding of ESD	P6,	P10	P1, P2, P4, P12,	P3, P5, P7, P9, P11, P13, P14, P15, P16.	P8,

▪ Level of Awareness of ESD

Question:	Participants' (P1-16) Response				
	a. (Not aware at all)	b. (Partially aware)	c. (Aware)	d. (More aware)	e. (Very aware)
2. Level of Awareness of ESD		P1, P3, P4, P10, P11, P15,	P2, P5, P12, P13, P14, P16	P7, P9,	P8

▪ List of keywords, concepts, ideas or actions that come to mind.

Question:	Participants' (P1-16) Response	
3. List of keywords, concepts, ideas or actions that come to mind.	P1	Recycling, sustain mineral resources, conservation of energy
	P2	Helping the environment, Environmental safety, promoting a sustainable life, promoting awareness of responsibility towards global challenges
	P3	Teaching kids how to save electricity and water, implementation of recycling programs, encourage community participation in environmental restoration.
	P4	Biodiversity, poverty, climate change, landfills, drought, pollution, issues that occur in an environment affecting environment and society, awareness to what happens in our land and people.
	P5	Preserving, resources, awareness, taking care of.
	P6	Keep the environment clean, protect the environment, recycling,

		economic crisis, greenhouse gas.
	P7	Good education offered to students or learners that last for long, acquiring good skills and knowledge, improvement for bad reflections on teaching and learning, Education where you learn to take care of the environment and nature around us
	P8	Reducing greenhouse gasses, reducing pollution, carbon footprint, planting more trees, conservation of resources; reduce, reuse and recycle, solar power, renewable and safe resources, depleting of our country's and worlds resources.
	P9	Green economy, green growth, low carbon development, healthy natural environment.
	P10	Recycling, reusing, Organic materials and Nature conservation.
	P11	Resources, sustainability, United Nations, biodiversity, climate change, Methods that motivate and empower learners to change their behavior and take action for sustainable development.
	P12	Reduce, reuse, recycle; sustainable living, environmental consciousness.
	P13	Caring for the environment, impacts of pollution, recycling, awareness campaigns.
	P14	Recycling, reuse, encourage planting.
	P15	Environmental awareness, recycling, reusing, reducing; protecting the environment; sustaining resources for the future generation.
	P16	Recycling, Reducing, Reusing, go green, ozone friendly materials.

▪ **Definition of ESD by participants**

Question:	Participants' (P1-16) Response	
4. Definition of ESD by participants	P1	Education for sustainable development is about educating people to conserve what they have e.g. water, electricity, food, keep the environment clean by recycling and ensure the sustainability of mineral resources e.g. coal, fuel.
	P2	Education for sustainable development is about helping the environment and people to live a sustainable life, they achieve this through educating people.

	P3	Sustainable Development is important to ensure the sustainability and development of a country. Implementation of ESD in schools will ensure that the future generations know how to sustain the environment. It will also ensure the future generation.
	P4	Sustainable development is an organization that needs people to try and solve problem or common problems in South Africa. Both natural and synthetic. It is only a matter of making good decisions when it comes to our environment and society and how we want our future generations to live like.
	P5	Sustainable Development deals with preserving the environment, country, economy for future generations. Basically, taking care of something so it can be used for a longer period of time.
	P6	Education for sustainable development means being able to take care of the environment and teach other people about it.
	P7	Education for sustainable development is education which is offered must be worthy and useful of acquiring necessary skills and knowledge. With this the education, will be sustainable and last for future generation. Also, it is the education or work that is taught to us to be environmentally friendly.
	P8	Education for sustainable development would be education that promotes sustainable development where we can meet the needs of people but at the same time have for the future people (enough resources).
	P9	Sustainable development is development that meets the needs of the present without compromising the ability of future generation to meet their own needs.
	P10	Education for sustainable development, is about educating people about sustainability. This is done through recycling and reusing or organic materials in order to conserve nature (natural resources). Or preserve them.
	P11	It describes the practice of teaching for sustainability.
	P12	The practice of developing skills, knowledge and values that promote the activity/ active participation in sustainable living, environmental consciousness and acknowledgement of the indispensability of natural

		resources.
	P13	Teaching and educating people about preserving and conserving the environment for future generations and doing your part to ensure the environment is clean and healthy to reside in and also make yourself aware of harmful threats that could be fatal to society. You can make a difference by reducing pollution.
	P14	It is providing education which enlightens individual on how to live causing, the least amount of damage on the environment.
	P15	Sustainable development is using resources in a way which will sustain it for the future generation, promoting ways in which we can help and prevent harm to the environment by educating people.
	P16	Using/ by applying the above elements we can meet the needs of present generations without compromising the needs of the future generations.

▪ **Perception of ESD Contents included in Natural Sciences and Technology modules undertaken by participants.**

Question:	Participants' (P1-16) Response	
5. Perception of ESD Contents included in Natural Sciences and Technology modules undertaken by participants.	P1	Recycling- because it stresses the issue of keeping the environment clean.
	P2	In technology, under plastics, we were thought about how plastics can be reused and recycled in our everyday life.
	P3	ESD is teaching kids how to save electricity and water, implementation of recycling programs, encourage community participation in environmental restoration, planting of trees- it's to teach them to prevent wasteful consumption.
	P4	By including Natural Sciences and technology, we learn about 2 aspects. Our environment and also technology involved with environments. How these affect each other in many ways. ESD involves both our environments and society. This puts together how the society is influenced by our technology which causes trouble to the environment. Natural sciences and technology go hand in hand.
	P5	In science Sustainable Development teachers us how to conserve the

		environment, habitat, trees, plants. In technology, sustainable development is linked with resources and materials e.g. coals diamonds, woods, plastic.
	P6	Not to pollute land, air and water because that will cause disease in other people near polluted area. It can also cause damage in our ozone layer. Preventing all types of pollution.
	P7	Some of the things learnt in science and technology is to be able to take care of the environment so that it is sustainable. This is carried down to us by our lecturers so that we can pass it down to the learners. We also taught good ways of becoming teachers that are confident and prepared.
	P8	The science and technology modules teach us to be aware of our environment and its surroundings also we have become aware of resources that are adequate for sustaining the world. Allows us to use our knowledge and skills to improving the standards of living and being environment friendly, we learn about conservation and have new knowledge about the world around us.
	P9	It develops awareness of sustainable development. It provides adequate information and the content is relevant as it provides opportunities to practice skills of enquiry, values, analysis, clarification and problem solving that could be adapted to everyday life for a greener planet. If they are taught to have indigenous gardens/farms- they will have food, be healthy, have energy to work on their farms they could trade their crops- so they won't be poor.
	P10	-----
	P11	I feel that there is more of learning about the ecosystems and biodiversity as a whole with little information or precautions as to how we should sustain the environment. There should be greater information given, through science expos and workshops and also on lecture theaters.
	P12	Empowering and enlightening: the content offers us as students' options, methods and insights in the impact we as mankind have on the environment and provides a platform for discourse about potential

		solutions.
	P13	There are many aspects that reinforce education for sustainable development in our modules. Recycling is a common and very important concept and its content is well related to students, in creating awareness. Even though we at the university level, some students are still unaware of the dangerous and harmful practices put direct on the environment, so it is important for us to study.
	P14	It promotes sustainable development as it encourages us as students to use recyclable goods to create projects.
	P15	I think that the content that was included was interesting. E.g., we studied the impact of plastics on the environment and how they can't be decomposed resulting to pollution. It was good to have a link between the topic studies and the environment. It makes it more realistic and fun.
	P16	-----

▪ **Challenges or facilitators of learning ESD in NS and Technology Modules**

Question:	Participants' (P1-16) Response	
6. Challenges or facilitators of learning ESD in Natural sciences and technology Modules.	P1	What I learnt is not actually practices in the society, for instance people do not recycle and some do not even know what it means.
	P2	Not enough focus or time spent on education for sustainable development.
	P3	
	P4	Majority of the information about the environment, I do not know of and technology on the other hand makes life easier but it is difficult to use it and not worrying about the environment. I seem to think that at the end these two will be maintained separately. I do not understand the ESD very well so it is difficult to engage in the organization.
	P5	What I feel is a challenge is not understanding the content at first. So researching the content by means of books, internet, questioning enables us to learn and understand better.
	P6	-Being always busy, -Practicals everyday

	P7	Without a detail background of FET standard, is a great challenge when doing science modules. Making recycling or upcycled products that would be used to clean and save the environment.
	P8	Science and technology is taught in a way that is of high standard and we learn the topics covered well and sustainable development can be challenging as many people are not interested in looking after or sustaining the environment so it becomes hard to get them to understand.
	P9	Content of sustainable development was very effective. More time should be spent on teaching the sustainable development content.
	P10	We'll learn more about diversity in science, and this chapter speaks more about how to preserve and protect the variety of life forms that we have. In technology, we deal with processing new products but using renewable materials and natural resources. So, these give me more knowledge about sustainable development.
	P11	-----
	P12	Learning is enabled through visual and discursive means where we can sensitised to the realities of what is learned in an exciting and open manner.
	P13	Firstly, the content thought may be difficult to relate to but with the help of lecture and own research we can form our own understanding. Discussions among peers is also important as everyone has their own views.
	P14	What is being taught is not being practiced in the real world, therefore as much as I can try and be environmentally friendly, there are influences in the society that cause a hinder.
	P15	There are limited teaching of this aspect, therefore it may be difficult at times, because we do not have a clear knowledge and understanding of this aspect.
	P16	Most of the information is explained clear to us but there is little application of what is taught.

