Exploring how Science Teachers Engage in Curriculum Innovating in Environment and Sustainability Education

By

Raeesa Ismail

A thesis submitted in fulfilment of the academic requirements for the degree of Doctor of Philosophy, School of Education, University of Kwa Zulu-Natal

Supervisor: Dr R Mudaly

January 2017

ABSTRACT

Life Sciences and Natural Sciences teachers are expected to adapt and to implement curriculum changes that are designed by the Department of Basic Education. The new Curriculum and Assessment Policy Statement (CAPS) for Life Sciences and Natural Sciences stipulates that teachers are expected to integrate environment and sustainability content knowledge in their science teaching. In order for this to materialise, a specialised multi-pronged approach is necessary. It is argued that teachers work in diverse contexts and need to be innovative in order to teach science that is relevant to the lives of learners. I argue that effective professional development incorporating innovation can enable teachers to successfully teach environment and sustainability education.

This study was located within a critical paradigm which was underpinned by a qualitative approach. This study involved ten practicing Life Sciences/Natural Sciences teachers who were purposively selected to form the research sample. These participants were part of the Science and Mathematics Education Honours programme and studied a module which required them to engage with the idea and practice of curriculum innovating, as part of the programme. The study was conducted at a teacher training institution in Kwa-Zulu Natal.

This qualitative case study sought to explore the experiences and challenges of participants as they engaged in curriculum innovating in environment and sustainability education. The factors that enabled or constrained participants' efforts to engage in curriculum innovating were also examined. This study also focused on the role of professional development in capacity building for the purpose of curriculum innovating.

Drawing on the theoretical constructs of Vygotsky's Zone of Proximal Development (ZPD), Rogan's Zone of Feasible Innovation (ZFI) and Vygotsky's Engagement Theory the experiences and challenges of participants were analysed. Multiple data generation strategies were employed, namely: individual interviews, reflective journals, photo narratives and document analysis. Content analysis was used to analyse the data sets that emerged from the data generation strategies. The use of coding was employed to develop categories and patterns within the data sets. The findings included challenges and experiences of curriculum innovating in environment and sustainability education. A key finding was that participants expressed a need for the inclusion of innovating in more of the modules of the Honours programme. Findings from this study also revealed that the individual school context,

resources and support from Heads of Department (HODs) were factors that enabled or constrained participants in their efforts to engage in curriculum innovating. The study provides insights into how a professional development module can provide teachers with strategies for critically appraising their context, thinking deeply about the type of support they need and how this can be leveraged, planning lessons in order to prepare for curriculum innovating, engaging more knowledgeable others to critique their lesson plans, implementing new strategies and reflecting on their experiences. The participants reported feeling renewed, refreshed, re-invigorated and intrinsically motivated to experiment with new ideas in order to engage in curriculum innovating.

Recommendations from this study will be significant to curriculum designers, higher education department officials involved in teacher professional development, teacher education institutions and school teachers.

DECLARATION

I, Raeesa Ismail declare that:

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

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

(iii) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;

(iv) This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

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

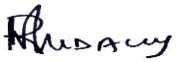
b) where their exact words have been used, their writing has been placed within quotation marks, and referenced.

(v) The work described in this thesis was carried out in the School of Education, University of KwaZulu-Natal, from 2014 to 2016 under the supervision of Dr. R. Mudaly (Supervisor); and

(vi) The Ethical clearance No. HSS/1561/014D was granted prior to undertaking the fieldwork.

Signed: Date: 16/01/2017

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

Signed:  Date: 16/01/2107

ACKNOWLEDGEMENTS

First and foremost I would like to thank God Almighty, for He is the one who has given me the strength, inspiration and courage to complete this study.

Special thanks to my supervisor Dr Ronicka Mudaly for the continuous suggestions, comments, critique and willingness to assist with various aspects of the study. Your calm nature and deep academic insight steered me all the way.

I am grateful to the editors of PONTE International Scientific Researchers Journal and Southern African Journal of Environmental Education (SAJEE) for publishing full articles based on this work in their peer reviewed accredited journals (see appendix 13).

I would like to thank my mother and sister who have given me the love, support and guidance throughout this study. Despite the many hours I did not spend time with you, you have shown me nothing but understanding, constant encouragement, motivation and support.

I acknowledge the contributions of my dear friend Stanton for the countless discussions and proof reading of my work. Thank you for playing an inspirational role in shaping my academic ambition.

I would like to thank the National Institute for the Humanities and Social Sciences (NIHSS) for awarding me a scholarship.

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

DEDICATION

This thesis is dedicated to my mother, Rookaya Ismail who has been instrumental, not only in the completion of this thesis, but in every facet of my life.

TABLE OF CONTENTS

ABSTRACT ii

DECLARATION iv

ACKNOWLEDGEMENTS v

DEDICATION vi

TABLE OF CONTENTS vii

LIST OF TABLES xi

LIST OF FIGURES xii

GLOSSARY OF ACRONYMS AND ABBREVIATIONS xiii

CHAPTER 1 ORIENTATION TO THE STUDY

1.1. Introduction and background 2

1.2. Purpose and focus of the study 5

1.3. Location of the study 5

1.4. Rationale of the study 5

1.5. Significance of the study 7

1.6. Research aim 7

1.7. Research questions 7

1.8. Research design 8

1.9. Findings 8

1.10. Overview of the chapters 10

1.11. Conclusion 11

CHAPTER 2 LITERATURE REVIEW

2.1. Introduction 14

2.2. Curriculum innovating in science education 14

2.3. Innovative teaching methods 21

2.4. Curriculum innovating versus curriculum implementation 23

2.5. Some key curricula developments in environmental education in South Africa 25
2.6. Curriculum change and environmental education 26
2.7. Professional development in science education 27
2.8. Embracing change for effective professional development 31
2.9. Teachers: Agents of educational change 40
2.10. Professional development to support teachers to teach environment and sustainability education 45
2.11. Challenges experienced by learners who are taught environmental education 48
2.12. Fundisa for Change: A CAPS^{++} approach 49
2.13. Theoretical and conceptual frameworks guiding the research 50
2.14. Vygotsky's Zone of Proximal Development 50
2.15. Rogan's Zone of Feasible Innovation 52
2.16. Vygotsky's Engagement Theory 59
2.17. Link between theoretical constructs and this study 60
2.18. Conclusion 60

CHAPTER 3 RESEARCH METHODOLOGY
3.1. Introduction 64
3.2. Context of the study 64
3.3. Paradigm 65
3.4. Approach 66
3.5. Design 67
3.6. Sample 69
3.7. Data generation 72
3.8. Triangulation 79
3.9. Data generation methods fit for purpose 80
3.10. Pilot study 82
3.11. Data analysis 83
3.12. Rigor of the research 86
3.13. Ethical issues 88
3.14. Limitations of the study 90
3.15. Conclusion 90

CHAPTER 4 DATA PRESENTATION AND ANALYSIS
4.1. Introduction 93
4.2. Data analysis and presentation of findings 93
4.3. Research question one 96
4.4. Research question two 102
4.5. Research question 3 114
4.5.1. Research question 3.1. 114
4.5.2. Research question 3.2. 121
4.6. Research question four 145
4.7. Conclusion 163

CHAPTER 5 SUMMARY, RECOMMENDATIONS AND CONCLUSIONS
5.1. Introduction 166
5.2. Summary of significant research findings 166
5.3. Recommendations: Insights derived from findings 174
5.4. Implication for further research 181
5.5. Limitations 181
5.6. Conclusion 181

REFERENCES 183

APPENDICES 197
1. Ethical clearance from the University of KwaZulu- Natal 198
2. Letter to the Head of School 199
3. Letter to the Head of Science and Technology Cluster 201
4. Letter to Life Sciences/Natural Sciences Teachers 203
5. Letter to school principals 205
6. Document analysis schedule 207
7. Photo narrative schedule 208
8. Individual interview schedule 209

9. Reflective journal schedule 210

10. Individual interview transcripts 216

11. Reflective journals of participants 252

12. Critical reading approval letter 290

13. Published articles approval letter 291

14. Turnitin Report 293

LIST OF TABLES

Table 1	Typology of approaches to educational change and improvement	24
Table 2	Summary of participants indicating the subjects currently teaching, years of teaching experience and the type of area the school serves	70
Table 3	Summary of the methods used to generate data and justification for the methods	80
Table 4	Summary of research questions and themes	95
Table 5	Challenges prior to engaging in the Honours professional development programme experienced by science teachers when they taught environment and sustainability education	102
Table 6	Analysis of lesson plans – teaching strategies used by participants	115
Table 7	Analysis of lesson plans – assessment strategies used by participants	119
Table 8	A summary of the responses from participants regarding their personal capacity building to support innovation after having engaged in the Honours programme	163

LIST OF FIGURES

Figure 1	Ismail's model illustrating the key features of curriculum innovating	17
Figure 2	Model depicting effective professional development	32
Figure 3	Model depicting the theoretical relationship between professional development and learner achievement	34
Figure 4	A model of teacher change	37
Figure 5	The interconnected model of professional growth	39
Figure 6	Influence of school context on teacher professional development	41
Figure 7	Ellsworth's model of change	42
Figure 8	A theory of educational innovation	44
Figure 9	Learning challenges experienced by learners in environmental education	48
Figure 10	Zone of Proximal Development	51
Figure 11	The location of the ZFI in a continuum of practice	59
Figure 12	Diagrammatic representation of data generation	73
Figure 13	Diagrammatic representation of data analysis	84
Figure 14	Views expressed by teachers as they engaged in curriculum innovating	168
Figure 15	Ismail's model on enabling teachers to engage in curriculum innovating	179

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

B.Ed – Bachelor of Education

CAPS – Curriculum and Assessment Policy Statement

DBE – Department of Basic Education

EECI – Environmental Education Curriculum Initiative

EEPI – Environmental Education Policy Initiative

HOD – Head of Department

IC – Interim Curriculum

ICT – Information Computer Technology

Nated – National Assembly Training and Education Department

NCS – National Curriculum Statement

OBE – Outcomes Based Education

RNCS – Revised National Curriculum Statement

SIS – School Innovation in Science

UKZN – University of KwaZulu-Natal

ZFI – Zone of Feasible Innovation

ZPD – Zone of Proximal Development

CHAPTER 1

Orientation to the study

CONTENTS **PAGE**

1.1.	Introduction and background	2
1.2.	Purpose and focus of this study	5
1.3.	Location of the study	5
1.4.	Rationale for the study	5
1.5.	Significance of the study	7
1.6.	Research aim	7
1.7.	Research questions	7
1.8.	Research design	8
1.9.	Findings	8
1.10.	Overview of chapters	10
1.11.	Conclusion	11

1.1. Introduction and background

Bertos (2014) underscores the importance of the role of the teacher in the process of teaching and learning in environmental education. The role of the teacher becomes more crucial when one considers assertions about environmental challenges by researchers such as Misfud (2012), that as populations of the world are developing more pressure is being exerted on the available natural resources, and this has led to environmental degradation. A persistent ecological challenge of the 21st century is the fragility of the life giving systems of the earth which are more vulnerable now than ever before (De Beer, Dreyer & Loubser, 2014). Lateh and Muniandy (2010) support this by mentioning that due to the increase in globalisation and modernisation, issues regarding the environment have become critical. De Beer *et al*. (2014) stress that the negative impact humans have made on the environment has been tremendous. Environmental degradation is highlighted by Dimenäs and Alexandersson (2012, p.6) who state that "the ecological footprint shows that humankind over consumes natural resources by nearly 30 percent." Due to the advancements in technology and the number of people making use of these technologies, humans have introduced an immense number of environmental problems (De Beer *et al*., 2014). Literature abounds with descriptions of global environmental crises (Park, Conca & Finger, 2008; Oosthoek & Gills, 2008; Farbotko & Lazrus, 2012). It is for this reason that governments around the world view the education curriculum of their respective countries as one vehicle to remedy these crises and move towards sustainability. This resonates with the views of Campbell, Medina-Jerez, Erdogan and Zhang (2010) who assert that many countries around the world have become aware of the importance of environmental education and have included it in their country's formal education system. Dimenäs and Alexandersson (2012, p. 6) concur with the preceding view by asserting that "in order to increase awareness, participation and the prerequisites for sustainable development, the vision of a sustainable future is increasingly explicitly formulated in the agenda of the educational institutions of several nations."

Given the emphasis of the role of education in addressing environmental crises, this study focused on how practicing teachers can be educated/trained through a professional development module to address environmental crises, through curriculum innovating in environment and sustainability education.

Global and local curriculum changes are a necessity due to the ever-changing nature of society and technology, in the modern era (Smith, 2006). Socio-political imperatives also underpin the impetus for curriculum transformation. The science curriculum in post-apartheid South Africa has been changed several times after the inception of the democratic political order in 1994. Throughout these changes science teachers were required to teach according to the policy requirements of these different curricula. During the apartheid era, the National Assembly Training and Education Department (Nated) 550 was the chosen curriculum. In 1995 this was changed to the Interim Curriculum (IC), which still drew from Nated 550. In 2006 the IC was changed to the National Curriculum Statement (NCS). The NCS underwent three revisions from 2006 to 2012. In 2012 the Curriculum and Assessment Policy Statement (CAPS) policy document was introduced in South African schools. South African teachers were expected to continually adapt to new curriculum polices, but they were expected to do this with a deficiency of effective support to guide them through this terrain. It must be noted that a key figure in the process of curriculum change is the teacher (Leung, 2008). In this study, teachers' capacity to innovate while adapting to new science curricula was examined.

The participants in this study comprised 10 practicing science teachers who were registered for an Honours module at a higher education institution. This study aimed to achieve the following goal: To determine how teacher participants who engaged in a professional development module in the Bachelor of Education (B.Ed.) Honours programme enacted curriculum innovating in environment and sustainability education. The module activities were based on the framework devised by a national professional learning community named Fundisa for Change which focuses on a CAPS plus plus ($CAPS^{++}$) strategy. $CAPS^{++}$ is an approach which orientates teachers to a much broader knowledge scope than that which is expected by CAPS, but which at the same time, equips teachers to teach CAPS successfully (Lotz-Sisitka, 2011). The Fundisa for Change programme focuses on three essential aspects of teacher development related to teaching, namely, **knowing your subject**, **improving your teaching practice** and **improving your assessment practice.** The participants engaged in learning activities adapted from Fundisa for Change. These learning activities afforded practicing teachers the opportunity to develop the three essential aspects of teacher professional development emphasised by Fundisa for Change.

The theoretical constructs from Rogan's (2007) Zone of Feasible Innovation (ZFI) underpinned this study. A review of literature reveals that research conducted on the ZFI has

focused primarily on the theoretical aspect of the ZFI. The review of literature revealed a paucity of research related to the practical implementation of the ZFI and the production of empirical data in this respect. My study explored the implementation of the ZFI through teacher professional development. The teacher professional development in this study focused on engaging teachers in curriculum innovating. My view is that educating teachers for curriculum change is more effective if teachers can be equipped with the skills (e.g., skills to help teachers develop innovative methods of teaching and assessment) related to curriculum innovating. This pragmatic approach to curriculum change, which breathes life into theoretical constructs, is what makes my study new. I explored how science teachers can be educated to be innovative in order to implement the curriculum in environment and sustainability education effectively.

According to literature, in order for environmental education to be integrated into the curriculum, a multi-pronged approach is necessary. This raises the need for innovation and outside support. Rogan's ZFI is therefore relevant to my study because the ZFI focuses on innovation that moves teachers from routine practices to what they envisage to be their ideal practices by receiving, among other things, outside support. The ZFI draws from Vygotsky's (1978) Zone of Proximal Development (ZPD) because it focuses on learning from outside support. Rogan (2007) asserts that the ZFI exists in a continuum of practice. In this continuum of practice, through innovation, the routine practices of science teachers can advance towards the achievement of ideal practices. In my study the professional development B.Ed Honours module, based on the activities proposed by Fundisa for Change, provided teachers with one form of outside support. This outside support was intended to build their capacity for innovation so that they could move from their routine practices to ideal practices and successfully teach environmental education. It is envisaged that teachers' capacity for curriculum innovating will not be delimited to one particular topic or subject, but will inform teaching practice in general.

1.2. Purpose and focus of the study

The purpose and focus of this study was to explore how practicing science teachers engage in curriculum innovating when they teach environment and sustainability education in the new CAPS curriculum. This engagement is examined as the teachers studied a professional module. The CAPS curriculum which is a revision and re-orientation of the Revised National Curriculum Statement (RNCS) aims to incorporate curriculum and assessment policy into one document. My study was located within a B.Ed Honours module at a tertiary institution in KwaZulu – Natal. This Honours module aimed to expose science teachers to changes and development in curriculum, specifically as it relates to science education. This study also explored what professional development related to innovation in environment and sustainability education, is being offered at a higher education institution, in the B.Ed. Honours programme for science teachers. This was explored by analysing relevant Honours module course outlines. The review of literature revealed a dearth in research related to supporting science teachers to innovate in environment and sustainability education. Within the context of curriculum change and policy, literature is replete with research studies related to outcomes-based education (OBE). This study intends to provide new insights and contribute to the body of knowledge regarding implementation of the CAPS curriculum, and innovation in environment and sustainability education through the means of professional development.

1.3. Location of the study

This study was located at a higher education institution in KwaZulu – Natal which is one of two universities in the province that offers teacher education programmes (excluding universities of technology). This higher education institution draws a diverse student population from the entire province, as well as from other provinces in South Africa, and from abroad. There were 759 students registered for postgraduate degrees at the above mentioned university in 2014, of which 410 were accepted to be part of the Honours programme (in education) offered at the university.

1.4. Rationale for the study

The rationale for this study is firstly located in the requirement enshrined in the CAPS document for Life Sciences and Natural Sciences which expects teachers to integrate "up to 50% of environmental content knowledge" (Songqwaru, 2012, p. 1). Nkosi (2012) mentions

that teachers will not be able to implement the new curriculum (CAPS) due to insufficient training and professional support. He expresses the concerns of many about the quality of CAPS training which is provided by provincial education departments. Bertram (2012) echoes the same concern by stating that she is "not confident the CAPS training workshops will have any effect on the quality of teaching and learning" (Bertram, 2012 cited in Nkosi, 2012, p. 2). She further recommends that "what many teachers need is to build deep disciplinary knowledge and content knowledge of how to effectively teach their particular subject, and one-off workshops seldom lead to deep teacher learning and transformed professional practice" (Bertram, 2012 cited in Nkosi, 2012, p. 2).

Secondly, and from my personal experience which is supplemented by conversations with practicing teachers and subject advisors, I am aware that the implementation of environmental education is not successfully facilitated in many schools because many science teachers do not have adequate content knowledge and professional support to teach environmental education. My view is that teachers need more than professional support in order to teach environmental education successfully. I contend that teachers need to be creative to adapt the curriculum to their context. This highlights the need for science teachers to be innovative. According to Songqwaru (2012, p. 3) "the inclusion of environmental education in the school curriculum cannot be disputed but the way it is implemented is primarily flawed". Reddy (2011) mentions that teachers lack the capacity to implement environmental content in the curriculum, due to a lack of professional development. Furthermore Lotz-Sisitka (2011, p. 34) argues that "a poor understanding of sustainable development exists amongst teachers and thus teachers have little capacity for integrating environmental issues and sustainable development into teaching and learning". Lotz–Sisitka (2011) offers a reason for this by arguing that the Department of Basic Education (DBE) is focusing on improvement in areas of literacy and numeracy and that insufficient attention is being given to the new knowledge area which is environment and sustainability education.

Thirdly, literary sources revealed that the focus of innovation and implementation of a new curriculum has been well documented on OBE within the South African context. There is a gap in literature exploring the new CAPS curriculum with regard to support given to science teachers to innovate when engaging with environment and sustainability education. This research terrain appears to be uncharted and thus the reason for conducting this study.

1.5. Significance of the study

The significance of this research is that it will contribute to teachers acquiring a deeper understanding of how to engage in curriculum innovating in environment and sustainability education specifically, and in their teaching of science in general. This study will also enable a more meaningful implementation of the school curriculum in environment and sustainability education. Through effective professional development this study will support practicing science teachers to engage in curriculum innovating while promoting a CAPS $^{++}$ approach, which advocates that teachers must have a more extensive knowledge scope than that which is contained in the CAPS document (Lotz-Sisitka, 2011).

1.6. Research aim

The following research aim is central to this study:

To explore how science teachers who have engaged in professional development activities enact the curriculum by innovating in environment and sustainability education. In order to do this I studied module documents to determine what professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution. I also examined what types of strategies science teachers use when innovating in environment and sustainability education and which factors are obstructive to curriculum innovating in environment and sustainability education.

1.7. Research questions

The following research questions underpin this study:

1. What professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution?

2. What challenges did teachers encounter when working with environment and sustainability education before they engaged with the professional development module at the higher education institution and did teachers display a transformation in their teaching after engaging with professional development?

3. How do science teachers who have engaged in professional development activities enact the curriculum by innovating in environment and sustainability education?

3.1. What types of strategies do science teachers use when innovating in environment and sustainability education?

3.2. Why do science teachers use these strategies?

4. What factors are obstructive to curriculum innovating in environment and sustainability education? How do science teachers respond to these factors?

1.8. Research design

A case study approach was used to explore how 10 practicing Life Sciences/Natural Sciences teachers (who are referred to as science teachers) engaged in curriculum innovating in environment and sustainability education through an Honours module at a teacher education institution in KwaZulu-Natal. A critical paradigm was used to frame this research with the intention to bring about positive changes in teacher practices in environment and sustainability education. Furthermore, this study made use of a qualitative methodological approach because qualitative research aims to understand and describe human behaviour from the insider's perspective (Babbie & Mouton, 2001). This study employed four methods of generating data, namely: reflective journals, photo narratives, document analysis and individual interviews. The aim of using multiple methods for data generation was to answer the research questions from different perspectives, thereby triangulating data and thus enhancing trustworthiness of the findings.

1.9. Findings

Multiple methods were used to generate data that informed the findings of this study. Themes emerged from the data in response to the four research questions.

The exploration of what professional development related to innovating in environment and sustainability education is being offered in the B.Ed Honours programme revealed that there was only one module which included innovating in the content. This module was beneficial to participants and improved their teaching of environment and sustainability education.

On how teachers enact the curriculum by innovating in environment and sustainability education findings revealed that eight out of ten participants achieved success in curriculum innovating as they taught environment and sustainability education. Participants expressed challenges that they had encountered as they engaged in curriculum innovating. Participants' capacity to innovate was increased by the one module, Curriculum Development in Science and Mathematics Education in the Honours programme. This module provided them with the pedagogic content knowledge and the skills of how to innovate when they taught environment and sustainability education. Improved learner performance and enthusiasm in response to teachers' innovative strategies fuelled teachers' motivation to sustain their new methods of teaching and assessment in environment and sustainability education.

The exploration of pedagogy related to innovating in environment and sustainability education revealed that participants chose different strategies of teaching and assessment to innovate in environment and sustainability education. A key finding was the usefulness of technology in assisting participants to innovate in the classroom. Participants also revealed that by engaging with the curriculum development in the Curriculum Development in Science and Mathematics Education module, their capacity to innovate had been increased because they were trained to be more acutely aware of their context, as well as their capacity to innovate. Their capacity to recognise the need for support in order to be able to engage in curriculum innovating increased and they were confident to adopt newly learned skills of how to innovate, not only in environment and sustainability education, but in any subject that they taught. Most of the factors that enabled and constrained teachers' efforts to innovate when they taught environment and sustainability education were contextual in nature. The experimentation with curriculum innovating in environment and sustainability education heightened teachers' confidence to be creative, and this infused in them a new sense of empowerment. This study revealed that intersecting school-based factors (e.g., supportive school management, adequate resources, effective subject advisors) outside support factors (e.g., relevant professional development activities) and personal factors (e.g., progressive teacher who is a conscious practitioner) contributed to teachers' enactment of curriculum innovating. Although the initial plan was to focus on professional development as a primary contributor to curriculum innovating, other factors emerged as being equally influential. It is for this reason that professional development was not privileged in the title of this thesis. The term professional development appears in some research questions because the unit of analysis was teachers who engaged in professional development.

1.10. Overview of the chapters

Chapter one provided a general introduction and background to the study. The study was introduced through a discussion of the inclusion of environment and sustainability education as part of the CAPS curriculum for both Natural Sciences and Life Sciences. This inclusion of environmental education has not been unproblematic, because it has been dogged by a lack of understanding about the *what* and the *how* of teaching environment and sustainability education. This study proposes the use of effective professional development to increase science teachers' capacity to innovate as they teach environment and sustainability education. The purpose of the study and rationale for pursuing this study are presented. The key research questions informing this study are also highlighted. A brief outline of the research methodology employed in this study, and a few insights into the findings, brings this chapter to a conclusion.

Chapter two focuses on the review of literature, both international and local, related to the chosen area of research. First, the review of literature begins by discussing the need for curriculum innovating and associated teaching methods. The differences between curriculum innovating and curriculum implementation are elaborated, with a discussion on the need for accurate implementation of the curriculum instead of simply completing the syllabus topics for the purpose of compliance. Second, the relevance of environmental education as a part of the school curriculum in South Africa is discussed with the transformation of the school curriculum in South Africa at the apex of the discussion. Third, the effectiveness of current and future professional development programmes for science teachers is deliberated. Various literary sources underline the need for professional development that assists teachers to effectively teach environment and sustainability education. Finally, the challenges faced by learners when they are taught environment and sustainability education are reviewed. A discussion of the theory that underpins this study which is the ZFI, derived from the ZPD, concludes this chapter.

Chapter three focuses on the major methodological approach adopted in the study. The paradigm, design and sample are discussed. The choice of data generation tools, which were reflective journals, document analysis, photo narratives and individual interviews schedules, are justified. The ethical considerations are then highlighted. Finally, the limitations of the design are presented.

Chapter four presents the findings and the analysis thereof. Content analysis was used to analyse the data obtained. The data is firstly presented and this followed by a discussion of the themes that emerged inductively from the data.

Chapter five presents a summary of the findings from this study. This is followed by some recommendations directed at various institutions.

1.11. Conclusion

In this chapter I presented the introduction and background of the study. The purpose and rationale for the study were highlighted. The methodology employed for this study and the key research questions were alluded to. Finally, the structure of the dissertation was outlined, by discussing what each chapter entailed. The next chapter will survey scholarly articles, books and other literary sources which are related to the research focus of this study.