- **Participants views on enhancing learning of ESD with Natural Sciences and Technology.**

Question:	Participants' (P1-16) Response	
7. What can be done to enhance learning of ESD with Natural Sciences and Technology.	P1	What is taught should be practiced in real life.
	P2	Maybe have separate programs to engage learners, This will help them in future to practice some of the aims sustainable development offers.
	P3	
	P4	Get people or someone to explain or talk about it so it is noted information. Research more about it, get included in projects that will teach me more about the ESD.
	P5	It can be more open minded. Research the topic. Make people in any community more aware.
	P6	Get more knowledge and information about education for sustainable development.
	P7	To do more research and find out more information. To put an interest in ESD and ask people who will know about these things. Overcome challenges and learn things the hard way.
	P8	Introducing fun activities with demonstrations included. Field trips that can teach learners about resources, also, learners can be introduced to learning outside the classroom places like school gardens, the school grounds, take learners to public places. Videos should be shown. Get learners to share their ideas on sustainable development and know the importance of it. Get up awareness posters everywhere in and out the classroom.
	P9	Learning outside the classroom can be used to facilitate education for sustainable development, this includes short visits into school grounds and local community, as well as visit to farms, factories and natural settings such as a forest or beach. Experiences out of the classroom also enhance learning.
	P10	-----
	P11	Quizzes where prizes could be won, Rewards for children who should be good examples in sustainability of the environment.

	P12	More practicals and real-world application of the theory we learn is needed.
	P13	Show more interest, be more open minded, do your own research, familiarize yourself with your surroundings, engage with people.
	P14	Be more exposed in and out of the educational institution and join environmental organization.
	P15	Engage more in this aspect, by participating in programmes that help the environment and also by doing investigations. Introducing a broader content of this aspect in the module, so we are able to have a better understanding.
	P16	Enhance the level of application to involve people more in this education.

▪ **Participants Behavioral Practices and Motivation in Respect of Education for Sustainable Development.**

Proposed Reasons (Participants Response)	Tick √
Because I understand the need to teach the younger generation the need to protect the environment.	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P12, P13, P14, P15, P16,
Sincerely, I don't know	-----
Honestly, I don't know; I have the impression that I'm wasting my time doing things for the environment.	-----
For the pleasure, I experience when I find new ways to improve the quality of life and the environment.	P1, P3, P4, P5, P7, P12, P13, P14,
Because it is a reasonable thing to do to help the environment and the society as a whole, and its part of citizen responsibility	P1, P2, P3, P4, P5, P7, P8, P9, P10, P12, P13, P15, P16.
Because I like the feeling I have when I do things for the environment.	P3, P7, P8, P9, P11, P14, P16.
I think I'd regret not doing something for the environment	P3, P7, P8,
Because it's a sensible thing to do something in order to improve the environment	P1, P2, P3, P4, P5, P7, P8, P10, P12, P13,
Because other people will be upset if I don't	-----
For the recognition, I get from others	-----
Because I would feel bad if I don't do anything for the environment	P3, P4, P8, P12,
Because taking care of the environment is an integral part of my life	P1, P2, P3, P7, P8, P10, P12,

and social responsibility	P14,
Because my friends do it	-----
Because it seems to me that taking care of myself and taking care of the environment are inseparable	P1, P3, P4, P8, P10, P12,
Because I would feel guilty if I don't, because being environmentally-conscious has become a fundamental part of who I'm	P1, P3, P7, P8, P12,
Because it is part of the way I've chosen to live my life	P3, P5, P8, P12,
To preserve our resources for the next generation	P1, P2, P3, P4, P5, P7, P8, P9, P10, P12, P13, P14, P15
To avoid being criticized	P13,
For the pleasure, I experience while mastering new ways of helping our environment	P1, P3, P5, P7, P8, P12,
Because I understand that the environment clings to the social and economic wellbeing of the society.	P1, P3, P5, P7, P8, P10, P12,
To empower myself and other people economically and grow our country's economy	P1, P3, P5, P8, P9, P12,
I don't know, I can't see how my efforts to environmentally conscious are helping the environmental situation	-----
Because I think ESD would help me to understand how to sustain our cultural values	P1, P3, P5, P7, P10,

▪ **Nature of Participants activities**

Activity (Participants Response)	Tick \checkmark
Buy energy efficient appliances	P1, P3, P5, P7, P8, P9, P12, P14,
Using a fuel-efficient car	P3, P9,
Recycling (paper, cardboard, cans, phone books, etc.)	P1, P2, P4, P5, P6, P7, P8, P9, P11, P12,
Use permanent plates, silverware and coffee mugs instead of disposables	P1, P3, P5, P8, P9, P10, P12, P13, P14, P16,
Take shorter showers	P1, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P16,
Use e-mail system to cut down on paper usage	P2, P3, P4, P7, P8, P9, P12,

	P13, P14, P16,
Turn lights off when I'm leaving a room	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15,
Double-sided printing	P4, P6, P7, P8, P9, P10, P12, P13,
Turn water off while soaping my hands, shaving, or brushing teeth	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P13, P14,
Donate re-usable goods to those in need (food drives, Goodwill, cell phone emergency re-use programs)	P5, P6, P8, P9,
Use CFL (Compact florescent lights) instead of incandescent light bulbs	P1, P3, P8, P9, P13, P14,
Unplug chargers and appliances when not in use	P1, P3, P4, P5, P6, P7, P8, P10, P13, P15,
Walk or bike instead of using car or public transport to near destinations	P5, P7, P10, P13,
Talk to friends, family or associates about environmental issues	P4, P5, P7, P8, P16,
Eat less beef/meat	P5, P14, P16,
Wash and dry larger loads of laundry	P3, P4, P7, P10, P16,
Composting	P1, P8, P13, P14,
Wash clothes in colder water (warm instead of hot, or cold instead of warm)	P1, P7, P10, P16,
Improve home insulation	P8,
Repair all leaking taps	P2, P3, P5, P7, P8, P9, P15,
Do not dump illegally	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P13, P15, P16.

▪ **Attitude towards sustainability and wise consumerism**

Participants Response (Proposed attitudinal responses)	Tick √
A waste of time and effort	-----
It's ok if other want to do it	P4,
Why bother not everybody is interested	-----

It's good	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16,
Passionate advocate	P1, P3, P7,
I don't care about sustainability there are bigger issues at hand	-----

- As a society, we should change our way of living to offset the danger of global warming, climate change, greenhouse effect, over population, depleting natural resources, and economic crises.

Participants' Response (Options)	Tick \sqrt
Strongly agree	P1, P3, P4, P5, P6, P7, P8, P10, P11, P12, P13, P15, P16.
Agree	P2, P9, P14,
I don't care	-----
I do not know	-----
Disagree	-----
Strongly Disagree	-----

- Participants attitude towards avoiding buying from a company which shows no concern about the environment.

Participants' Response (Options)	Tick \sqrt
Strongly agree	P6, P7, P10,
Agree	P5, P8, P9, P11, P12, P13, P14, P15,
I don't care	-----
I do not know	P1, P2, P3, P4, P16.
Disagree	-----
Strongly Disagree	-----

- South Africa should maintain high levels of economic growth even if it disregards the environment and the global regulations in respect of the environment and sustainability.

Participants' Response Options	Tick \checkmark
Strongly agree	P6,
Agree	P4, P11,
I don't care	-----
I do not know	-----
Disagree	P2, P5, P7, P8, P9, P10, P12, P13, P14, P16.
Strongly Disagree	P1, P3, P15,

▪ Participants' Conclusion

Participants' Response Options	Agree	Strongly agree
Every girl or boy should receive education that teaches the knowledge, perspectives, values, issues and skills for sustainable development in a community.	P2, P4, P9, P12, P13, P16.	P1, P3, P5, P6, P7, P8, P10, P11, P14, P15.
The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today or even better.	P2, P4, P12, P13.	P1, P3, P5, P6, P7, P8, P9, P10, P11, P14, P15, P16.
Manufacturers should discourage the use of disposables	P2, P3, P8, P9, P10, P12, P13, P14, P15, P16.	P1, P4, P5, P6, P7, P11.
Over use of our natural resources is a serious threat to the health and welfare of future generations.	P2, P4, P7, P9, P12, P13.	P1, P3, P5, P6, P8, P11, P14, P15, P16.
We need stricter laws and regulations to protect the environment.	P2, P5, P9, P12, P13, P15.	P1, P3, P4, P6, P7, P8, P10, P14, P16.
Poverty alleviation is an important topic in education for sustainable development	P2, P4, P6, P8, P9, P10, P11, P12, P13, P14, P15, P16.	P1, P3, P5, P7.
Sustainable Development will not be possible until wealthier	P2, P5, P6,	P1, P3, P4, P7, P8,

nations stop exploiting the labor and natural resources of poorer nations.	P10, P12, P13, P14, P15.	P9, P11, P16.
Companies that are environmentally sustainable are more likely to be profitable over the long run.	P1, P2, P4, P5, P6, P9, P10, P12, P13, P14, P16.	P3, P7, P8, P11, P15.
The teaching of sustainability principles should be integrated into the curriculum in all disciplines and at all levels of schooling.	P2, P4, P13, P15	P1, P3, P5, P6, P7, P8, P9, P10, P11, P12, P14, P16.
Government should encourage greater use of fuel efficient vehicles and should provide safe public transport	P2, P6, P8, P13, P14.	P1, P3, P4, P5, P7, P9, P11, P12, P15, P16.
Citizenship education is an important component of Education for Sustainable Development	P1, P2, P3, P5, P8, P9, P10, P11, P13, P14, P15.	P4, P6, P7, P12, P16.
Taxes/fines on polluters should be increased to pay for damage to the communities and the environment	P2, P4, P7, P13, P15, P16.	P1, P3, P5, P6, P8, P9, P10, P11, P12, P14.
There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.	P3, P6, P7, P8, P9, P10, P11, P15.	P4, P12, P13.
We owe a duty to our children and grandchildren to preserve the environment	P2, P4, P5, P9, P13, P14.	P1, P3, P6, P7, P8, P10, P11, P12, P15, P16.
I want my child and grandchildren to see and enjoy those things I enjoyed	P2, P6, P13, P16.	P1, P3, P4, P5, P7, P8, P9, P10, P11, P12, P14, P15.
We owe a duty to animals and nature; they don't exist just for our enjoyment	P2, P13.	P1, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P14, P15, P16.
The earth and nature are fragile and we can easily cause irreversible damage.	P2, P6, P13.	P1, P3, P4, P5, P7, P8, P9, P10, P11,

		P12, P14, P15, P16.
We have no choice: we have to protect the environment or we will destroy the human race.	P1, P2, P5, P6, P13.	P3, P4, P7, P8, P9, P10, P11, P12, P14, P15, P16.

Demographic Data Presentation of Question Data

Gender		Race				Age		Year of study			Home		Residence	
F	M	B	C	I	W	15-20	20-25	2 nd	3 rd	4 th	Ct/Sb/Ts.	Cs/Ra	Hm	Res
P1, P2, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15.	P3, P12, P16.	P1, P4, P6, P10, P11, P12, P16.	Non	P2, P3, P5, P7, P8, P9, P13, P14, P15.	Non	P7	P1, P2, P4, P5, P6, P8, P9, P10, P11, P12, P13, P14, P15, P16.	P2, P3, P4, P5, P7, P15.	P6, P8, P9, P10, P11, P16.	P1, P12, P14,	P2, P3, P4, P5, P6, P7, P8, P9, P11, P13, P14, P15, P16.	P1, P10, P12,	P2, P3, P4, P5, P7, P8, P9, P10, P12, P13, P15.	P1, P6, P11, P14, P16.
Ft. = 13	Mt. = 3	Bt. = 7	Ct. = 0	It. = 9	Wt. = 0	15-20 = 1	20-25 = 15	2nd Yr. = 6	3rd Yr. = 6	4th Yr. = 3	Ct/Sb/Ts. = 13	Cs/Ra = 3	Hm. = 11	Res. = 5

KEY

F- Female, **M**- Male, **B**- Black, **C**-Colored, **I** – Indian, **W**- White, **Ct**- City home, **Sb**- Suburb home, **Ts**- Township home, **Cs**- Countryside home, **Ra**- Rural Area home, **Hm**- Living at home, **Res**- Living at University Residence

APPENDIX K
TABLE OF FOCUS GROUP INTERVIEW 1 & 2 DATA PRESENTATION

Focus Group 1 and 2 Data Presentation

Focus Group Schedule Question	Focus Group 1 Response	Focus Group 2 Response
<p>1. Please could explain in your own opinion what you understand by Sustainable Development (SD)?</p> <p>2. Based on your own experience, can you please define Education for Sustainable Development?</p> <p>3. Does your experience of ESD contribute to your change in attitude and behaviour towards the environment?</p> <p>a. If yes, please elaborate</p> <p>b. If No, Why?</p> <p>4. What are the</p>	<p>Researcher: Please could explain in your own opinion what you understand by Sustainable Development (SD)?</p> <p><i>Participant 7: ‘Ok.. I feel that education for sustainable development is the wise usage of natural resources in order to meet basic needs, so that we can save it for the future generations to come so that they can use it and they can also have availability to it.</i></p> <p><i>Participant 7: and also, ok.. education for sustainable development is about emm.. teaching about how to protect the environment, how to keep the environment clean by emm.. also using the resources properly, and to prevent like pollution and stuff like that</i></p> <p><i>Participant 7: So that is, so that you can save for the future generation to come- sustainable development, ok that’s my understanding of it.</i></p> <p><i>Participant 2: Its basically you preserve what you have now for future generation, the key word in sustain is to preserve, if you don’t sustain it, it’s not going to last, so sustain and preserve kind of go hand-in-hand, just like when you have aaa.. if you give a child a new toy, if you don’t sustain it, it not gonna last, so you end up buying more and more and more. But toys and resources are different things,</i></p>	<p>Researcher: Please could explain in your own opinion what you understand by Sustainable Development (SD)?</p> <p><i>Participant 12: If I will try... based on natural science and technology, Sustainable development is all about maybe empowering... I don’t know if I can call it like mention the link between the reality... the real-life with what is taught in the class, when we are studying the environment, within the concept of the environment, we have to apply that concept that we a taught in real life.. I think it’s all about that...</i></p> <p><i>Participant 16: When I think of sustainable development within Natural Science and technology, firstly, sustainable means, I think of maintain, maintaining eem I guess the knowledge that we impart on the learners, making sure like he said that relates to the reality of eee...real life, You cant teach learners something they cant relate to, so if you involve like sustainable development in it, then they can relate to it in real life.. For example, like he said</i></p>

<p>things that you do in your daily life that prick your feeling that they are not helping our society in terms of sustainable development?</p> <p>5. What are the things that you do in your daily life that you think would help our society now and in the future in terms of sustainable development?</p> <p>6. What specific topics do you think reflect ESD in your natural Science and Technology modules?</p> <p>7. How are those topics on ESD being taught on how to teach them as you go into the field?</p> <p>8. What are the challenges you face a preservice teacher when you learn about teaching for SD?</p> <p>9. What do you think is the best part of your learning in</p>	<p>resources, if you use it you are not gonna get it again, yeah.. the natural ones. That's basically, my understanding of sustainable development.</p> <p>Participant 8: I think it's just about teachers educating learners, about saving the resources for the future</p> <p>Participant 15: I think that not everybody is aware about the impact that umm.. if you don't sustain, what what.. the impact will actually be, so its creating awareness so that more people will actually be umm.. save umm.. doing right to the environment, so they will actually do things right.</p> <p>Participant 5: Like she said, I think that basically we have natural resources and we have to use it now, because it's a part of our daily lives, but also the way which we use it, we have to keep it? Preserve it, use it sparingly and carefully, at the same time, not only natural resources but everything in our lives and the needs or things in our lives, they all add up to that.</p> <p>Researcher: Based on your own experience, can you please define Education for Sustainable Development?</p> <p>Participant 8: is it not having programs to educate other people?</p> <p>Participant 7: or some sort of lesson plan, or plan of action to educate people about sustainable Development.</p>	<p>environment, they are aware of the environment, and we can be a part of the environment by making eemm, when you teach photosynthesis they can apply it in their real life</p> <p>Participant 11: Eee... I think ee sustainable development means, to use science and technology to develop but then again to take into consideration the environment and some factors, ee.. some effects that technology can have in our society</p> <p>Participant 11: So we have to develop, through scii.... I mean science and technology, but we have to take ee.. environmental factors into consideration</p> <p>Participant 16: ok.. If I may like relate to education as major, major impact in our society, first of all, I may relate to our economy, so sustainable development in terms of education by creating maybe like scientist, because that is the major like deficiency in south Africa. So if you can maybe create more science teachers, then maybe it can influence our economy better, if my relate in south Korea, in south Korea, they are like emphasizing mostly in science routed in its economy now, I'm also relating this concept with education, then there economy is</p>
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<p>Natural Sciences and Technology that will help you to teach SD?</p> <p>10. Do you think that the content and concepts in Natural Sciences and Technology modules that you have undertaken are sufficient and have equipped you enough to teach the concepts of SD in your classrooms?</p> <p>i. If Yes, please elaborate</p> <p>ii. If No, why?</p>	<p>Participant 15: like you asked from the presentation, we had to be a part of a group, so that we act like certain organization whose work is to deal with SD, such organization that that's their main focus and involving people that create awareness.</p> <p>Participant 7: Maybe also to come up with solutions like to protect the environment, like there is so much of pollution so what you do to reduce that, like when we did our presentation, they gave us a problem, so we had to come up with a product in order to solve the problem, so maybe something to do with that as well</p> <p>Participant 5: maybe we can also show them the consequence if they don't sustain the cities</p> <p>Participants 7: And we should nurture the children from small, that's why we educate them from small on how to protect the environment so that as when they grow up they know, they know that this is the science that they are learning, and they must know their role in the society why they are there, what is the role what can they do to protect the environment.</p> <p>Participant 8: as small as the foundation.</p> <p>Participant 8: I think that's why maybe the reason they don't actually know what is about that, because you are not educated from small on how to sustain the environment</p> <p>Participant 2: The just take it for granted, that it's going to be there, let's use it, it's going to be there, don't worry about it. like let's just do</p>	<p>empowered through education of science, so I think its more like it..</p> <p>Participant 11: So I think ee you said sustainable development?</p> <p>Participant 11: I think it means that ee.. our curriculum should comprise of eemm the things that should enable us as the society to create sustainability in our lives and in the environment... like ee.. we can maybe talk about food processing ".... we can maybe talk about food processing in technology, indigenous food production in science to educate people so that everyone has food, there is no starving children, everyone has good health, everyone does some job or farming so there is no poverty. In technology, so educating people about food technology and teach them ee an idea of development of the ways of processing food, but then again, they... they have to sustain the environment by maybe like taking into consideration the factors that maybe be harmful to the environment by processing food like using pesticides..</p> <p>Participant 11....so using pesticides, doses not only kill pesticides but they kill any other indigenous plants, so we have to teach them, how to use ee.. those pesticides in the right way so that our environment will be sustained.</p>
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	<p>it</p> <p>Participant 7: Like just now we have so much of it, they think it will last forever, so they take advantage of the resources, so they don't use it wisely</p> <p>Participant 2: Because eeemmm they don't have emm.. they don't have enough knowledge of it.</p> <p>Participant 8: I think at the intimate phase, they have, they will be able to understand, so they will know what's wrong and what's right... yeah</p> <p>R: Does your experience of ESD contribute to your change in attitude and behaviour towards the environment?</p> <p>Participant 7: Because we learnt about science, and then we came to know about the environment and what is science on its own, and then we came to know our roles in the society and the environment, and that we should conserve!!.. This is our society, and we should not pollute it, we should take care of it, we should make it last forever. whatever the know Whatever knowledge we got, it will be taken with us, and anytime, like if we eat something we know that we must put it in the bin, not outside, do not litter, so we know now from this knowledge it just enlightened us more.. so it did help</p> <p>Participant 5: I think that at the university level, we went a more in-depth with the applications of what will actually happen, I think at school</p>	<p>Participant 12: when I think of education for sustainable development... education for sustainable development... ok.. amm.. I think it means awm.. in my own opinion, that it means that aa.. in within the education sector, especially in our majors in science..</p> <p>Participant 12: Yes.. aa mm.. our main focus should be on umm.. educating the learners about sustaining our environment, about sustaining umm..or preserving the environment as well.. umm as umm.. Buu said, ee.. ensure that we teach them enough that they know like how to treat the environment, how to maintain it, umm... going forward even when they leave like umm the school environment, they can even have the opportunity to take umm science based tertiary education, science is not only for boys aa mm.. yeah, its for everyone, so everyone should sustain, so that, they can help everyone and things like that.. yeah to sustain the environment if I can say that..</p> <p>Participant 12: and other things as well.. aamm yeah</p> <p>R: Based on your own experience, can you please define Education for Sustainable Development?</p> <p>Participant 16: I can say it has like an</p>
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	<p><i>level we just learnt what will happen, but like at university level we went in-depth, they actually informed us about pollution and other impacts that it will have on society and the environment, how everything links together, and one certain wrong doing to the environment, the impact that It will have in the future</i></p> <p>Participant 7: <i>And also, we learnt about... we learnt about caring for the environment, biodiversity and how much pollution ...we cause as men and women that it destroys that biodiversity of our animals, of our plants and it causes great damage.</i></p> <p>Participant 2: <i>In Natural sciences, they taught us effects of biodiversity of adverse effects biodiversity.</i></p> <p>Participant 5: <i>‘Sustainable Development deals with preserving the environment, having food, conserving resources all of which is linked to the economy.</i></p> <p>Participant 7: <i>And also, Technology we learnt about plastics, so there we learnt about plastics how we must recycle and upcycle the plastics, do not just throw it all around, maybe accumulate it, do something, have a program to accumulate it so you can use it in a better beneficial way</i></p> <p>Participant 8: <i>we also have activities, for us to do like this aaa... presentation, we used recyclable products, that also show that we actually learn something at the university level.</i></p>	<p><i>impact because, that's what's drawing us to like decide to have like chosen these as natural science and technology, it was our values, our motions to join, driving us to chose these majors, so these majors have major impact in our lives, in our values. We know we have to like, as my brother said before, we have to sustain. Learn to sustain the environment, because we know that, lets say now the weather conditions are changing an have begin to change, we need to know how to sustain that for the future because what we are doing now, it will contribute to the purpose, you may not be in the future but what we are doing now will contribute, like wasting of water.. if we waster water today, somebody gonna need that water in the future.</i></p> <p>Participant 16: <i>yeah yeah.. so that's like science and technology has major influence on SD in my own perspective</i></p> <p>Participant 16: <i>yeah, yeah.. I'm now aware,.. being aware of that, I now have to teach, like to teach, as I'm a teacher, I now have to teach my like learners to sustain the environment and stuff, then how they can influence, like to contribute to the economy itself, so that's it..</i></p> <p>Participant 12: <i>well I thin that</i></p>
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Participant 7: *Let's see, when ummm...we learnt about plastic, it's made from crude oil therefore we must recycle and upcycle the plastics, we must reduce our use of plastics by reusing it – we can also reuse all materials do not just throw it all around, maybe accumulate it, do something, have a program to accumulate it so you can use it in a beneficial way.... our lecturer told us that it must be recycled because if it thrown into like aamm... the sea and maybe animals have to consume it will go into their tummy and they will die because they will think that its food but they are not food...''*