CHAPTER 2

Literature Review

CONTENTS **PAGE**

2.1. Introduction 14

2.2. Curriculum innovating in science education 14

2.3. Innovative teaching methods 21

2.4. Curriculum innovating versus curriculum implementation 23

2.5. Some key curricula developments in environmental education in South Africa 25

2.6. Curriculum change and environmental education 26

2.7. Professional development in science education 27

2.8. Embracing change for effective professional development 31

2.9. Teachers: Agents of educational change 40

2.10. Professional development to support teachers to teach environment and sustainability education 45

2.11. Challenges experienced by learners who are taught environmental education 48

2.12. Fundisa for Change: A CAPS^{++} approach 49

2.13. Theoretical and conceptual framework guiding the research 50

2.14. Vygotsky's Zone of Proximal Development 50

2.15. Rogan's Zone of Feasible Innovation 52

2.16. Vygotsky's Engagement Theory 59

2.17. Link between theoretical constructs and this study 60

2.18. Conclusion 60

2.1. Introduction

The literature review explores local and international literature related to the core aim of the study, which is curriculum innovating in environment and sustainability education. This chapter presents rationale for curriculum innovating and the challenges associated with this phenomenon. This chapter is structured according to five main foci. First, innovative teaching, teachers' resistance to change, and the complicity of the Department of Basic Education to this resistance, by endorsing teachers' roles as technicians instead of creative, innovative practitioners, are alluded to. Second, a critical appraisal of the history of environmental education, especially within the context of more recent curriculum changes in South Africa, is presented. Third, a review of professional development in science teacher education is described, and the need for more effective professional development, is argued for. Fourth, several models of teacher professional development are presented, and these culminate in the contention that through professional development teachers can be transformed into agents of educational change. Finally, the chapter ends with the selection of apposite theoretical constructs, which are embedded in Rogan's Zone of Feasible Innovation (ZFI), Vygotsky's Zone of Proximal Development (ZPD) and Vygotsky's Engagement Theory.

2.2. Curriculum innovating in science education

Crucial to the study of curriculum innovating is the understanding of the concept first in its separate parts, and then holistically. Tytler, Symington and Smith (2011) are of the view that innovation in education is characterised by a distinct type of change process. They add that this change process connects new knowledge production, creative solutions and new alliances. Drawing from van Laren, Mudaly, Singh, Mitchell and Pithouse-Morgan (2012) the word curriculum is traced back to its Latin origin and its root word which is *currere*, which means "to run". If we look at the term curriculum as something that is running, or moving, this changes the term from a noun (a course to be run) to a verb (to run) (van Laren *et al*., 2012). This re-conceptualising of the term curriculum is crucial because it can be viewed as something that is dynamic and evolving. The term innovate can be traced to its Latin root origins, *innovare* which means to renew or to make new (van Laren *et al*., 2012). Using the re-conceptualised meanings of these terms it is apparent that curriculum innovating can mean

to renew or make new the way education is progressing. From this it is evident that the curriculum that is implemented at a specific time may not be as appropriate in another time period or context. This is why curriculum innovating is conceptually appropriate in my study. However I have used the term "curriculum innovation" when it has been mentioned in this way in literary sources. (It should be noted that these two terms curriculum innovation "and curriculum innovating" have not been used synonymously).

McFarlane (2013) asserts that teachers must broaden their horizons to incorporate new knowledge that is more relevant than previous knowledge which they may have perceived as fixed. He adds that science teachers must understand that some practices and knowledge can become obsolete and must be replaced with new practices and knowledge. This dynamic approach sets the stage for innovation and specifically, in this study, curriculum innovating in science education. The method or strategy that is being used to teach a specific science curriculum can, over time, become obsolete. In order for the teaching of the same specific science curriculum to remain effective, curriculum innovating should be at the forefront of science teaching (Emo, 2009).

Williamson and Payton (2009, p. 4) define curriculum innovating as that which takes place when "policy, research and practice are seen as a triangular framework for reconsidering and renewing curriculum design and related practices". They add that curriculum innovating refers to the factors that effect transformations in classroom practice (Williamson & Payton, 2009). Curriculum innovating is necessary in the contemporary education landscape (*ibid*). Ferrari, Cachia and Punie (2009) also assert that innovation must not only be viewed as an opportunity, but it must be seen as a necessity. This is in alignment with Kärkkäinen's (2012) assertion that in order to improve the quality of education, education systems need to become more innovative. She adds that the introduction of curriculum innovating may lead to educational innovations regarding how and what learners should be taught. But, according to Kirkgöz (2008) and Johnson (2007) there are a number of factors that make curriculum innovation difficult in the classroom. These include teachers' background knowledge and training, a lack of support, and the influence of textbooks (Kirkgöz, 2008). Kärkkäinen (2012) concurs with the challenges of curriculum innovating highlighted by Kirkgöz (2008), by asserting that every school is different and not all schools possess the relevant resources required to develop high quality innovations. This amplifies the call for effective professional support (development) for teachers, and professional support that is contextualised. The call

for effective professional support is further augmented by Johnson's (2007, p. 657) assertion that "administrators cannot give verbal support without backing it up with resources and protection from outside forces that can take the steam out of teacher efforts to improve instructional practices and grow professionally".

Fishman and Krajcik (2003, p. 572) mention that "the challenge of creating sustainable cognitively orientated science curriculum innovations is ultimately a challenge of increasing capacity, both of school systems and of research organisations." This correlates with Lamie's (2004, p.115) assertion that "the process of curriculum innovation abounds with the assumption that change is a difficult, often painful and highly complex process". Lamie (2004) adds that the roles of the teacher in curriculum innovating are of vital importance. This concurs with the view of Kirkgöz (2008) that the teachers' background knowledge, training and their understanding of the principles of an innovation have a major role in the degree of implementation of an innovation.

Smith (2006) states that in education it is not guaranteed that the knowledge conveyed to learners by teachers will achieve the intended outcomes. But in order for education to realise its full potential "innovation itself is in urgent need to be renewed, re-formed and re-conceptualised, so that it can be rigorously and productively employed within the discourses of educational transformation" (Smith, 2006, p. 10). This resonates with Jiménez-Aleixandre's and Santamaria's (2010) assertion that successful innovations in one context cannot be imported directly without being adapted into a new context. The arguments postulated by both Smith and Jiménez-Aleixandre and Santamaria, indicate that there is a great need for innovation in education but there must be a visible understanding of the contextual nature of any innovation. This peculiar characteristic of innovation calls for a deep understanding of the context within which the innovation is to be implemented.

Emo (2009) states that the field of teacher-initiated innovation is rarely researched. She adds that the general focus of research on education and change is centred on change that has been initiated by people other than teachers. My study will address this silence by exploring how science teachers initiate innovation in South African classrooms.

Chee, Mehrotra and Ong (2014) assert that innovation involves change. They add that innovation transforms the role of the teacher to one of an actual facilitator of learning in the classroom. Smith (2006, p. 1) defines innovation as "a particular type of process that offers teachers the means to implement change, which is inherently dynamic, inclusive and open-ended". He adds that innovation could be seen as sort of a wager where there is hope of a positive outcome but without it being guaranteed. Williamson and Payton (2009) assert that innovation within a curriculum involves an innovation of practice. Tytler *et al*. (2011) provide an expanded definition of "innovation" drawing from Smith (2005) cited in Tytler *et al.* (2011). They state that innovation incorporates four key features. First, innovation is not an invention, is it a process of assembling and reassembling. Second, ideas in innovation are continually tested and refined so that they remain relevant. Third, what counts as innovation at one school, may not be applicable in another. Innovation is context specific and purposeful. Fourth, innovation should be an attempt to respond to a need of a school, or to make improvement to educational programmes (Tytler *et al*., 2011). Figure one represents a model which I developed in the form of an adapted diagrammatical representation of these key features.

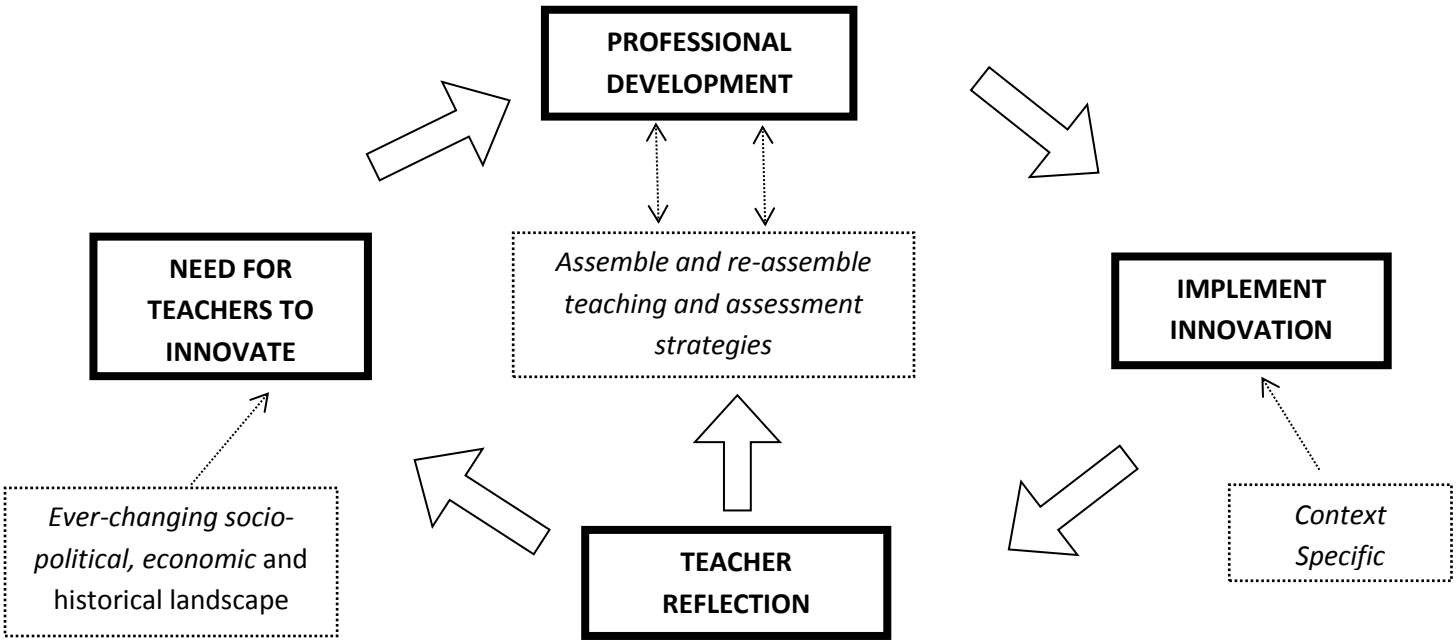


Figure 1 – Ismail's model illustrating the key features of curriculum innovating (adapted from Tytler *et al.*, 2011).

Lamie (2004) provides further insight into innovation by identifying key aspects of the innovation process. The process involves the following: relevance and feasibility, compatibility, knowledge, awareness of the impact of external factors, discussion and collaboration, and adequate support and training. Rogan (2007) emphasises that the ZFI involves teachers moving from routine practices to ideal practices through some kind of support. It is this movement, this dynamism, that makes the term "curriculum innovating" instead of "curriculum innovation" more apposite for my study. The preceding key aspects identified by Lamie (2004) resonate with Rogan's ZFI. Teachers can learn new teaching techniques by being involved in discussions, collaborations and by receiving training. These activities could provide support to teachers (Rogan, 2007).

Van Driel, Bulte and Verloop (2005) postulate that previous failures in educational reform projects occurred because teachers were unable to implement the curriculum in the manner envisaged by the curriculum developers. Bantwini (2010, p. 83) supports this by stating that "it would be irrational and naive for educational authorities to expect teachers easily or without any objections to accept educational reforms". Curriculum developers assume that they know how the curriculum needs to be changed and they have the expectation that teachers will adapt their classroom practices according to the changes made (van Driel *et al*., 2005; van Driel, Verloop, Inge van Werven, & Dekkers, 1997). van Driel *et al*. (1997) add that the weakness of many innovations is attributed to the failure of teachers to implement the innovation according to the blueprint set out by the developers. This indicates a gap which is positioned between teachers' capacity to innovate and the expectations of curriculum developers.

Chee *et al.* (2014) assert that teachers are the defining factor in innovation because innovation is contingent on their capacity and willingness to effect educational change. This resonates with Fishman and Krajcik's (2003, p.566) assertion that "the distance between the innovation and the origin represents the gap that exists between the capacity required to successfully use the innovation and the current capacity of the teacher". The origin refers to the point at which there is a call for innovation (which is developed by the teachers themselves). There is a gap between the call for innovation and the capacity of the teacher to be innovative. If this gap was to be closed then teachers would possess the capacity required to successfully use an innovation. My work is based on the assumption that if teachers receive adequate support (effective professional development for example), then this is likely

to increase their capacity for innovating. This resonates with ideas embedded within Rogan's (2007) ZFI which indicate that by receiving support in some form, teachers will acquire ideal practices through curriculum innovating. This means that teachers will acquire the knowledge and skills of how to develop and use the most relevant methods of teaching and assessment for their specific context.

However, the ability of the teachers to engage in curriculum innovating is determined by the degree of support (e.g., professional development) that they receive. This concurs with the view espoused by Kirkgöz (2008) that teachers need support and help to adapt and accommodate new strategies and methods into their teaching. Steyn (2011) is in agreement with Kirkgöz (2008) and states that any change in education is dependent on the quality of teachers. The goal for teacher education programmes to generate high quality science teachers is not impossible, but teachers of science require support. Kärkkäinen (2012) is of the view that teachers are sometimes unaware of the potential for curriculum innovation and they require support in this regard. Ferrari, Cachia and Punie (2009) argue that the teacher is the fundamental element in educational innovation. They add that if teachers are crucial to this process then support must be made available to teachers (Ferrari, Cachia & Punie, 2009). Pintò (2005) concurs with this view by asserting that teachers need direction and guidance from those individuals directing curriculum change.