Participant 7: *... like we used ummm...a 2litter tropica bottle, but before, like before we could even come to campus, we never knew that what could be made from that bottle until we came here to realize that we can make a dustpan, why just throw it, because you can make a dustpan that will help you, so it actually did help, it did change our attitude towards this...*

R: **What are the things that you do in your daily life that prick your feeling that they are not helping our society in terms of sustainable development?**

Participant 7: *some things like umm.. having a long shower, showering everyday*

Participant 2: *(chuckles).... traveling*

Participant 7: *that's one of the main course, so we can... that's something that we can't really do much about it because we have no option. we*

aamm.. learning about like the subject like within tertiary sector, it changes our attitudes towards the environment, and also that will help us as he said, when your are going tro the classroom, to change the mindset of the child that doesn't know how to sustain the environment. Aamm.. to in turn their attitude as well will also be changed, maybe for the better, I don't know but, if you teach someone about a certain thing, like lets say waste of water,

Participant 12: *..... then their attitude will change the next time when they see a tap like dripping of water and they will go and they will turn it off and like if they weren't taught about sustaining it, then they will just leave it like that..*

Participant 12: *I think our attitude.. Positive attitude towards learning about it will also influence the children positively when you teach them.*

Participant 16: *what I taught before learning more about technology, and natural science, like when using a fertilizer, I thought you know at home they use chicken droppings and cow dungs for fertilizers, so if I saw them doing that, I thought maybe like effect of being poor or maybe they don't have enough money to to buy fertilizers like the Nitrates sulfates,*

have to shower.... (laughs), yeah so that's one of the things

Participant 15: *I think we are all guilty of wasting water*

Participants 5, 2, 8 and 15: *Yeah... lots of water*

Participant 5: *even leaving the light on at home, just being honest*

Participant 15: *broken taps too*

Participant 8: *what about chargers?*

Participant 5: *yeah.. leaving the chargers on.. laptop chargers.. electricity*

Participant 15: *I can try but I can tell that I'm guilty and I don't really think about it*

Participant 7: *we are so used to it and luckily that we don't appreciate what we have*

Participant 7: *Until it taken away from you.. Humans in general but everybody*

Participant 8: *Like we are talking about it now but when we go we the same thing, so we have to do it, its part of everyday life.*

Participant 2: *That's why I guess we should educate them from small.*

Participant 8: *yes so that it become a habit, there is so much to do. Like if you are not from the rural areas*

Participant 7: *That's why we should create the change now, when we go as teachers, we don't*

Participant 16: *So when I got to to learn about ee sustainable sustainability, e so education through sustainable development changed that mentality, ee because it teaches about always using ee natural fertilizers. So I learnt that ee having that in mind, people who are using cow dung are poor, so it changed me.*

Researcher: *ok..*

Participant 16: *so I knew that ee cow dung contribute a lot in sustaining the environment because the manufacture fertilizers can sometimes damage soil, even contributing soil erosion so, learning about sustainability changed what I heard and I think it helped me understand what actually sustainability is.*

R: **What are the things that you do in your daily life that prick your feeling that they are not helping our society in terms of sustainable development?**

Participant 12: *first of all, if I'm right to answer that questions, first of all we need to know about waste disposal, as the way I'm am stuff, some of us are still teenagers some of us, if we dispose like nitrogen, if like after eating my chips and stuff then I'm gonna throw it away, plastic we know that plastics doesn't decompose, its damaging the*

want this to be repeated, we don't want people like us to be grown again.

R: What are the things that you do in your daily life that you think would help our society now and in the future in terms of sustainable development?

Participant 7: *Ok.. when you eat something, you take the dirt and put it in the bin, that's one of the daily things, when you finished using, ok when you are using the tap you close it, don't deceive the body.*

Participant 8: *In my case, it's different, I live in a flat, so the only time people actually come out to talk is when there is a fight happening or something is happening outside and someone is getting involved then all the plastics come because its 3 story's, like 7 houses in each row, otherwise everyone will be inside, so after the drama has happened everyone gets together and they start talking about the political issues of the country that is everywhere right now, like ee what's happening to our country, we are actually at junk status now, and they read in the newspaper and they watch news saying that ee.. there won't be electricity, there won't be like enough water supply and there will be the rainfall so that's how we educate them and then they ask us ;''is it you going to campus, what are doing in school, are you all doing this in school'', they ask the younger children, I mean this is the elderly people now, the adults in the flat, that's how I feel myself and everyone else*

environment so what I learnt like, the thing that i learnt is using, mostly, mostly using the bins, you can.. if you go like in the t-block, you usually find bins near in the corner, still they, they are not like ..

Participant 12: *..... they are no rubbish in the bins but they are on the floor, even though there are still bin on that corridor or something like that, I think like, using like more like, sustainability is more like being aware of like if the.. like the the prevention is given like given, the bins are given to dispose on it but us us as teenagers you know like students, we don't like use that.. that.. those prevention like properly, if i may say that.*

Participant 16: *Yeah.. e.. whenever, i use something that is disposable, before i...i..i i dispose it or throw it away, i ask myself ee can this be usefully again?..*

Participant 16: *.... so asking that question can make you ee come up with another ideas of of.. using that product again instead of throwing it and littering the environment. so Like if a...a i buy the drink ee with a plastic bottle, i finish the drink and then i decide to throw it away, before throwing it away, i ask myself, can I use this again? then maybe the idea will come that you are going to use*

educates the society, because unless they don't ask us and they won't know, because like they have the doubt in their minds, so they need to confirm it by asking us, they feel that we study now and we have more knowledge than them, that's how we educate the society.

Participant 7: *Not really but amm... if we have children in our homes like maybe if our nephew or something stay with us, from small you can teach them about it*

Participant 7: *...Like don't leave the tap, do not waste water, do not leave the tap open, do not just leave the tv on if you are not watching, like you teach them from small, like that time like at home type of stuff, but not really outdoor.*

Participant 5: *I think its not only about small children, I sometimes I can tell how much I bath..... laughs..*

Participant 8: *even my parents at home, "even my parents at home.....they just take it for granted, like amm our house is small, so all the lights are on... like every light is on and I'm like why are you leaving the light on? Put it off. There is nobody in the bathroom, put it off...there is no point wasting it.. there is nobody there... so put the light off. You educate the elders as well the elderly people as well.*

Participant 2: *You but sometimes actually if the adults that also educate us, I know my granny she is the one who tells us that please put the lights off.. yeah*

water..for so for you to get water you have to use this container, so every time before ee m considering throwing something away, ee.. I ask myself if i can use it over and over again yeah.