Kärkkäinen (2012) states that continued change can never exist in a school that has no support and leadership (professional development) from educational departments. These views resonate with those postulated by Fishman and Krajcik (2003) that curriculum innovation must be scalable; the innovation must be at a level that can be enacted by the teacher at a classroom level. The teacher must be able to understand how to innovate. Rogan (2007) asserts that the ZFI is designed to operate at a micro-level. This means that it can operate at a classroom level. The implementation of any new practice is the sole responsibility of the teacher (Rogan, 2007). By curriculum innovating being scalable (at a classroom level), the teacher would be able to successfully use an innovation. Fishman & Krajcik, (2003, p. 566) add that "too frequently, following the initial research on the innovation researchers leave unexamined future implementations, which are treated as just implementations, something that happens after research". The absence of unexamined future implementations indicates that there exists a methodological gap in research on innovation. Scholtz, Watson and Amosun (2004) state that even if teachers view an innovation as

appropriate and it meets their need, it does not necessarily mean they will be able to implement it. They add that "teachers need support in adapting innovations to their own priorities so that they address the realities of the contexts within which they work" (Scholtz *et al.*, 2004, p. 52). This resonates with Pintò's (2005) assertion that teachers will effectively carry an innovation into their classrooms if they have a sense of ownership of the innovation. This highlights the need for teachers to be actively involved in curriculum innovating.

Curriculum development does not automatically translate to curriculum implementation. Bantwini (2010) states that the initial meaning teachers attach to any curriculum reform is their map that guides their understanding of the reform. Roehrig, Kruse and Kern (2007) assert an important aspect of curriculum reform depends on structures and processes at individual schools which may promote or prohibit it. Research conducted on science teachers by Roehrig *et al.* (2007) reveals that teachers are in fact implementing reformed or changed curricula, but there are a variety of implementation strategies being employed. Two teachers teaching the same subjects can implement the same reformed curriculum, but adopt different strategies of implementation. This indicates that there is little or no monitoring and support for these teachers. This is highlighted by Pintò (2005) who affirms that if teachers are asked to implement a new curriculum without direction of how to be innovative, the implementation will not be successful. On the other hand, if innovation related to curriculum reform is given to teachers (in the form of a policy document for example) and they are required to implement it they will feel no sense of ownership of the innovation (Pintò, 2005). Gulamhussein (2013) asserts that many programmes on professional development involving curriculum reform place the teacher as a passive listener and not someone actively involved in the programme.

Pintò (2005) states that many teachers lack confidence in themselves to master the roles curriculum innovation requires them to play. This resonates with Lamie's (2004) view that curriculum innovating challenges teachers' roles as professionals and as people. Curriculum innovations must never be forced onto teachers (Pintò, 2005). Pintò (2005) emphasises this point by stating that literature reveals a consensus that those innovations which are enforced onto teachers are generally unproductive. These innovations are presented to teachers in the form of single workshops, which are largely ineffective and do little to change the practice of teachers (Gulamhussein, 2013). Johnson (2007) affirms Gulamhussein's assertion that once off workshops do little to develop teacher. She asserts that teachers are similar to learners

because they learn and change at different rates. Furthermore, professional development programmes that are once off or of a short duration have been found to be ineffective.

2.3. Innovative teaching methods

Various reasons are postulated to explain why innovations fail. Van Driel, Beijaard and Verloop (2001, p. 140-141) provide the following fundamental reason for the failure of an innovation: "teachers do not tend to risk changing their own practice which is rooted in practical knowledge built up over the course of their careers". This is an important yet changeable trait that many teachers possess as part of their teaching DNA make up. This is a notion that is shared by Chee *et al.* (2014) assert that if the identity of the teacher (the presence of the teacher) is neglected, then the probability of an innovation failing is greatly increased. This extends the role of the teacher in innovative teaching. Chee *et al.* (2014, p. 21) further assert that "a deep understanding of change processes and how to manage them is needed if innovation is to take root, be sustained, and spread throughout the entire practice of teaching and learning in schools".

Educational institutions should be implementing innovative teaching methods, because these methods have the potential to improve education, as well as to empower people (Damodharan & Rengarajan, 1999). According to them traditional teaching methods are ineffective and the learner assumes a passive role in the classroom. The traditional "chalk and talk" is regarded as a one way flow of information and is deemed to be inappropriate in modern classrooms. Kirkgöz (2008) asserts that in order for teachers to be innovative in their teaching they need to undergo a change in their behaviour, beliefs and understandings. Archer (2013) argues that innovative teaching is a necessity in the South African classroom. This is in accordance with the World Competitive Report for education where South Africa ranks 133 out of 142 countries (Archer, 2013). She adds that coupled with this is the severe lack of skills in South Africa. It is for this reason that corporate companies in South Africa are increasingly getting involved in funding innovative educational initiatives (Archer, 2013). She asserts that one such initiative is the use of ICT (Information Computer Technology) in the classroom. This is a programme that uses digital literacy as an alternative and innovative strategy to educate learners. Archer (2013) argues that this innovative teaching strategy cannot be ignored as a potentially highly effective method of teaching, especially because it relates to contemporary modern society. Archer (2013) calls for more corporate companies to fund the education of

teachers to use the innovative strategies embedded in ICT in the classroom. The call for innovative teaching methods cannot be denied but Kirkgöz (2008, p. 1860-1861) cautions that "since many innovations tend to be of Western origin, developed in a different cultural and educational context, a major issue that needs to be considered in designing training courses is to account for contextual realities by recognising the value of host culture for a given teacher and classroom situation".

The role of the educational department in innovative teaching is of high importance. In South Africa the DBE assumes the role of decision maker and filters decisions to schools and practicing teachers. This organisation holds the power and most directives (decisions) emanate from this governmental structure. The educational authority dictates the rules, roles and boundaries which govern the curriculum playing field. But Kärkkäinen (2012) calls for a school-based approach to innovation. In this approach the decision-making power is transferred to the school and the educational authority (DBE) allows the school to initiate innovations and innovative teaching methods. Kärkkäinen (2012) adds that these innovations will in no way be uniform across every school, but what this does allow is for the innovation to be responsive to the individual context of the school and its learners.

Oversby (2014) suggests different innovative teaching methods that can be used in the classroom. He adds that these teaching methods can be used to ensure learners are working progressively, as they are the key components in a classroom. Oversby (2014) proposes the following teaching methods aimed at promoting innovative teaching of science in particular:

- True false with discussion – a short discussion of content followed by learners critically evaluating the information discussed for validity. This will aid learner understanding.
- Questions generating – this is an open-ended method that recognises that learners in a classroom are at different cognitive levels. This method involves the teacher giving part of an answer to the learners, and then encouraging learners to formulate possible questions that fit the answer.
- Promoting graph reading and use of graphs for prediction – this method can be used to explore the nature of a phenomenon. Learners can be given graphs and be asked to identify evidence of a particular phenomenon.

In a study conducted in Australia, specifically in the Victorian district, Tytler (2009) provides insight into the process of innovating in the teaching of science. His study comprised of the analysis of the School Innovation in Science (SIS) programme which is an initiative supported by the government of the state of Victoria. Tytler (2009, p. 1782) asserts that "a key feature of SIS is that it aims to raise with schools fundamental issues of science teaching and learning, and to give ownership and responsibility for initiatives to the school". This delegation of responsibility to the school is indicative of the process of empowering teachers to be agents of change and implement innovation in their science teaching. Tytler (2007) goes on to describe the SIS initiative as "the process by which schools review their practice, plan, implement and monitor new initiatives, to improve their science teaching and learning" (p. 1782). He does, however recognise a vital feature of any change initiative, which is that change cannot materialise without the teacher's participation. This feature must also form part of the process of educational change in South Africa. Drawing from Tytler's (2009) study in Australia, innovation should be focused on dispensing responsibility to teachers and the school as a whole in evaluating and analysing their current teaching and learning techniques in science. This should be done so that the school can appraise their context, identify their needs and challenges, and then pursue professional development that can effectively respond to challenges, turning them into opportunities for innovative teaching and assessment.

2.4. Curriculum innovating versus curriculum implementation

The preceding literature suggests that teaching science by incorporating environmental and sustainability education should not be about simply implementing a curriculum that is prescribed in a policy document. It should incorporate key components that constitute the classroom dynamic and should be an innovative process that is vibrant and encapsulates the attention of learners. My view is that curriculum implementation may occur due to the requirement for compliance by teachers, while curriculum innovation is contingent on attitudes and beliefs which inform the teacher's practice. Altinyelken (2010) asserts that the introduction of a new curriculum may be well designed and constructed, but it remains to be seen if that curriculum will be successfully implemented in the classroom. Frost (2012) provides deep insight into the realm of curriculum innovating versus curriculum implementation. He states that there is an assumption that professional development is a method or a strategy for the implementation of curriculum. He argues that this should not be

the case because professional development is viewed in different ways under the preceding two concepts. With regards to curriculum innovating, professional development should be viewed as an engine that drives the innovation (*ibid*). In curriculum implementation however, professional development is seen as far more docile and could tantamount merely to being a vehicle for delivery (*ibid*). Professional development of teachers is viewed as development to support "the pursuit of both national and local priorities for curriculum and school development" (Frost, 2012, p. 207). Altinyelken (2010) postulates that for curriculum implementation to be successful, more planning and consideration must be given to be strategies of implementation.

Frost (2012) contrasts two approaches to educational change and improvement, namely, implementation and innovation. This is outlined in Table one.

Table 1 – Typology of approaches to educational change and improvement (Frost, 2012, p. 207).

IMPLEMENTATION	**INNOVATION**
• Design at the centre of it	• Distributed design
• Behavioural specifications	• Proposals expressed as principles of practice
• Hierarchical accountability	• Professional accountability
• Training is the mode of knowledge transfer	• Practitioner-led enquiry-based modes of knowledge construction

Table one illustrates the contrasting nature of implementation and innovation. Implementation focuses on working towards prescribed aims and objectives with limited space for flexibility. It positions accountability with powers above the teacher and has its focus on the amount of content taught rather than the way content should be taught. Innovation on the other hand, focuses on the principle of flexibility. The context is important and teachers are accountable for their own methods of teaching based on context. Transfer of knowledge is based on action teaching rather than facilitator-led workshops. The problems experienced by teachers to implement curriculum changes in education in general and environment and sustainability education in particular are not new to South Africa. It is for this reason the history of environmental education in South Africa will be outlined.

2.5. Some key curricula developments in environmental education in South Africa

The evolution of environmental education into a multi-dimensional socioecological global movement is staggering (Irwin & Lotz-Sisitka, 2014). Environmental education is now a professional field that embraces an array of knowledge platforms. It is important at this juncture to highlight the history of environmental education in South Africa.

Irwin and Lotz-Sisitka (2014) provided a transition of the Environmental Education Policy Initiative (EEPI) to Curriculum 2005 (C2005). The EEPI was established in 1992 with the aim of including environmental education in formal education. The EEPI was politically aligned and in 1995 environmental education was part of the White Paper on Education and Training. The EEPI was later changed to the Environmental Education Curriculum Initiative (EECI), which was a partnership between civil society and the government. This partnership aimed at developing policies on formal education curriculum. The EECI was also involved in the formation of Curriculum 2005 (*ibid*). In the current South African educational curriculum, environmental education is located in the policy documents of all subjects that form part of the formal South African school curriculum.

Dreyer and Loubser (2014) assert that in the Southern African region environmental education has for a majority of the time, been part of the non-formal education system. The main focus of environmental education in the non-formal sector has been on outdoor activities and practical learning (Dreyer & Loubser, 2014). From this it is clear that for many years the environmental education curriculum in Southern Africa has not been formally structured. They add that it seems as though, at the time, education departments and governments of countries did not view environment education as something of high priority. Governments rely on their education systems to achieve their political aims and objectives, and for that to be done environmental education needed to be given a louder voice in order for any change to be effected (*ibid*). Dreyer and Loubser (2014) state that there have been efforts to integrate environmental education in the formal school curriculum, but there exists a lack of clarity regarding how environmental education can be implemented in formal school curriculum.

2.6. Curriculum change and environmental education

Commenting on the curriculum reform and development in Africa Altinyelken (2010) asserts that they are often well designed and have worthwhile aims. Williamson and Payton (2009) state that a curriculum is designed to provide learners with the relevant knowledge and skills that will enable them to lead successful lives. They add that what is included and what is not included in a curriculum changes over time due to political needs and aspirations of the government of that country. Green (1998) however, argues that the manner in which curriculum reforms are introduced has a direct influence on the degree of acceptance from teachers.

Smith (2006) states that the need for educational change and innovation is more acute now than ever before due to the need for a rapid response to globalisation. According to Down (2006) for the implementation of any curriculum change, there needs to be direct and indirect co-operation among all key stakeholders of the educational institution. Down (2006) concurs with Green (1998) by stating that any change must be reflective of the institution of delivery. In curriculum reform that would mean the change must be reflective of the school in which the change will be initiated. Green (1998) adds that the design of any curriculum is contingent on the motivation of the staff of the institution as well as the institution itself, so that the changes or innovations can be implemented.

Powell and Anderson (2002) assert that change in science curriculum is a systemic approach focused on altering what is being taught in science, as well as how content is taught in science. According to Onwu (2000) governments from both developed and developing nations are coming to the realisation that in order for their country to have a sustainable future, emphasis must be placed on the quality of science education. In 1997 environmental education became part of formal education in South Africa (Le Grange, 2010). Rogan and Aldous (2005) assert that political change in South Africa called for a change in education. In 2012 South Africa's formal education system was revised from the RNCS to the new CAPS curriculum, with environmental education becoming a part of the Life Sciences and Natural Sciences curriculum. Lotz-Sisitka (2011, p.31) postulates that "analysis of the CAPS shows that in some subjects, up to 50% of content is environment and sustainability; and that environment and sustainability content permeates a wide range of subjects, in line with a curriculum principle that seeks to ensure an environmentally literate citizenry."