Participant 11: *eem.. for me personally, eem especially ever since like I did the module 220, and we started with the plastic I think..*

Participant 11: *Yeah... I became more aware of like the different uses of plastic, even though i knew them from like high school and stuff but now i have a different attitude as like i'm an educator and i know that i should be part of sustaining the environment.. so eemm when i go to the shop, yes i do buy packet and almost every time i go i buy a packet.. So when you get home you take out your groceries, you put them there.. we have like ee.. a drawer that we put the plastic packets and, so instead of just throwing away the packets empty like that, we use it for the waste disposal. we put it in the kitchen and we put the ee.. as the lining for the bin, you put it.. you put the dirt inside. So even though it still gonna go to the dump site, i found a use for it that, its gonna ensure that it doesn't, i mean there is not like more of the packets in there and even if it goes there it still*

R: What specific topics do you think reflect ESD in your natural Science and Technology modules?

Participant 5: I think for ESD, they just link it to some topic they don't have it like a whole topic itself., like for plastics she said you link it to that., and for biodiversity, they link it to that, but they don't have like a specific topic on its own.

Participant 7: Even in chemistry, the module that we are doing right now, there is a section, there is something about 'going green' and a few points in chemistry

Participants 8, 15, 5, 2: all echoe yes..

Participant 8: they link it its not a topic on it own

Participant 15: it just like a basic basic thing

Participant 8: Its not a topic on its own

Participant 7: just to give you a friendly reminder that you are using all these for the purpose of science but you need to conserve it as well. That basically what they teach us, there are other alternatives to it.

R: Should ESD be taught as a module

Participant 2: on its own, like a module on its own, not just linking it to any line.

Participant 8: Because if you really look at it, ESD is very amm in-depth, there is a lot to learn about it, and its going to link with everything, I

goes there with something else.

Participant 11: and also aa... i get a bit frustrated when i see dirt..

Chuckling.. When i.. Like if i'm sitting outside the LT.. I usually sit outside there, people come and then they will eat and just leave the packet there and they will walk away, in my mind, like that frustrates me because its like there is the bin, why dont you use it, and you an adult and you know that you should be using it.. For.., I bought water and i really use it, aam.. it doesn't last that long but i will probably use it for like a week to carry water everyday because i know i drink a lot of water when i come to school, i drink water and stuff. yeah.. so i, my mind set has been changed alot ever since i went through that module with regards to dirts especially plastic, i even thought of asking Dr. S.P. if we can't have like these bins that they have usually in schools..

Participant 11: put they packets there, put they can glass there, put the cans there.. so that we will also be a part of sustaining the environment and ensuring that less dirt go into the dump sites..

Participant 11: Yeah..

R: What are the things that you do in your daily life that you think would

	<p><i>can be taught on its own</i></p> <p>Participant 15: <i>yeah..</i></p> <p>Participant 8: <i>and even though you have to teach it in the foundation phase, its never too late to learn</i></p> <p>Participant 7: <i>and its very little that is put into a module, its very little, there is more to it,</i></p> <p>Participant 8: <i>and we as teachers they always say that we are life-long learners,</i></p> <p>Participant 15: <i>so obviously if you teach it to teachers they will take to advanced level ..</i></p> <p>Participant 8: <i>they will pass it on.</i></p> <p>Participant 15: <i>I think that's why the school did teach us because we didn't have it in the university module</i></p> <p>Participant 8, 2 and 7: <i>yeah</i></p> <p>Participant 7: <i>probably it should it should be brought up as a subject or module.</i></p> <p>Participant 15: <i>and they it needs to be like a compulsory module, it mustn't be a choice because if it is a chose then you are making no difference, let's say you have a choice to put the lights off at home or fix the tap, this needs to be compulsory so you have to take it to learn, like it should be compulsory.</i></p> <p>Participant 7: <i>yes because some people might not be interested, people will say it too simple and they will do it, but they don't really do it, they will say they know but they don't know it.</i></p>	<p>help our society now and in the future in terms of sustainable development?</p> <p>Participant 11: <i>ok..for example, if i go and sit here, i would aa.. maybe i'm eating something or maybe there was dirt there before, if i get up i'm gonna collect all that dirt and put it in the bin because its not use leaving it there and just say, i didn't put it there..</i></p> <p>Participant 11: <i>..And, aa m, what else, ok.. i cant go around in the street.. (chuckling)... and pick litter, but if i see that there is maybe like my environment that i'm currently in, if i came in here and there was dirt here, i will pick it up and throw it away before i will work in that space, because personally, i can't work in a dirty environment.</i></p> <p>Participant 11: <i>.. yeah..</i></p> <p>R: What specific topics do you think reflect ESD in your natural Science and Technology modules?</p> <p>Participant 12: <i>..mmm... structures and materials in technology also reflect..mmm.. i mean sustainable development, how.. I Know that we make structure to use like wood and stuff, if you are making a material like paper and stuff, you use wood and stuff, being sustainable is like, if you can cut down one tree, you need to plant one</i></p>
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Participant 8: *They don't know it.*

R: **How are those topics on ESD being taught on how to teach them as you go into the field?**

Participant 7: *ok how they taught was that they forward eemmm, they forward the situation to real-life, like ee.. when we learnt about plastic, our lecturer told us that it must be recycled because if it thrown into like aammm the sea and maybe animals have to consume it will go into their tummy and they will die because they will think that its food but they are not food. So the lecturer make us to realize and we remember it, think about it and how much of damage it causes, that, also they use case-studies to teach it to us, case studies that we could refer to that we like some more think and then write...*

Participant 5: *"We learnt about the properties of plastics ... then as a follow up application activity we had to design. with specifications, a waterproof and fire resistant informal dwelling... using recyclable plastics.... I did not think it possible we also learnt to work as a team"*

Participant 2: *Also, they use videos, videos, and then picture of schools and parks that we can relate to maybe from wherever you are, a certain area or school that is damaged, if its picture or videos and they come show it to us and say so so area before and after, like a before and after pictures, before polluted and*

more tree so that the environment will still continue like developing. If you like can cut one tree without replacing it, so its more like a waste in the environment and stuff. so structures and materials in technology.

Participant 16: *In technology also, especially in grade 7, i think its term 2 or term 3, they learn about recycling, how to recycle and emm the ways in which you can recycle and the benefits of recycling, so I think that's an education for sustainable development'' if I use the can now, this can be still useful, I cannot just throw it away, I can use it for another purpose....actually they learn about cleaners what cleaners are, so they learn that cleaners are people who collect waste and sell it to those people like, if you collect cans and you sell it to collector can, you are a cleaner, so they differentiate between honest cleaners and dishonest cleaners, so dishonest cleaners are the ones who steal copper cables and sell them so those are dishonest cleaners. ee so in that part of recycling they they they...teach learners about how to recycle and emm the ways in which you can recycle and the benefits of recycling. so i think that's an education for sustainable development. because you now know that if i use the can now,*

now that its polluted

Participant 7: *yeah, also like land-fills, like we see it all around us*

Participant 7: *and also they use the ee.. latest technology, let's just say about the videos, latest technology, so that we should know our role as teachers so that when we go there, we should always be keeping up with technology, so that we will know what we speak about.*

Participant 8: *if we don't know what is happening in this world, how do we expect children to know, and some mall children are very smart, they can catch you, never mind that they are grade1s or grade 2s, they can catch you if you don't know the world, that's what.. it hasn't happened to me as yet, but every lecturer we have been too has said that so far.. we have done more than twelve 12 modules and every lecturer said the same thing, we need to know, we need to know we need to put up with what's happening, because even the smallest child can make you look stupid, you must know your work.*

Participant 15: *Yeah.. yeah..*

Participant 8: *Yeah.. because we already did.. DR S-P goes on and on about us as agents of change... how we can make a difference via our teaching as local curriculum developers to be reflective... how we need to respond to contextual issues... that's real learning"*

Participant 7: *"she demonstrates how we can*

this can be still useful, i cannot just throw it away, i can use it for another purposes. and in the Natural Sciences, they they... learn about biodiversity, in biodiversity, is a brother topic but most important thing is when they learn about eemm..conservation of plants, so we have to reduce cutting our indigenous plants and planting more alien or exotic plants and also we have to stop poaching like south Africa is facing a major issue on poaching of rhinos of their horns, so teaching the learners about that, i think its also education for sustainable development.

R: Should ESD be taught as a module

Participant 16 and Participant 12: *echoing 'Yes'*

Participant 16: *yes we we like eemm, in technology 220 as P2 mentioned, ee we we were eem assigned to do ee m em.. the emm.. For for our examination presentation we were expected to use plastic products to to to design out own product, so that*

Participant 16: *:.... It will help in recycling, so if you collect, maybe like you want to to make the the plastic bag, you will collect more and more plastics and and put them together and make the bag. soi think they they also teach it here.. and also in NS, 110, we also learn*

link what we teach to local issues... like using discarded plastics to make artefacts ... that can be sold... so in a way the environment is clean and we teach skills to address social issues like poverty, improve the quality of life prevent lack of food ...''

Participant 15: *I don't think they highlight it enough at campus level, as we said, we should have a module based on it*

Participant 15: *so that we gain more knowledge and insight to teach the learners*

Participant 5: *.. not when they want us to teach biodiversity....*

Participant 15: *That they just highlighted the traits to biodiversity and how it affects the sea creatures that she mentioned, but that was just like a highlight of it, they don't go in-depth*

Participant 5: *Yeah, it's not like it's part of sustainable development it's just aaa.. it's just like a reason that they need to add to the topic, just like taught like why we.. ok this is gonna happen because of this, like it's not adequate, the information is not adequate like they just say don't aa..*

Participant 15: *and that's is?*

Participant 5: *why shouldn't you, what's the impact? What's gonna happen, you know, it's not adequate*

R: **Other teaching methods which can be incorporated in the teaching to make**

about the biodiversity.

Participant 12:... *Yes*

Participant 11: *Yeah.. eemm as P2 was saying, in NS 110, we learnt about Biodiversity and that's where all the topics of conservation and sustaining the environment, where they came in with regards to also the rhino poaching and different plant and stuff for sustaining the environment. And then in Technology, 220, that's where the topic of recycling and the great use of products came in, so that's where we were enlightened about how we can change like a simple packet into a bag as he said.. Aaam... Different products we even aa.. when you are doing the exams because presentation, we take plastics, we were so aamm.. can i say, we were so fascinated by like when you are researching, by how many products you can actually make just by taking different waste products made from plastics, you can make piggy banks, you can make bags you can make shoes, you can make different things even aamm.. what's this thing... it was aaa.. vertical garden, its called a vertical garden using plastics...that vertical garden aaamm can fall into preserving environment using plants and also using plastic.. So yeah.. it has really*

preservice science and technology teachers aware

Participant 7: *maybe like ammm.. they should take us to field trips, like the way will be able to speak about that topic, we can probably plan a field trip so that they can take us to the places that are polluted so that we can visually see it and know that he is not lying that its something that is small while its something big and we need to do something about it.*

Participant 5: *doing something that I think we will remember for the rest of our life.*

Participant 5: *Even if you want to do you know some wrong doing, they remember that at the back of our mind, then we would remember what that section is.*

Participant 8: *We would even take them to like on cleanup like take them to the beach or to the park, in that way, it is like in the child's mind that I'm picking up everybody else's dirt, so I'm not gonna let anybody else litter, its like aa.. I don't know, sometimes boys think only girls must clean the environment, but its' not so. Everybody must be involved in ESD regardless of gender.*

Participant 7: *Yeah. true.*

Participant 7: *and also like take them to maybe rural areas to see how people go from their homes to fetch water from the rivers, maybe they will be able to realize how important the*

enlightened us..

R: **How are those topics on ESD being taught on how to teach them as you go into the field?**

Participant 16: *Emmm.. like case studies,*

Participant 12: *: they they.. mostly especially in biodiversity and and ee..in recycling, they they.. use mostly case studies to to to.. teach those, to show how ee..maybe to show how what issues we have with ee.. conserving plants ee and indigenous animals or recycling. Like ee.. they they.. make.. there is eem in NS method 2, in Natural sciences method 2, We learnt about the plant called hoodia.. so there was a case study on hoodia showing the the effect, the uses of hoodia and the the traits it have been facing over the years, like a case study was show that hoodia was the plant, was situated indigenously in in Africa, But so indigenous people used the hoodia to to.. for long harden trips, so that they can have no appetite for food and to to.. ee..release them of stomach pains.. so if the western culture came to Africa, they they came and wanted to to take that from us, like the over harvesting of hoodia and the manipulating, they change it to to make other products that could benefit them..*

	<p>water is..</p> <p>Participant 2: <i>even if you don't wanna take them, you can probably get people that will make spokes persons for such an organizations, like go out, give people talks and so that if they don't find it feasible to actually take the students out, if you get someone to come and enlighten them and explain to them, and maybe those people will come with like pictures or like they open a slideshow or something to show you know what the problem is</i></p> <p>Participant 15: <i>And like you mentioned, if we have a group for the You know education for sustainable development, we can even have groups though. Because you thought that we was a group, but we actually wasn't, but we can even create groups.</i></p> <p>Participant 2: <i>Yeah I think that's great</i></p> <p>Participant 15: <i>because you see, its with our basic knowledge that we know about it, we can make a lot out of it..</i></p> <p>R: What are the challenges you face a preservice teacher when you learn about teaching for SD?</p> <p>Participant 15: <i>I think because there is a lack, there is a limit, a limit to it yet then in my observation it becomes difficult.</i></p> <p>Participant 7: <i>I think we have to keep developing, because things don't remain the same, you have to keep on developing and keep</i></p>	<p><i>so, i thing the case studies are mostly used in these parts, the biodiversity and recycling.</i></p> <p><i>We learnt about the plant called hoodia. so, there was a case study on hoodia showing the effects, the uses of hoodia and ...biodiversity over the years... the case studies are mostly used in these parts.</i></p> <p>Participant 11: <i>And also the benefits of these case studies is that the eemm.. they they are actually based on like our environment and not ee.. maybe America's environment at times, its something that we can relate to and its also aamm starts a discussion that leads to us being more knowledgeable about the environment, so usually we we have case studies that we can relate to and we discuss, like most of our lectures we discuss about those specific topics</i></p> <p>Participant 11: <i>so that's how we learn more about the environment... because in the discussion, you get to know what he knows about the environment, he knows and we all contribute to being more knowledgeable about the topic.</i></p> <p>R: Other teaching methods which can be incorporated in the teaching to make preservice science and technology teachers aware</p>
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on researching, like about the latest technology, about the latest issues so because, probably new problems can come up which are not happening now, so you have to keep on researching.

Participant 5: *and even new ways of learning..*

Participant 7: *there will not be enough time to actually go out there and see, to go out there and watch news every single day, its gonna be hard as a life long teacher*

Participant 15: *As I said there is a limit in the modules ESD*

Participant 2: *“If you examine the NS/TECH CAPS policy ...it’s so lengthy there is so much content, it’s not easy to do justice to ESD in a limited time- I tried it during teaching practice and my mentor teacher was not happy with me, she said the syllabus was cast in stone, its ridged – I should not add to it”*

Participant 15: *... so it doesn’t provide much information.*

Participant 5: *For me its just teaching the learners our basic knowledge*

Participant 8: *and because you have our basic knowledge, if it is boring then there is no need to want to do it. But its actually not the case because there is more to it than that, because its limited and we already know, there is no need to do it.. its like boring, we need more time to learn about it. Besides how do you find time for learners to engage in SD project work – then*

Participant 11: *Yeah.. we also do get those little assignments like researching on hoodia and stuff, for NS in fact we did a presentation P3: And also in technology, aa..we used the... used the design process to design useful resources that many schools lack like pen and pencil holders, classroom bins, mats, brooms, dustpans ... we learnt how to innovate in our teaching. on timber we also learnt about like the awareness of cutting of trees and stuff, we had to design maybe like, we were examined on designing a structure that will be like good for like if you are padding on the wall, for hooking and stuff... i don't know what to call it.. but we had to design it so we are also taught like if the cutting of trees, they also have to be sustained like aa, the trees that are used to cut those timber, they need to be like sustained it, its also practical, we used practical.*

Participant 12: *Yeah...Dr S-P via the plastics content, empowered us about energy from waste, clean incineration, social equity, how to overcome the lack of resources by innovating, be local curriculum developers, we did a plastic audit in class, at home and res. I wish other tech modules could adopt an ESD approach” (Participant 12 - focus*

<p><i>time is fixed and the content is a lot.</i></p> <p>Participant 15: <i>its important to use that as a module based on that, I think we will gain more knowledge. it should be a compulsory module, you should not have a choice it needs to be compulsory so you have to take it to learn.</i></p> <p>Participant 7: <i>Yes because some people might not be interested, it should be compulsory module on its own or every course should include it.</i></p> <p>Participant 2: <i>I think in school level we only learn sustainable development, the definition it and that will be by hearted of it. We just by hearted it. In schools, NS and tech are integrated into one subject, we study these two subjects separately, its obvious that each lecturer is doing things on the own...we are not taught how to integrate ESD into any topic. I'm not confident".</i></p> <p>R: What do you think is the best part of your learning in Natural Sciences and Technology that will help you to teach SD?</p> <p>Participant 7: <i>well as we said, they enlightened us about various life situation about the animals, these are the things that we remember and keep with us.</i></p> <p>Participant 15: <i>"I want to make a difference. do a proper job .. but what do I focus on environment or technology issues. The definition of SD does not help as it focuses on three pillars. These pillars are in conflict with</i></p>	<p><i>group2)</i></p> <p>R: What are the challenges you face a preservice teacher when you learn about teaching for SD?</p> <p>Participant 12: <i>Resources that are used to like teach those topics, somehow you find out that its hard to work maybe if you are like placed in the rural schools so that you have to teach these these.. concepts</i></p> <p>Participant 12: <i>Yeah, i think the resources, limit limit limit us when teaching these topics..</i></p> <p>Researcher: <i>But I mean within the university here, as as ee.. preservice natural sciences and tech teachers, what challenges do you have in learning about the the concepts of ESD ?</i></p> <p>Participant 16: <i>: i think ee.. ee.. for for for natural sciences, in university, they they like put it more to be theoretical than be practical, so like when were learning about conservation of indigenous plants and indigenous animals, ee .. we are taught, we are given those case studies, we are taught different indigenous plants and we were shown the slides and, so i think the challenges is that some times you might not know what hoodia is, you can see it in the slide that they give you but you</i></p>
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each other- do I emphasize sustainability or development- it's confusing"

Participant 7: *and I will take it to the class when you learnt and have knowledge about it, and when we go out there we know, don't do this because we remember the consequences of it.*

Participant 2: *I think actually, that will be interesting, because everybody has his own opinions and the point of view, because everybody go together and we like shared amm.. thoughts, not everybody will forget, I believe in my opinion, you you learn from other people as well because you might want a view on something because, it has so much meaning, we learn from our friends. Peer group work. Yes we learn from our friends yeah..*

R: **is the content in NS and Tech sufficient and have equipped you enough to teach the concepts of SD in your classrooms?**

Participant 15: *to a certain extent yeah.. it did.. but non is the cossets, even as teachers we are obviously learning and amm..even though it might not be adequate, we have to know what is research, and observations, in order for us to nurture the one we know. Yeah..*

Participant 7: *it did set a platform for us or a step forward, but it didn't enlighten us so much so we have to keep on researching and keeping up with the development. in order to go out there and teach it.*

can pass by and not realizing that this is hoodia. So i think things like field trips could help us to have more knowledge of what is learnt in the classroom,

Participant 12: *"There are so many definitions of SD, its confusing –which one is right? The terms are so closely related, the SD goals have so many aims – which do I focus on? How would I know what to focus on?"*

Participant 16: *: And ee.. in technology, so if you just learn, learn about maybe food processing,*