Sahlberg (n.d., p.1) postulates that for teachers and the school as a whole, curriculum change is a learning process. Rogan and Aldous (2005) state that curriculum changes are often well designed, but the focus is primarily on *what* should be implemented and not on *how* the new curriculum should be implemented, and this is echoed by Reddy (2011). They add that the phase of implementation is often a hurried process because the aim of the curriculum change is the start of a new routine. The old curriculum is removed, the new is passed on to teachers, and the designers of the curriculum believe that simply presenting the new curriculum to teachers does not translate into a capacity for teachers to implement it (Reddy, 2011). Rogan and Aldous (2005) state that assumptions underpinning implementation are flawed and there is a lack of focus on the implementation of the changing curriculum. Based on this lack of focus on the implementation of the curriculum, Rogan and Grayson (2003) proposed three constructs that can be used to facilitate implementation of the new curriculum. These constructs are capacity to innovate, outside support and profile of implementation and are expanded in the theoretical framework in section 2.13.

2.7. Professional development in science education

Professional development is a necessary component of teacher education for science teachers because they are required to teach learners content using the most effective and appropriate method. Science teachers are also responsible for assessing learners and this must be conducted using appropriate methods that are not repetitive in nature. Professional development can be a useful tool to expose science teachers to alternative methods of assessment and teaching. Davis, Petish and Smithey (2006) assert that teachers must be aware of the needs of their learners in their classroom. They add that if teachers do not have this awareness then their teaching and assessment methods will be more hopeful than effective. This concurs with the view of Gulamhussein (2013) that it is not enough for teachers to get learners to work from the start to the end of the period, but that teachers must learn new, exciting methods to teach.

Teachers' awareness of the peculiar needs of their classes/learners correlates with another feature of effective professional development, and that is motivation to engage in professional development programmes. O'Sullivan, McConnell and McMillan (n.d.) conducted a study with teachers on professional development. Their findings include certain factors that motivate teachers to engage in professional development programmes. They

allude to a vital and probably defining characteristic of professional development: Is the process viewed as mandatory or mandated? If teachers are wilfully engaged in professional development, they will exude passion and enthusiasm in their professional learning, but if they are forced to engage in professional development "it is difficult to envisage such passionate commitment being nurtured through externally mandated practices" (O'Sullivan *et al*., n.d.).

According to O'Sullivan *et al.* (n.d.) teachers were motivated to engage in professional development by the following factors:

1. Having the freedom to choose to engage in an area of interest (e.g. post-graduate programme)
2. Promotion at school level.
3. Communication between teachers about the success achieved from their engagement with professional development provided motivation for other teachers wanting to engage with professional development.
4. Mandates issued to teachers by the Department of Education also proved to be a motivator for certain teachers.

Together with these motivational factors O'Sullivan *et al.* (n.d.) affirm that effective professional development is not a one-off occurrence. They state that learning requires time and that deep learning cannot be the result of short-term programmes that are characterised by quick-fix methodologies. They are of the opinion that deep learning brings about transformational learning which in turn leads to transformed practice within the classroom. This transformational learning should be the aim of any professional development programme. For this to occur professional development programmes need to incorporate experimentation, feedback, reflection on the feedback, planning and evaluation, all of which must be supported by professional dialogue (O'Sullivan *et al*., n.d.). It is for this reason that professional development should be a long-term committed process that reconceptualises the role of the teacher and the school day. The school day should be a balance between the teacher being involved in transformational teaching (to learners) and transformational learning (through self-reflection by the teacher) (O'Sullivan *et al*., n.d.).

Opfer and Pedder (2011, p.376) assert that "the importance of improving schools, increasing teacher quality and improving the quality of learning for learners has led to concentrated

concern with professional development of teachers as one important way of achieving these goals". Gulamhussein (2013, p.1) states that "the real issue isn't that teachers aren't provided professional development, but that the typical offerings are ineffective at changing teachers' practice and student learning". She adds that professional development should have one central focus and that should be to improve the way learners learn. Science teachers who engage with professional development broaden the teaching and learning opportunities in the classroom. However, from my experience, I have noticed that innovative science teachers are almost an endangered species (a diminishing number) in the teaching fraternity. Schools have outsourced the teaching of science to graduates from the science field who don't have any teaching qualifications. This in itself has implications for the teaching of science in school. Frost (2012) proposes that rather than seeking to dilute the teaching profession with "outsiders" who have better content knowledge, it would be more productive to focus on investing in continuous teacher professional development. Frost (2012) adds that this investment would enable progress in the direction of transforming teaching and learning. This resonates with the assertion by Clarke and Hollingsworth (2002) that facilitation of professional development of teachers requires investment in understanding how teachers grow professionally and what are the conditions that support and promote teacher professional growth. Lessing and de Witt (2007) concur with Clarke and Hollingsworth (2002) by stating that the view teachers have of professional development plays a vital role in their willingness to engage in programmes of professional development. They add that teachers must view professional development as something worthy of their time and effort as they make sacrifices to attend their programmes. This correlates with Gulamhussein's (2013) view that the biggest cost for developers of programmes on professional development is purchasing the time of teachers.

Kriek and Grayson (2009) attribute the current appalling position of science education in South Africa to teachers' unprofessional attitudes, their lack of content knowledge and inappropriate teaching methods being adopted in the classroom. Gulamhussein (2013, p.2) states that "the real challenge facing schools is how to create opportunities for teachers to grow and develop in their practice so that they, in turn, can help learners grow and develop their knowledge and ability to think critically". Singh (2011, p.1627) asserts that "the professional development of South African teachers has been sporadic, although a formal structure exists, implementation has been the problem". Singh adds that as a result of the sporadic nature of teacher professional development in the country, the quality of teachers in

South Africa has diminished. Johnson, Hodges and Monk (2000) highlight the need for research to analyse the professional development of teachers in southern Africa. They are in support of this research because they view southern African teachers as different to teachers from other European countries, the latter group which is extensively researched. Southern African teachers encounter many differences compared to their Euro-western counterparts, especially that of material poverty (Johnson *et al*., 2000). Kriek and Grayson (2009) are of the opinion that in order for there to be long-term improvements in the performance of South African learners in science, focus must be placed on professional strengthening teachers. Kriek and Grayson (2009) concur with Mashile (2002, p.174) who states that "in a transforming South African educational system, the need for opportunity for the professional development of teachers to enable them to meet the constantly evolving challenges of a society characterised by change and development, cannot be overemphasised". In South Africa, ongoing professional development of teachers is crucial (*ibid*). This is in alignment with the view of Supovitz and Turner (2000, p.965) that "the implicit logic of focusing on professional development as a means of improving learner achievement is that high quality professional development will produce superior teaching in classrooms, which will, in turn, translate into higher levels of learner achievement".

Lessing and de Witt (2007) assert that the structure of professional development programmes must be revised in ways which increase teachers' enthusiasm to attend workshops. This concurs with Singh's (2011) view that it is virtually impossible to have predetermined criteria for effective professional development due to contextual factors of schools. Gulamhussein (2013) asserts that it is not about merely providing teachers with professional development and expecting them to develop, it is about the professional development being effective. She goes on to state that "simply increasing the amount of time teachers spend in professional development alone, however, is not enough" (Gulamhussein, 2013, p.14). Gulamhussein (2013) postulates that support for teachers during the professional development as well as after (the implementation phase) is crucial to the effectiveness of the professional development programme. She adds that support in the implementation phase (actual teaching) will assist teachers navigate the frustration that can be associated with adopting a new teaching technique. This highlights the need for science teachers to be involved in effective professional development.

2.8. Embracing change for effective professional development

The curriculum for science education is continuously changing, and the South African science curriculum is no exception. For teachers to remain effective they must be involved in professional development. Professional development itself must also be effective and appropriate so that teachers positively gain from it. This affirms Singh's (2011) contention that the environment of a school is dynamic and is continuously changing. Thus, if teachers want to be effective cogs in this dynamic environment they will have to adapt quickly to these changes (*ibid*). Adaption to these changes in the environment of schools entails teachers engaging in effective, relevant professional development. The effectiveness of the professional development is based on the degree to which the teacher can relate what was in the programme to their own school context. This concurs with the assertion by Scholtz *et al.* (2004) that what teachers take away from professional development programmes and use in their classrooms is based on a number of social and physical influences. They add that this could include the number of learners in a class, the size of the classroom, the resources available and the scientific equipment at their disposal. Scholtz *et al.* (2004, p.50) postulate that "a key component in developing a teacher is to match the professional development programme with the individual teachers' needs and the situations in which they work". This is echoed by Johnson (2007) who states that professional development must be designed in a manner that addresses contextual need of a teacher. Singh (2011) calls for structured, effective professional development that addresses the individual contextual needs of the teacher.

Singh (2011) provides a model for effective teacher professional development.

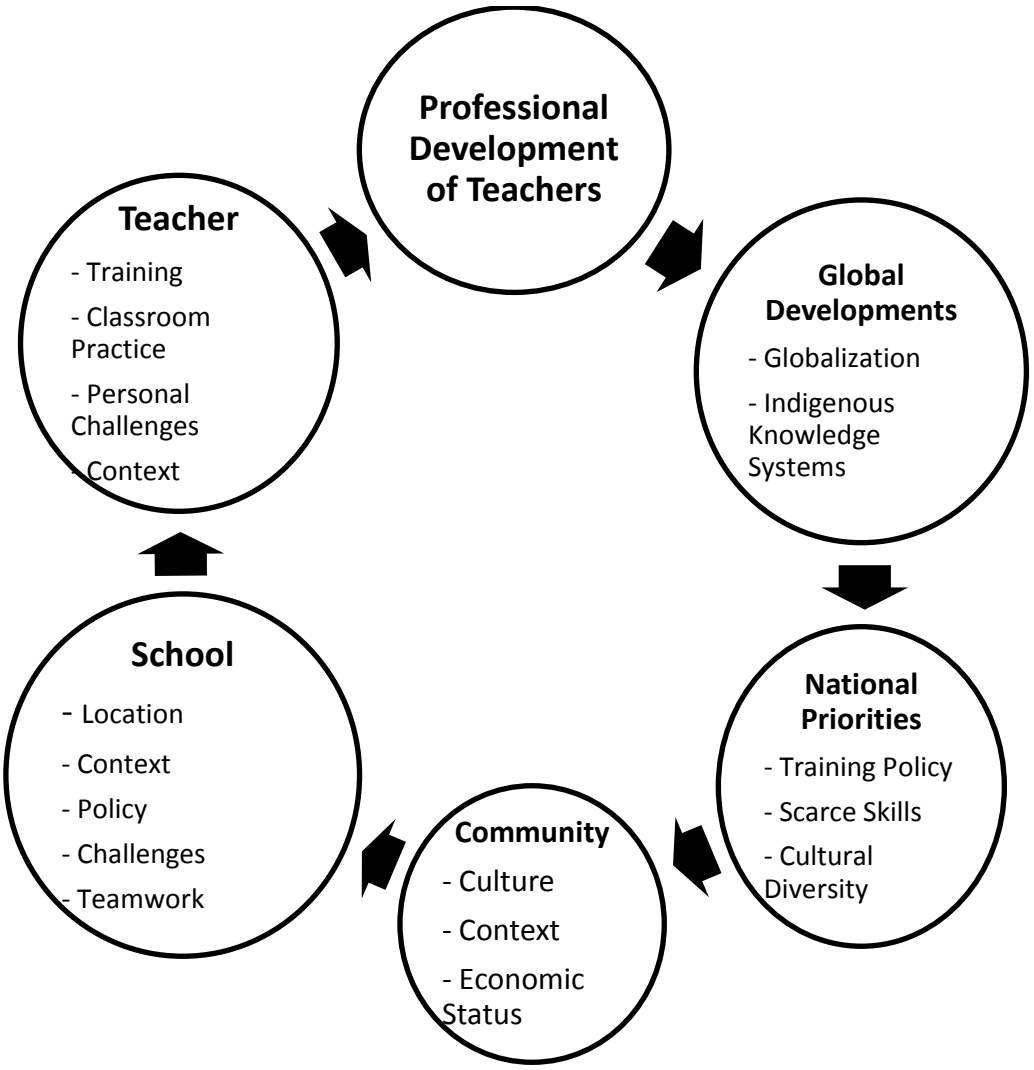


Figure 2 – Model depicting effective professional development (Singh, 2011, p.1634).

Singh (2011) asserts that this model can be used in any school context and that the teacher is the agent of change. He adds that the context in which the professional development takes place will determine the level of involvement of the different components of this model. Some schools could find a specific component of this model to be more applicable to their context than others (*ibid*). Singh (2011) highlights the point that the context of the professional development is most important.

Although specific criteria cannot be stipulated for effective professional development, Gulamhussein (2013) provides the following guidelines for designers/facilitators of programmes for effective teacher professional development:

- The professional development must be continuous so that teachers have sufficient time to adapt new teaching strategies and combat implementation problems that they might encounter.
- Support (from school management, subject advisors, etc.) during the process of implementation is imperative so that implementation can occur according to the context of the classroom. It must be noted that every classroom context is different.
- The professional development programmes should present teachers with new and innovative strategies in varied approaches, so that teachers can actively make sense of the new practice.
- Designers of professional development programmes must incorporate aspects of modelling (demonstration) so that teachers gain an understanding of the new practice.
- The content of the professional development programme must be specific to that subject and not be generic in any way.