Participant 16: *"About various ways of processing food, ...we have to process that food...we have to also make it practical so that we can have more understanding of what is being taught...I think what you do to the environment to benefit yourself, you must do it in such a way that the environment will benefit also"*

Participant 11: *Yeah.. mm to elaborate on what P2 was saying, i think as the students who are just like to have a live experience of the topic we are expected to learn and we are expected in the future to teach the learners, i can go a school as P1 said and teach a child about hoodia, but honestly i have never seen hoodia in my life, the only i know is Aloe because we can all relate to it, but*

	<p>Participant 15: <i>I think it wasn't sufficient enough..</i></p> <p>Participant 7: <i>And as we are learning about ESD, right now, we can when we go out there to schools, as she said, its not so much in depth right now, but when we go out there we can now, make it... make it whort while, make it important to the learners from now so that they know its important.</i></p> <p>R: what do you suggest that the, the college can do in terms of developing a better structure for learning about ESD in natural sciences and tech?</p> <p>Participant 15: <i>we can have programs.. yeah if not modules at least</i></p> <p>Participant 7: <i>yeah. at least programs. maybe once a week or something. where the students gathered clean up the environment.. like this environment is not even clean enough, yeah.. so .. from here to outside</i></p> <p>Participant 7: <i>and at this level here, people throw the dirt in classrooms, what do you really expect? That's they are a little bit naïve that they don't really help them, some of them, not everyone</i></p> <p>Participant 15: <i>maybe have more programs,</i></p> <p>Participant 5: <i>even if not programs or like a single module on its own, like in NS itself we have more to it, its not a module itself. For technology also</i></p>	<p><i>some of the plants that we learn about, some of us have never even seen it, and we can't identify it, yes i can cram the picture but as he said, if i walking pass it, i probably wouldn't even recognise it because i don't know what it looks like, i don't know what it feels like..</i></p> <p>Participant 12: <i>Yeah.. so if we have to have more practicals and experience what we have been taught, then we would have been.....</i></p> <p>Participant 11: <i>yeah.. field trips like, even i know for bio students they go to plants and stuff like plants, so if we as NS students are also given that chance to actually have a plant in front of us and plant it and see that we are part of conserving the environment, then we understand it more and would appreciate the topic more.</i></p> <p>Participant 16: <i>and P3: echoing yeah...</i></p> <p>Researcher: Ok.. Thank you so much.. any other contribution? What do you think is the best part of your learning in Natural Sciences and Technology that will help you to teach SD?</p> <p>Participant 12: <i>Ok.. i think aa.. its Tech 220 in plastics with Dr. S. P., she enlightened us about the like.. it was</i></p>
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	<p>Participant 8: Also what most of the lecturers no offense intended.. they don't actually teach.. they just read from the PowerPoint so like they don't relate it or link it to real-life.. how is that done.. its like just as we you all will agree with me, just remember what we write in our exam, they don't even understand our work because they haven't been thought to us properly. If you don't relate it, so how are you gonna understand..</p> <p>Participant 5: sometimes they don't bother themselves..</p> <p>Participants (All): Echoing... Oh my Gosh,,!</p> <p>Participant 2: sometimes when you ask questions in lecturers, if they don't know something they expect us to go and find it out.. it's a matter of.....</p> <p>Participant 8: it actually drops our confidence more because we scared that we don't know, we scared that if exams comes, we still wont know and our confidences dropped more because we don't know... so yeah.. they don't really link it enough..</p> <p>Participant 7: they also maybe they can include it as assessment task for us in each module..</p> <p>Participant 7: like something that is related to ESD... so that will encourage us without themselves..</p> <p>Participant 5: remember (name of student). Was telling us that sustainable development</p>	<p>broad in terms of that you can do some much about plastics and stuff in order to sustain the environment and stuff. So i think, Dr S-P enlightened us about, like enlightened me if i can say, how much i can do with plastics just like not like disposing then is of no use and stuff, so i think aa its plastics. It looks easy when Dr S-P does it, she refers to hands on, minds on , hearts on and the activities we do match this, but I'm not sure I can do this- we don't know the strategies to use to teach it- our methods lectures do not focus on ESD we really need to teach about SD.</p> <p>Participant 16: : eee.. I think eemm, this this have shown me that eemm especially natural sciences, it has shown me that even while you are developing yourself, and the society can also, the environment ca also develop through you, so if i use the environment for my own benefit, the environment must benefit from me also..</p> <p>Participant 16: : so like he he mentioned the cutting of trees, if i cut the trees, i have plant the tree to to ensure that the the the.. environment is developing and its being sustained. eemm., in grade 8, i think its grade 8, we were learning about food processing and planting of foods so what we were</p>
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shouldn't only be in the subjects of natural sciences and technology because every module aa with relation to the subjects... every individual have an impact on the environment including male and female. there is so much issues in the society, wars destroying the environment, racism, gender violence like rape, we aamm just need peace in society eem emm for our future kids, so even if its not necessarily recycling, every module not only NS and Tech should have something you know that creates awareness bout, you know engage in SD.

R: How can you relate these three ee spheres together, I mean, the society, the environment and the economy together in terms of sustainable development?

Participant 5: I don't think the community is not doing much with regards to it and the government also

Participant 15: yeah.. they don't do much , and the government also..

Participant 8: How often do we actually see something on news about ESD, what government is doing about it, and like our country itself South Africa is a very good example considering the deal that Jacob Zuma made with the Russian president on the nuclear power plant. We don't have money for that and our children children's children will be paying for that, and what will happen in the near future when the the nuclear power plant is not taken care of properly, because, he doesn't know what

taught is that you can eat the food and plant it again, so we they, they told us to make a project we have to take all the food that has been disposed from homes and put them together, so we took those food and mixed it with soil and we made what they called the beddings in the gardens, so when you make those beddings, you find that many various foods grown, you see beans, you see potatoes and so we we take those and plant them in the garden, they grow up and they become food so, i think what you do to the environment to benefit yourself, you must do it in such a way that the environment will benefit also.

Participant 11: you said your question is?

R: is the content in NS and Tech sufficient and have equipped you enough to teach the concepts of SD in your classrooms?

Participant 16: Like like I said eee... '...in natural Sciences, we learn about biodiversity....and need to conserve plants. So, we have to reduce cutting our indigenous plants and planting more....some are used for muti (medicine)... so we always have... also we have to stop poaching like south Africa is facing a major issue on poaching of rhinos of their horns, so

he did. Also our country is at the junk status so we are not gonna be trading along the trade of any company, sorry any other countries. Now people don't know this enough and if you educate them it links with your community, to your society, to the environment, it's kind of like one big chain.

Participant 7: and also they produce products the economy.. they produce products that are recyclable.. that you must ee.. dispose off correctly.. but why don't they help build shops or something that comes for like plastics for word for that, they don't have that kind of facilities, not everywhere and they they have it in this country

Participant 8: yeah... not everywhere, and they had it in this country, in certain places, like very very few places. But they don't actually promote it.. so what does the government do

Participant 2: Yeah I think the government is such a big burden, if they can't amm...show people and know they themselves want to be a part of this, then how do you expect the society to actually equally to do the same. The government is not interested

Participant 7: they should allocate some amount for ESD so that, there could be some improvement.

Participant 5: even have programs within the community about ESD, like how you do

Participant 8: Yeah.. like how you do before

teaching the learners about that, i think it's also education for sustainable development''.

Participant 11: In relation to NS, the topics of biodiversity and conservation, they have enlightened me because, it made me more aware of how to conserve the environment, what to do in order to sustain it, so that is beneficial to me and also in future beneficial to my learners. and in relation to technology, knowing that samples that we weren't even aware of are made from plastics like jackets as Dr. S. P. said, that i don't know, i'm 21 years old but i don't know that aa.. cloths that i actually wear have plastics in them,

Participant 11:i always thought that its just material so now, im more aware of how different products are made and how we can sustain different plastics and stuff.

Participant 16: : And ee in technology, the the the.. recycling part, ee.. when we were doing our examination presentation, we designed the plastic gift box,

Participant 16: :.... It was very beautiful and if i just put it in the store you can even also buy it, so that showed me that even with these thrown away products, you can even create something

like clean up on excursion, take the members of the community and go, clean up like a certain beach where everyone goes

Participant 7: *maybe as a society thy can have like fairs or weekend programs where they can accumulate funds to clean up the environment, if government is not willing to do it. As a society, as a community.*

Participant 2: *you teach them how important this is, you have to educate them first.. like she said you must have programs and all that thereby preventing all types of pollution. if you educate them first, then .. like you know we have, they don't have in most places, the bins, because actually, where I stay they do have that.. there is orange bin plastic, for plastics, then if you educate the community, maybe they will start doing that.. because not a lot of people do that. Because I have seen, they have like black bin plastic for normal dirt and then the orange ones are for plastics and the paper and plastics, but in like the bin there these only like there three over there.. maybe house in the whole area is actually doing that is .*

Participant 8: *on that point where I say, they give only the orange bags so everyone is putting all the dirt on the other side. As they come pick it all the can is there, you can just imagine how many that is just lying there, like its becoming like a land-fill site, also behind my flat, there is a hole there and its like broken swage pipes..*

Participant 8: *so all those crazy people dump*

that can that, that can give you money, that can help you

Participant 12:.... *That can help you develop, yeah..*

R: **what do you suggest that the, the college can do in terms of developing a better structure for learning about ESD in natural sciences and tech?**

Participant 12: *Eee.. i think my brother has mentioned that if like they got like make, encourage and existent with practical work and and concept with more like field trips and stuff so if they could like make it like more reality because technology and natural science are based on reality, so if they can make it more reality, maybe it will uplift other students or uplift us as students and such.. in terms of understanding in the terms of natural science and technology.. P2: Question again?*

Participant 16: *: eee.. I think they are enough..*

Participant 16: *:... only if we can put them into practice.*

Participant 16: *: Like if we we we are designing the maybe the school time table, there must be a day for for.. natural science and technology students where maybe they can, they they.. have to design, like in technology it it must*

in the hole, they dump all the dirt in there. Then they burn the corner whole of the flat. They gather all the leaves and dirt and they go burn it, one big pile and they burn it down.. how many times when my lift club came to pick me, believe me on they side of the road, they are burning. If they don't educate them.. you need to take all all this and you show them that what you doing is wrong, and there are signs over there but they just don't follow it, because they feel no one is gonna stop them, so let me just do it anyway. This is they way I can get rid of my dirt by burning it.