Gulamhussein (2013) asserts that if designers of teacher professional development programmes adhere to the above guidelines when formulating these programmes, then professional development would become more effective. She adds that most of the professional development programmes that are currently being offered are ineffective because they neither change teacher practice nor improve the learning of learners.

Supovitz's and Turner's (2000) model on the relationship between professional development and learner achievement can be used to illustrate effective professional development.

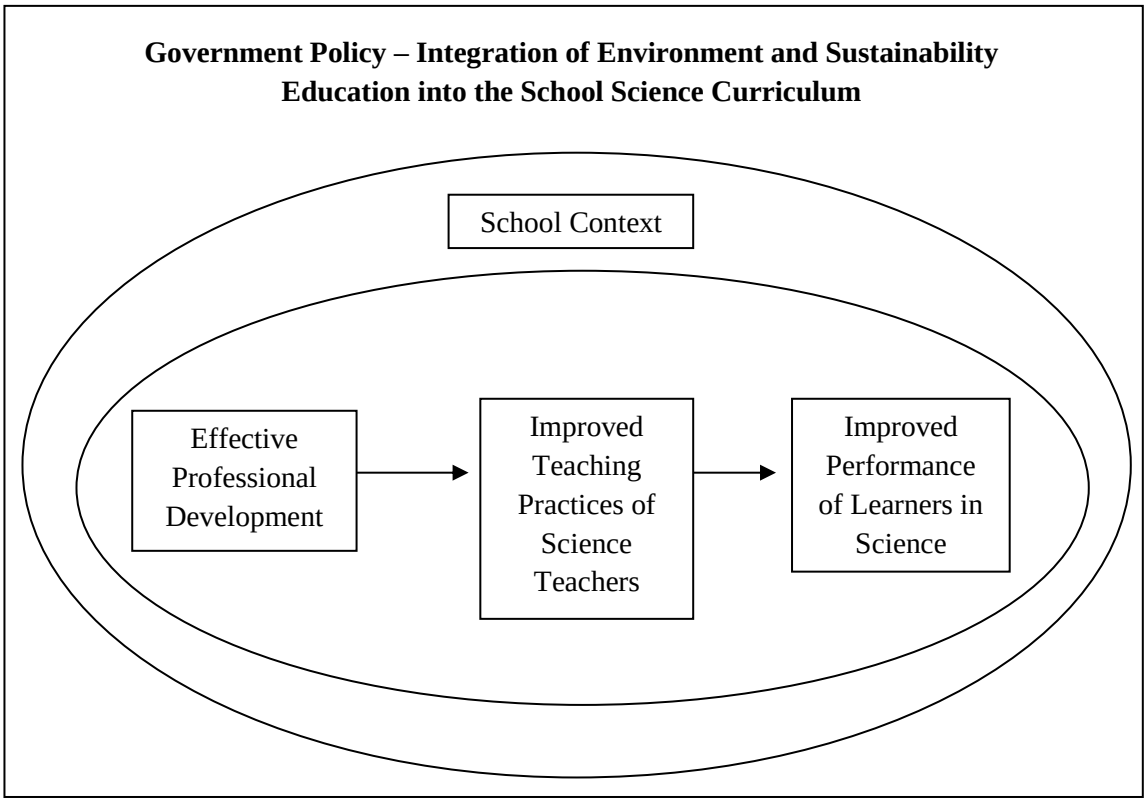


Figure 3 – Model depicting the theoretical relationship between professional development and learner achievement (Supovitz & Turner, 2000, p.965).

Figure three depicts a relationship between effective professional development, improved teaching practices of science teachers and improved performance of learners in science. One does not naturally lead to another, e.g. if professional development is done well but the school is poorly resourced (physical factors are limited), or if learners are problematic (learner factors) then improved teaching practice might not occur. However, the model in figure three does take context into account, and if this context is suitable then the suggestion of professional development leading to enhanced teaching strategies and improved learner performance is possible.

Hewson (2007) asserts that there are four attributes that programmes of professional development for science teachers must encompass. These will be stated below.

- The programme should involve the teacher and their practical and theoretical activities, the learners and their learning, and the educational system.

- The programme should include the knowledge base of the teacher as a professional, taking into account the beliefs and practices of the teacher, which they draw on in their individual classroom context.
- The programme should recognise the teachers as adult learners who should be involved in continuous development throughout their professional teaching career.
- The professional development programme should incorporate the uniqueness and distinctiveness of science and have integrated into it the epistemologies, methodologies and knowledge of the natural world.

Desimone (2011) asserts that professional development must contain core features. Any professional development activity must exhibit the following characteristics (Desimone, 2011):

- Content focus – the subject matter must be the key component together with how learners would go about learning the specific subject matter.
- Active learning –during the professional development activity teachers must be given the opportunity to become actively involved (observation, giving feedback, analysis of learners work, presenting findings).
- Coherence – the content discussed at one professional development session should be similar to content of other professional development activities, with regard to knowledge and beliefs and reforms in policies.
- Duration – activities must be continuous with a minimum of 10 hours per school term
- Collective participation - teachers of the same subject should be part of professional development activities together so that an interactive learning community can be built.

Desimone (2011, p. 70) further postulates four steps that should be followed for a professional development activity to be successful. These steps have implications for designers of professional development activities.

1. Teachers experience professional development.
2. The professional development increases teachers' knowledge and skills, changes their attitudes and beliefs, or both.
3. Teachers use their new knowledge, skills, attitudes, and beliefs to improve the content of their instruction, their approach to pedagogy, or both.

4. The instructional changes that the teachers introduce to the classroom boost their learners' learning.

Singh (2011) states that there are three crucial factors that must form part of a professional development programme for it to be effective:

1. Teachers must be engaged in the process and understand the reasons for their engagement.
2. The leadership within the school (principal and school management team) must be well versed in how to assist teachers when called upon.
3. Teachers must acknowledge and understand their responsibility to their school as well as the learners that they teach.

Lessing and de Witt (2007) state that designers of professional development programmes must be engaged in reflection regarding the aims and goals they want to accomplish. Hewson (2007) adds that programmes for professional development in science should be designed bearing in mind two focal points: the programme and the people. The programme refers to the actual professional development as well as the developers of the programme and what they have decided to be part of the initiative (Hewson, 2007). He adds that the "people" refers to the science teachers. They should be integral to the process of professional development itself (Hewson, 2007). Desimone (2011) concurs with Hewson (2007) by emphasising that teachers themselves are tools of professional development. Teachers, by their personal and individual experiences in the classroom, can learn from themselves through self-examination and observation (Desimone, 2011).

Tan and Leong (2014) contend that teachers have an important role to play in the development of curricular materials and it is for this reason that teachers need to be continuously engaged in professional development. According to Guskey (2002), although many teachers are accepting of professional development due to their contractual obligations, most of them state that they engage in professional development because they want to become better teachers. He adds that many teachers believe that becoming a better teacher basically means devising better learning outcomes (*Ibid*). Guskey (2002) concurs with Kahle and Boone (2000) by asserting that research conducted with science teachers reveals that these teachers express a great need for professional development.

Tan and Leong (2014, p.17) state that "good practices in teacher professional development come with enlightened school management and offer insights into the roles teachers can play." This articulates with the views by Sherron and Fletcher (2008) that high quality professional development will encourage enhanced teaching in the classroom, which will promote higher levels of learner performance and achievements. The view of Mestry, Hendricks and Bisschoff (2009) is in alignment with Sherron and Fletcher (2008) as they assert that improving the quality of teacher performance through effective professional development programmes is one way of improving an education system. Mestry *et al.* (2008) add that in order to improve the quality of education teachers must develop professionally by acquiring new knowledge, skills and values.

Guskey (2002) asserts that change in the classroom practice of teachers, change in the attitudes and beliefs of teachers, and change in the learning outcomes of learners are three outcomes of professional development programmes. Guskey (2002) argues that the sequence of the outcomes is vitally important in the process of facilitating change. He adds that many professional development programmes assume that if the attitudes and beliefs of the teacher can be changed then the task of professional development is complete. This articulates with views of Kalimaposo and Muleya (2014, p.84) that "teachers as implementers of government policies in education need to have in-depth knowledge for them to articulate issues at a comfortable level." Guskey (2002) proposes a re-shuffle of the outcomes so that the aim of professional development should be a change in the classroom practices of the teacher. Guskey (2002) proposes the three aims of professional development should progress in the following order:

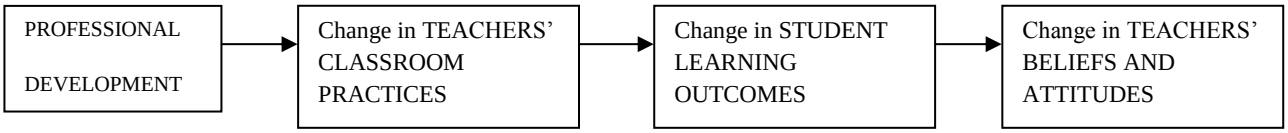


Figure 4 – A model of teacher change (Guskey, 2002, p.383).

Guskey (2002) explains that by changing the classroom practices of the teacher, the performance of the learners in the classroom can improve, and this can lead to a transformation of the beliefs and attitudes of the teacher. This resonates with Steyn's (2008) suggestion that the purpose of professional development should not be to train teachers on how to implement new curriculum policies, but it should rather be to improve the classroom

practices of teachers. Johnson (2007) is supportive of both Steyn's and Guskey's contentions. She asserts that "in order to facilitate change in belief and practices, professional development providers need to include opportunities for teachers to engage in discourse with others… first addressing science teachers' existing beliefs about instruction and student learning and using this as a platform for professional development experiences focused on addressing and re-shaping those beliefs" (2007, p.657).

Teachers who experience successful implementation undergo a change in their attitudes and beliefs (Guskey, 2002). Through quality and effective professional development the classroom practices of teachers change i.e. that is their teaching method for a particular topic in science will be changed as learners perform better through a new teaching approach. This new teaching approach encourages and promotes enhanced learning for learners and they in turn perform more successfully. The teacher repeats effective practices, abandons ineffective ones and this re-shapes the teachers' attitudes and beliefs (*ibid*). This resonates with research done by Sherron and Fletcher (2008) who, from their study of teachers and learners in Texas, found that a relationship exists between the teaching practices of teachers and learner achievement. The more teaching and learning time spent with the teachers, the better the performance of the learners. Rogan (2007) and Rogan and Aldous (2005) also state that change should occur in steps considering all the elements that are part of the change.

Clarke and Hollingsworth (2002) propose an alternative view to that of Guskey (2002). They state that Guskey's model is somewhat flawed in that it represents teacher change as a linear process. Clarke and Hollingsworth (2002) assert that teacher change is not a linear process and propose their own interconnected model of professional growth of teachers.

The Change Environment

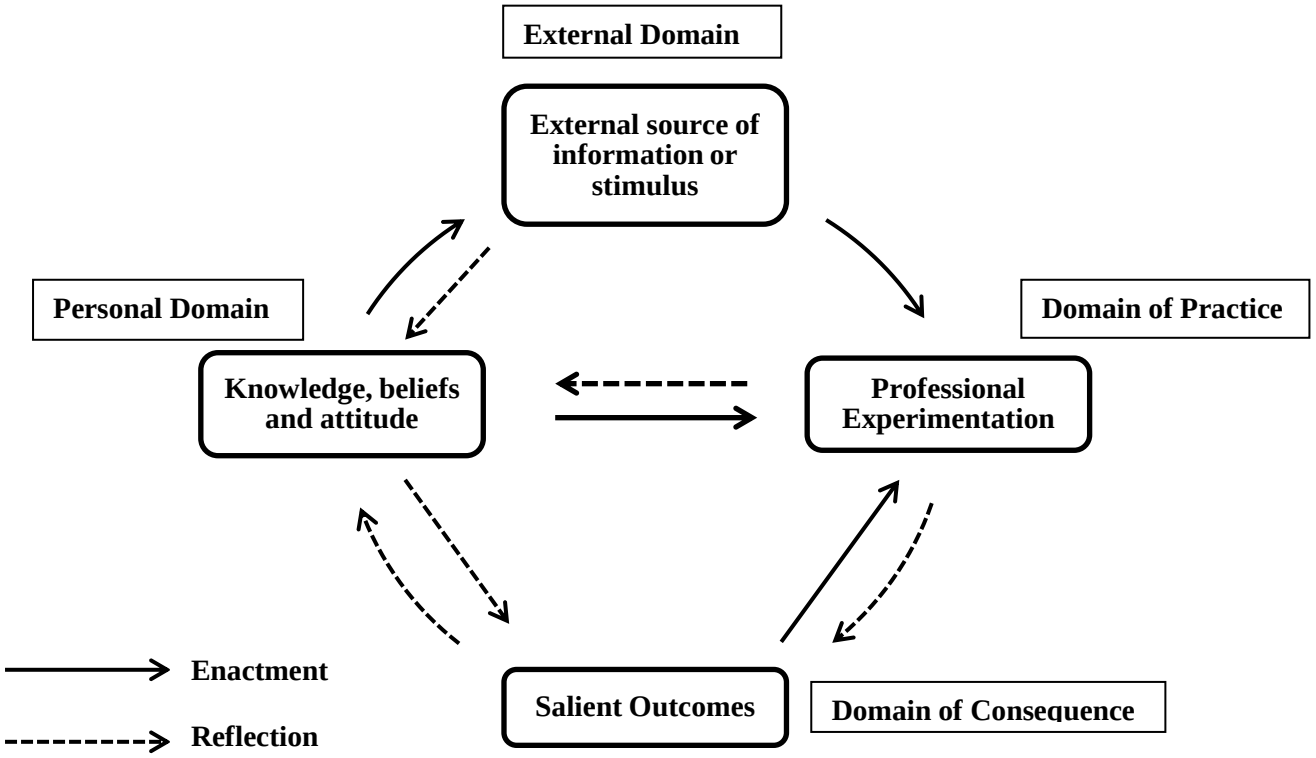


Figure 5 – The interconnected model of professional growth (Clarke and Hollingsworth, 2002, p.957).

Clarke and Hollingsworth (2002, p.950) argue that change can occur in four distinct domains which form part of the teachers' world. These domains are:

- Personal domain (teachers' knowledge, beliefs and attitudes)
- Domain of practice (professional experimentation)
- Domain of consequence (salient outcomes)
- The external domain (sources of information, stimulus or support)

According to Clarke and Hollingsworth (2002) the model represents two types of domains. The external domain is distinguished from the other domains because it is located outside the teachers' personal world. They add that the other three domains constitute the teacher's individual personal world. Change can occur in any of the four domains although change is specific and different in each domain (Clarke & Hollingsworth, 2002). They further argue that there is translation of change between the domains through mediating processes of reflection and enactment.

Clarke and Hollingsworth (2002) assert that this model recognises the complexity of professional growth of a teacher by identifying multiple pathways between the domains. Speaking of the model they add that it's non-linear form and its emphases on professional growth as being continuous is what distinguishes this model from others (Clarke & Hollingsworth, 2002). Effective professional development has to be contextualised because much of it is based on the environment of teaching and personal domain of the teacher.

2.9. Teachers: Agents of educational change

Educational change takes time. Johnson (2007) asserts that when teachers learn from professional development programmes time is needed for them to internalise and then integrate ideas into their teaching practice. In addition, effective professional development can enable teachers to become agents of change. Educational innovation and change are interlinked (Chee *et al.*, 2014). Chee *et al* (2014) add that teachers can become active agents of change or be agents of resistance. This resonates with Lee's and Luft's (2008) contention that teachers are the core agents of any educational reform and they possess a vast amount of specialised knowledge that they have acquired through their individualised and personal teaching experience. This resonates with Johnson's (2007) affirmation of teachers as key elements in educational change and reform. If teachers are involved in educational change they will be able to provide input regarding the intended change, and this in turn will minimise the possibility of them being agents of resistance. There is a need for increased teacher inclusion in educational reform. Hewson (2007) asserts that if teachers are not involved in educational reform, then the change cannot transpire. This articulates with the research findings of Kahle and Boone (2000) that teachers possess definitive ideas about effective teaching strategies and their ideas can be utilised in the development of professional development courses for science teachers. Johnson (2007) asserts that when change occurs it is a very personal experience. Each teacher experiences the change in a different and unique manner and there are a number of variables that come into play when teachers are then required to implement that change.

Teachers are positioned at the nexus of the intended change and the school itself. In other words teachers are the implementers of any change filtered through by the education policy makers. Cotton (2006) asserts that the teacher is the critical intermediating element between the curriculum and the classroom. This resonates with Hameed's (2013) assertion that

teachers are the implementers of any curriculum change and only they can decide on whether curriculum change is implemented in its true sense. He adds that if teachers lack understanding of implementation of curriculum change then "false clarity occurs when people think that they have changed but they have got a superficial meaning of change" (Hameed, 2013, p.28). However, Chee *et al.* (2014) and Johnson (2007) argue that the facilitation of any change should be preceded by professional development support.

Clarke and Hollingsworth (2002) assert the following as factors of the school context that have an influence on the professional development of the teacher:

- Access teachers have to opportunities to engage with professional development programmes
- Restriction or support from the school as teachers engage in professional development programmes
- Does the school provide teachers with opportunities to experiment with new teaching methods/approaches
- Does the school provide support for teachers in the long term application of new teaching methods/approaches

These factorial influences are illustrated in the figure below:

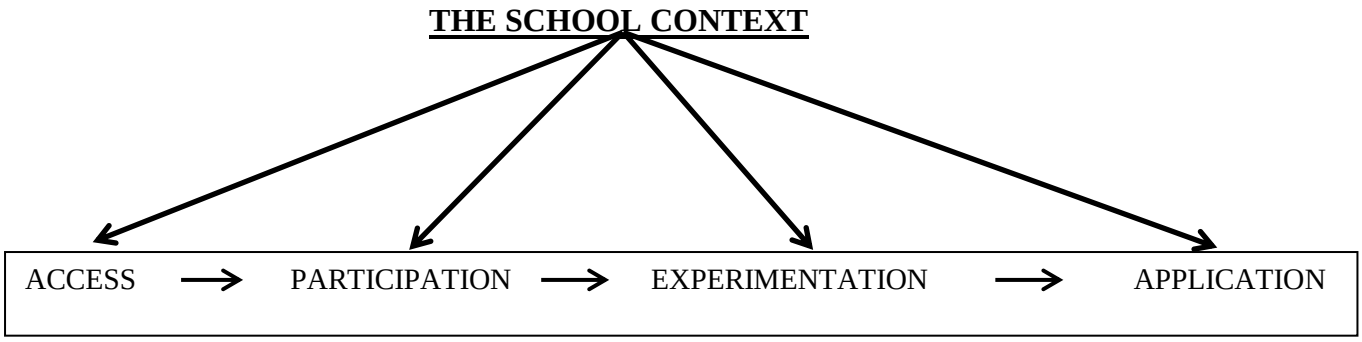


Figure 6 – Influence of school context on teacher professional development (Clarkes & Hollingsworth, 2002, p. 963).

Figure six highlights the importance of experimentation within the context of the school. For innovative teaching to occur teachers must have structural and institutional support to experiment with new ideas, reflect on these ideas and thus attempt to improve their practice.

Ellsworth (2000) states that in order for educational change to occur, there must be a strategy to be followed. He proposes a model of change.

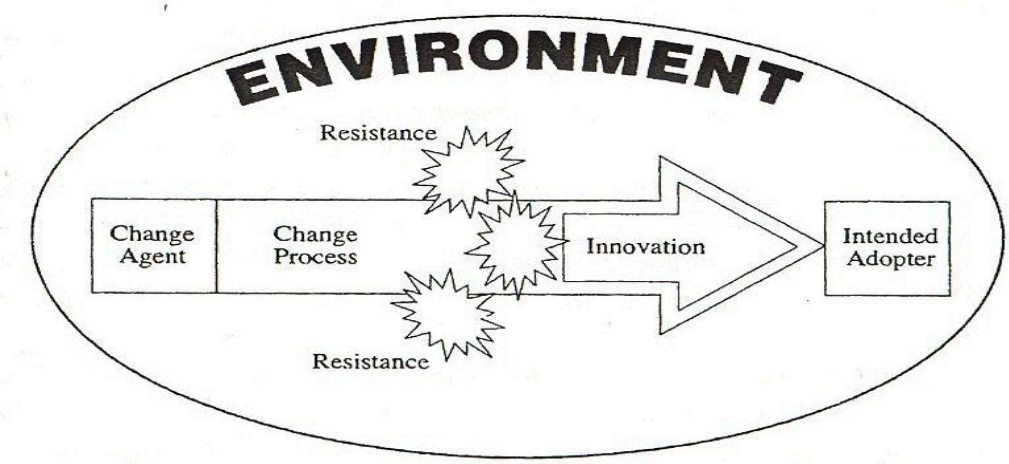


Figure 7 – Ellsworth's model of change (Ellsworth, 2000, p. 22).

Ellsworth (2000) suggests that change occurs in a two-way process of communication. He adds that a one-way approach to change is unethical and is likely to be unsuccessful. The two-way process of communication is evident when the adopter becomes the change agent. I argue that change (curriculum innovating in environment and sustainability education) is difficult to achieve because teachers are expected to implement change, with little or no communication from the department of education, in the form of professional development. I base this argument on my experiences and the experiences of other teachers, as well as research findings undertaken by, among others, Powell and Anderson (2002), van Driel *et al.* (2005), Scholtz *et al.* (2004), Lamie (2004) and Pintò (2005).

Ellsworth's model of change shows that resistance to change can exist. This can manifest in the form of teachers not receiving adequate professional development, and not implementing the curriculum (teaching environment and sustainability education). The innovation phase of this process is where teachers would draw on the knowledge and teaching methodologies gained in effective professional development programmes, and implement the curriculum successfully.

Teachers as leaders of educational change

According to O'Sullivan *et al.* (n.d.) school leadership is second only to effective professional development. This correlates with the assertion by Frost (2012) that teacher leadership is vital in the process of school change and educational innovation. This resonates

with research conducted in Singapore, by Hairon and Dimmock (2012), who found that there is an increasing trend of education policy makers to shift the responsibility of initiating curriculum innovations onto teachers and school leaders. Frost (2012, p.214) asserts that when teachers are given responsibility (by means of professional development), it makes the agenda personal and "is a powerful driver because it releases in those individuals intense enthusiasm and a strong sense of moral purpose".

The teacher should be a leader who can make decisions regarding teaching. Frost (2012) states that by giving teachers leadership portfolios (as they go through professional development that builds their capacity to lead) they are not restrained or limited; they are mobilised and able to delve into their own untapped potential to be leaders of innovation. What is important to note is that teachers do not necessarily have to be elected and be given the title of a leader, all they need is to be given the opportunity to develop the characteristics and attributes of a leader, and they will be motivated to be innovation leaders in the classroom (Frost, 2012). Mestry *et al.* (2009) state that a teacher must be self-directed and should display a willingness to acquire new skills and knowledge. This is supported by Derrington's and Angelle's (2013) assertion that teachers who assume roles as informal leaders can, by using their influence rather than control, have a positive effect on the achievement of learners as well as nurture a healthy school dynamic. This kind of leadership does not denote the managing of the school. It is a teacher assuming a leadership role regarding the learning programme related to disciplinary knowledge, and the strategies of teaching and assessment which are subject specific. Teachers who initiate innovation can be leaders in the subject.

Teacher leaders still require guidance and support from their superiors. This can manifest in the form of support from the principal, subject advisors and HODs. Steyn (2011) asserts that research suggests that teachers need support and guidance from principals in the form of monitoring and feedback sessions after they have engaged with professional development programmes. Steyn adds that support and guidance from principals and even school management, is crucial in the implementation of knowledge acquired by teachers at professional development programmes. Derrington and Angelle (2013) support Steyn's notion of support for teacher leaders. They assert that the principal is critical to the success of teachers as leaders within the school. The principal is the individual to whom teachers look for recognition of a job well done, empowerment with regards to making decisions and

support in the event of failure of an initiative. Derrington and Angelle (2013) postulate that empowering teachers to lead alongside the principal builds collegiality and cultivates a desire for school improvement in the co-operative sense. If teachers do not have this support from their principals or heads of department, they will lack the enthusiasm and confidence to implement new teaching approaches and strategies. Derrington and Angelle (2013) provide further insight into the benefits of teacher leaders. They state that teacher leaders are productive to the school as a whole because they serve as role models for other teachers. Teacher leaders are people who are risk takers and grasp opportunities that others may not see or be willing to seize (*ibid*).

Frost (2012) proposes a theory of educational innovation incorporating teacher leadership.

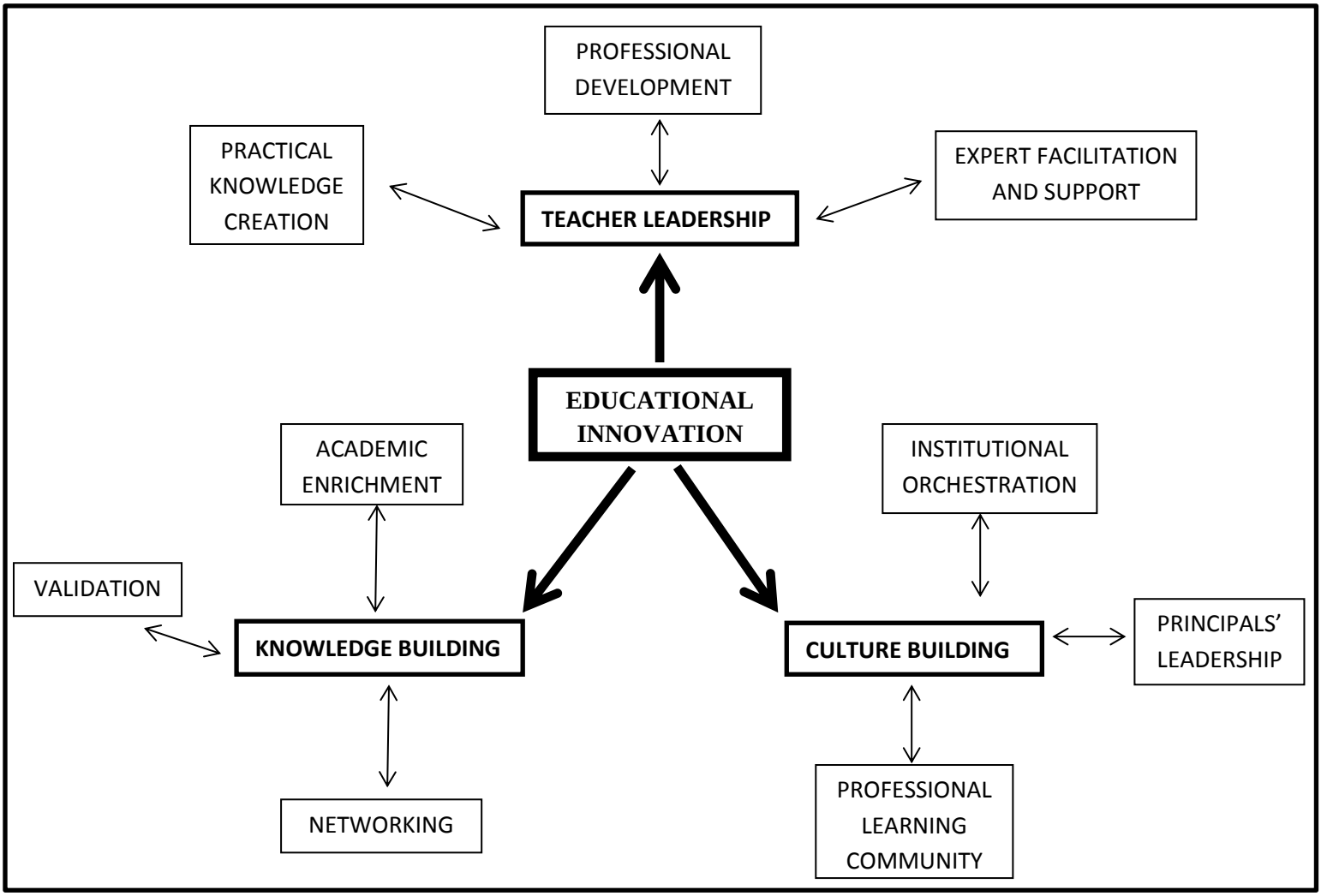


Figure 8 – A theory of educational innovation (Frost, 2012, p.214).