Participant 2: *some of some of them actually have the knowledge but they don't just apply it. They have, they go take the dirt and burn it.., can we say flammables... clashing voices.....*

Participant 15: *Government should actually have rules..*

Participant 7: *I think it all starts with the government, if they have strict rules, this would not be happening..*

Participant 2: *I think there is so many good things that can done, it's a know fact that people don't just show it..*

Participant 2: *The know that the black bag and the orange bag were obviously created on different materials, now obviously the orange bag for the people who like dirt, they will still go and take all the kitchen aamm.. whatever usage and some other thing.. Even though the*

ee em rotate on the design process, so if they maybe on Thursday, we we..say that Thursday this week, we have the session for technology, its designing or maybe its recycling, and the following week, it will be natural science ee.. we we.. are going maybe to to.. plant indigenous plants or maybe we are going to go around to our local communities and see what indigenous plants they have.. but for me, i think ee in terms of the concept, it its enough. it just that they.. they don't put it into more reality, into more practice.

Participant 16: *: but in terms of concept its enough.*

Participant 11: *I also think its enough because, with the knowledge that we have we are enable to go to a school and teach about it, and they learners will understand about it, it enough but more can be done for us to be more knowledgeable, so like they said, if they involved more practical work that we can actually relate to the topic that we are doing not just, like in technology i remember that the only practical that we did was something about electricity, its not something that you can do on an everyday basis for a child it doesn't teach them that much about conservation or sustainability and*

	<p><i>blue one for you know like for garbage and kitchen pills and people use that for flammables themselves.. so, they are clearly mixing up.. Clashing voices.....</i></p> <p>Participant 15: <i>and then the bin trucks don't come and take it.. yeah they don't come.. if they see the wrong things in the bin plastic they, they actually leave it there</i></p> <p>Participant 7: <i>they leave it there.. they don't take them..</i></p> <p>Participant 2: <i>it actually lies there for weeks and the people, they go and burn it..</i></p> <p>Participant 5: <i>they don't take them because they have the wrong materials inside them.</i></p> <p>Participant 2: <i>is they don't have the, like the orange bags, and if you have all the other stuff in there, they leave it over there..</i></p> <p>Participant 7: <i>it's the people's fault because they are not applying their knowledge, so they leave it there</i></p> <p>Participant 15: <i>they leave there for weeks.. if they don't leave there for weeks they go end up burning it right over there.</i></p> <p>Participant 5: <i>it because the type of one that habit for them.</i></p> <p>Participant 8: <i>yeah.. because they gonna burnt it, that's what they usually do and seriously they end up burning it..</i></p> <p>Participant 15: <i>they burnt it, actually on the</i></p>	<p><i>stuff. so if they taught us more about how to plant, which plants to plant because there are certain plants we can't, that are not need and stuff, so yeah if they just had more practicals and hand on experience for us before we go into the field, then we we... would be better, but they are doing enough.</i></p> <p>R: what do you suggest that the, the college can do in terms of developing a better structure for learning about ESD in natural sciences and tech?</p> <p>Participant 12: <i>yes that would like help a lot if we have a module like in this field..</i></p> <p>Participant 12: <i>Yeah that can help</i></p> <p>Participant 11: <i>We are just getting a bit here in tech and a bit there in NS, more time needs to be devoted to ESD if we are serious about it...there is a little information about the ecosystems and biodiversity as a whole more should be done to teach sustainability.</i></p> <p>Participant 12: <i>if there is a module that talk about sustainability as a whole because although sustainability come through technology and natural sciences but it doesn't come as much as it should be, you know if there is one module that separately talks about it, we must have organized activities, excursions, site</i></p>
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	<p><i>side of the road when I'm driving they are burning..</i></p> <p>Participant 7: <i>But this your get free bin packet, we don't even get them in our area, we don't even get free bin packet, neither does the trucks come to fetch the dirt, they only come once in a week and normal all dirt one time.</i></p> <p>Participant 5: <i>yeah one day, once they come.. but where do they get free bin packets,</i></p> <p>Participant 7: <i>we don't get any free bin packet</i></p> <p>Participant 2: <i>its actually 24 packets for three months split up to use.. so people, I don't know why, they end up burning, I'm serious, we are too lazy to go buy bin plastics, so they end up burning this rubbish.</i></p> <p>Participant 8: <i>some people, I don't know if they are just complaisant or what, so like they all dump the dirt in one place and people....</i> <i>Laughs...</i></p> <p>Participant 7: <i>... laughs... Oh my God!!</i></p> <p>Participant 5: <i>.... Laughs You don't dispose of that separately you leave your broken plates with vegetables..</i></p> <p>Participant 7: <i>but the burning of these stuff, it leads to pesticides, coming into the neighborhood and houses there.. it leads to a lot of pesticides</i></p> <p>Participant 2: <i>I don't know if people actually understand the consequences of all those</i></p>	<p><i>visits that lets us get first-hand experience in ESD.</i></p> <p>Participant 11: <i>or even if it wasn't a module but within the module itself not just have like one slide on sustainable development, who about we have like a whole topic maybe that will last for a lecture of maybe a week and we are learning about it and going to specific details about it than just having one slide about it, that 'this is sustainable development, this is how you should do it' and then its done. its like a little literally just a couple lines about it and then its over and we forget about it</i></p> <p>Participant 11: <i>... and honestly that does not stay in our minds because we are just learning to know and then we move out of it....So if they had like more focus on it even if its not a module because maybe that would be like more complicated to establish.</i></p> <p>Participant 11: <i>... Just focus, have a focus on sustainable development, that's it..</i></p> <p>Participant 16: <i>Yeah, i think ee, it must not be kept as a separate module..</i></p> <p>Participant 16: <i>It must be there because you find that ee... when you talk about maybe biodiversity, the biodiversity cannot be the same as</i></p>
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	<p><i>things.. yeah..</i></p> <p>Participant 5: <i>They think burning is the easy way to get rid of the dirt..</i></p> <p>Participant 7: <i>how much of emissions is given up:</i></p> <p>Participant 8: <i>that's the think and after a while like burning, I guess at 2 in the evening or like about 6oclock, I don't know why my chest is sore..</i></p> <p>Participant 5: <i>they don't treat themselves well,</i></p> <p>Participant 8: <i>they actually do that, but this is the burning of the dirt, you know why is my child getting sick, he was ok, now he is screaming</i></p> <p>Participant 8: <i>in the flat I don't say it because I cant fight alone. I will just be inside like "god...!! you are stupid" you burn the dirt and you caused the problem for yourself, and now you are asking why your child is sick. They don't know that...</i></p> <p>Participant 8: <i>We know the stuff because we on the ground, we get affected, the worst ..the worst.. the worst!!</i></p> <p>Participant 2: <i>maybe government should do something about it because they are heavy burden to the community and the society..</i></p> <p>Participant 2: <i>I think this is a very interesting topic, I have not really thought of it. I'm really enjoying ESD- I feel so proud to take up issues affecting a community ...it shows me how we</i></p>	<p><i>matter and materials, so if they are not the same, so there are ways in which you can be educated for sustainable ee.. development can also be different, so in this case when we learn about biodiversity, we have to actually also learn about eemm how we can sustain the environment under the biodiversity section. And in the matter and materials, it has its own aspect, like maybe ee..throwing of chemicals, we learn abut molecules and stuff so if we we.. maybe are doing a practical eemm, we can tell learners that you dont have to just throw the chemicals away because they they.. cause this to soil</i></p> <p>Participant 16: <i>yeah.. so if it can be kept as a separate module on it own, it will be more complicated and it will not be clear as to what is its purpose and how can we we.. develop sustainably..</i></p> <p>Participant 12: <i>: we are having it as a topic in our modules but they don't like plan much on it because like it maybe like one slide like my sister said, as one slide even if you ask some one he is gonna say sustainability is this and that and that.. Doing a proper job integrating SD into the curriculum consumes energy and time as a first year teacher next year I don't know if I will have time to try out new ideas- I'm</i></p>
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	<p><i>are an interconnected system and how schools extend into communities”.</i></p> <p>Participant 2: <i>and I think its endless like you just keep on learning and learning and learning..</i></p> <p>Participant 8: <i>and I wasn't maybe eemm excited about ESD but now my perception has changed, it's really nice, and I knew I had prior knowledge but from what I have learnt from this discussion today, I have learnt a lot... I learnt more today..</i></p> <p>Participant 5: <i>and we are willing to share our knowledge about it..</i></p> <p>Participant 2: <i>and even in doing that because it actually opened our mid more in this discussion.</i></p> <p>Participant 7: <i>yeah.. maybe some of us didn't know what we actually did.., what is called ESD until we go the questionnaire.. yeah..</i></p> <p>Researcher: Thank you so much, I really appreciate all your contributions and we have come to the end of this focus group interview.</p>	<p><i>nervous – about next year”.</i></p> <p>Participant 12: <i>then we move on, there has to be more like diversity, already it a broad topic so in order to do much, we need to pay much attention also..</i></p> <p>Participant 16: <i>And so if we were learning about chemicals, when we want eee.. to put education for sustainable development in that part of chemicals, we have to to.. mention the negative effects chemicals have on the environment, and how to prevent that from happening ok..</i></p> <p>Participant 16: <i>Yeah i think it, not specifically the topic, but it must emphasize what do we have to consider for the environment.</i></p> <p>Participant 16: <i>yes...</i></p> <p>Researcher: Thank you so much, I really appreciate all your contributions and we have come to the end of this focus group interview.</p>
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