Figure eight emphasises teacher leadership as a construct of educational innovation. The sub-constructs of teacher leadership are important to the holistic outcome of educational innovation. If the teacher is unable to assume a leadership role then the entire process of educational innovation will collapse.

2.10. Professional development to support teachers to teach environment and sustainability education

McFarlane (2013) asserts that there is an increasing number of scholars from various fields who recognise the impact and the importance of science education. Literature is replete with discussions around the emerging challenges and opportunities surrounding science education in modern society (McFarlane, 2013). Suave (2002, p.1) asserts that environmental education "is an essential dimension of basic education focused on a sphere of interaction that lies at the root of personal and social development; the sphere of relationships with our environment, within our common home of life". Tan and Leong (2014) extend the argument that due to various economic, social and political challenges the role of education has become more critical now than ever before. According to Campbell, Medina-Jerez, Erdogan and Zhang (2010) there is a unique place for environment education in formal education. Sauve (2002, p.1) highlights the nature of environmental education by asserting that it "aims to induce social dynamics, first in the local community and subsequently in wider networks of solidarity, fostering a collaborative and critical approach to socio-environmental realities and an autonomous and creative grasp of current problems and possible solutions". Carleton-Hug and Hug (2010, p.159) concur with Sauvé's (2002) assertion by stating that "environmental education strives to engage the global citizenry in new ways of thinking and acting in, with, and for the environment – contributing to a more environmentally literate population".

Cotton (2006) asserts that in literature there is an ambiguity attached to environmental education in that it is viewed as non-essential when compared with other topics in science education. He adds that this must be corrected because the teachers' pedagogical understanding of environmental education is the foundation of their teaching of this knowledge area. McFarlane (2013) underscores the role of the science teacher in enabling adaptation to a transforming world. Science teachers must also learn to adapt and be aware that they are not teaching a static discipline (*ibid*).

Conde and Sanchez (2010) assert that a coherent approach of the integration of environment education into school science is necessary for there to be progression towards sustainable development. Part of this coherent approach should be relevant professional development for teachers. Le Grange (2010, p. 24) cautions that "the inclusion of environmental education in the formal curriculum could merely be cosmetically added onto subject matter, diluting it and thwarting its transformative potential", if a coherent approach is non-existent. This resonates with the views of Kalimaposo and Muleya (2014) that environment issues are often taught at the discretion of the teacher. If a teacher is not confident in the teaching of a particular topic in environment education they will overlook it or ignore it. The views of the preceding scholars resonate with the findings of Cotton (2006) who states that if more environmental education is to be taught in the formal school curriculum, then teachers need to be convinced that it is necessary to teach it. This points to philosophical underpinnings of teacher beliefs, attitudes and practices. Lotz-Sisitka (2011, p.35) provides further insight by stating that "teacher education for environment and sustainable development education has, on the whole, been neglected in teacher education innovations in the past 15 years, as institutions have struggled to adjust to mergers and changed institutional forms." This resonates with the assertion by McDonald and Dominguez (2010) that teacher training institutions need to make provisions to address the lack of competency of teachers to teach environmental education, for both in-service as well as pre-service teachers.

McDonald and Dominguez (2010) underscore the importance of knowledge and skills to teach environmental concepts. McFarlane (2013) asserts that science teachers must demonstrate an understanding of the rationale and elements of science. Science teachers should be able to harness this knowledge and be able to promote new learning paradigms in the science classroom that should have no boundaries regarding the global environment (McFarlane, 2013). Lotz-Sisitka (2011) states that research studies conducted show that teachers lack knowledge on environment and sustainability. She adds that teachers' lack of knowledge on environment and sustainability has implications for the career choices that learners will make, and this has a larger impact on the development of South African citizenry. This calls into question the quality of continuous professional development available to teachers and the relevance of this professional development. Hameed (2013) states that there is a need for continuous in-service training (professional development) in the field of environmental education. Mestry *et al.* (2009) stress that teachers should be intrinsically motivated to engage in professional development if professional development is

to be effective. Singh's (2011) view resonates with those of Mestry *et al.* (2009) that effective professional development programmes must be entrenched in the day-to-day reality of teachers and their work in the classroom. The importance of contextual relevance emerges as a chief concern by the preceding curriculum scholars.

Reddy (2011) states that current professional development programmes in South Africa relate to educational transformation and school reform. He adds that "if schools are to meet the needs of all learners and implement the curriculum imperatives developed in policies, the teaching approaches of teachers must be examined" (p. 18). This has direct implications for the professional development that is available to teachers. Reddy (2011) asserts that professional development is the vehicle through which these teaching approaches should be examined. According to Little and Houston (2003) cited in Reddy (2011, p.21) "effective professional development is a complex and comprehensive process of change, including multiple constituents within a system". Reddy (2011) states that there are spaces and opportunities for professional development but that South Africa lacks the capacity to implement the processes required to facilitate this type of professional development, due to the lack of resources in many schools and ineffective professional development. This resonates with Rogan's (2007) view that the capacity to introduce and sustain change of developing countries is deficient.

For teachers to be positive implementers of environment and sustainability education they require professional development that will give them the knowledge and methods of how to implement change. Roehrig *et al.* (2007) state that emphasis must be placed on exploring the actual classroom beliefs and practices of science teachers, to find out what enhances and what hinders their teaching, so that more accurate professional development can be implemented. The success of the professional development is one of the chief factors which determines whether or not teachers are able to implement change. The professional development itself must be designed to so that knowledge, skills and attitudes of teachers can be enhanced (Guskey, 2000). Facilitators of professional development need to take cognisance of what they want as the goals and objectives of programmes.

2.11. Challenges experienced by learners who are taught environmental education

According to Rickinson and Lundholm (2008, p.341) "within the field of environmental education research, there has been insufficient attention given to the questions of learners and learning". Rickinson and Lundholm (2008) in their research on the teaching of environmental education state that many learners experience three possible challenges as they are being taught environmental education content.

1. Learners experience a different emotional response compared to teachers, to the content on environmental education because their learning experiences are shaped by their emotional reaction.
2. Content in environmental education that forms part of the curriculum may conflict with the beliefs of learners and this conflict resonates between the teacher and the learners. The teacher is seen as adopting the beliefs of environmental education, which conflict with the beliefs of learners.
3. Learners disagree with the content being taught to them. They view it as inappropriate to their learning (Rickinson & Lundholm, 2008).

The following is a diagrammatic representation of these challenges:

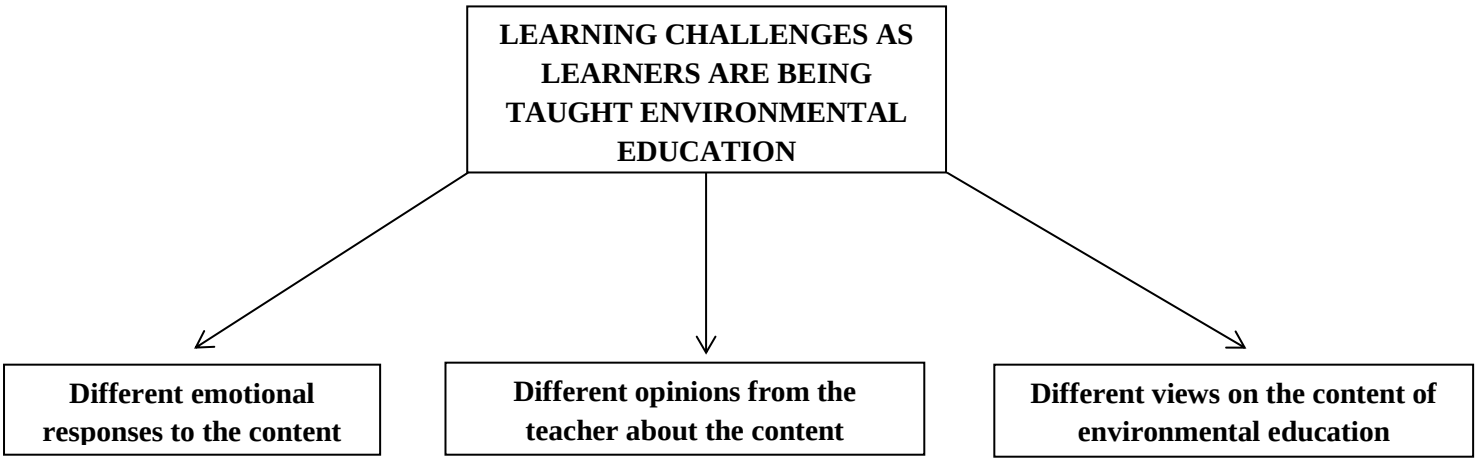


Figure 9 – Learning challenges experienced by learners in environmental education (Rickinson & Lundholm, 2008, p. 345).

Rickinson and Lundholm (2008) assert that there are various reasons for learners experiencing challenges as they are taught environmental education and that teachers should be aware of these challenges. They add that these challenges can stem from issues regarding learners' emotions and values, as well as from a lack of knowledge and understanding of environmental education. Whatever the reasons for the challenges, teachers and curriculum designers must be conscious of the fact that learners do bring knowledge and experiences into the classroom, and more emphasises must be placed on the content that is included in the environmental education syllabus (Rickinson & Lundholm, 2008). The content that forms part of the environmental education curriculum should be related to some prior knowledge that learners may bring into the classroom. Rickinson and Lundholm (2008, p. 350) emphasise the point that "environmental education subject matter evokes strong emotional responses amongst learners, which can influence the nature and depth of their engagement with any learning activities". They further assert that teachers must be aware that there will be similarities and differences between their views and the views of learners, and that this conflict can create problems for teaching and learning (Rickinson & Lundholm, 2008).

2.12. Fundisa for Change: A CAPS $^{++}$ approach

The Fundisa for Change programme aims to support and prepare teachers to engage with environment and sustainability knowledge pertinent to several subjects, including Life Sciences and Natural Sciences (Fundisa for Change programme, 2013). O' Donoghue (2013) mentions that the Fundisa for Change programme supports transformative environmental learning through teacher education. South Africa's new CAPS curriculum is rich in environment and sustainability content. However, "teaching about the environment can be challenging as the issues are complex and much environmental information is new to teachers" (Fundisa for Change programme, 2013, p. 2). According to the Fundisa for Change programme (2013), research documented in environmental education reveals that very few teachers understand the environment content stipulated in the curriculum. The Fundisa for Change programme focuses on enhancing three vital aspects of teaching, namely: knowing your subject, improving your teaching practice and improving your assessment practice. Lotz-Sisitka (2011) advocates for a CAPS $^{++}$ approach which promotes high quality education. She argues that "a teacher education curriculum that simply aligns with CAPS appears to be inadequate, as a more critical, expansive orientation to knowledge and

pedagogical content knowledge is required, if quality education is to emerge" (Lotz-Sisitka, 2011, p. 32).

The preceding review of literature reveals gaps in current research. First, the expanse of teacher-initiated innovation is rarely researched (Emo, 2009). Second, there is need for research into the kinds of professional development that facilitate the implementation of curricula (Penuel, Fishman, Yamaguchi & Gallagher, 2007). Third, even when there is research on teacher innovation it is done in isolation with no further research on future implementations (Fishman & Krajcik, 2003). My study is vital because it seeks to make a contribution to the academic debates in these uncharted areas. Literary sources reveal that the focus on implementation of a new curriculum has been well documented on OBE. However, the literature that was reviewed was silent on how teachers' engagement in innovation can enhance the implementation of the new CAPS curriculum in environment and sustainability education. This area appears to be under-researched. The importance of exploring this research area is highlighted by Songqwaru (2012) in her thesis where she calls for further research to be conducted on supporting teachers to teach environment and sustainability content knowledge effectively.

2.13. Theoretical and conceptual framework guiding the research

Constructs from the following three theories will frame my study:

1) Vygotsky's Zone of Proximal Development (ZPD)
2) Rogan's Zone of Feasible Innovation (ZFI)
3) Vygotsky's Engagement Theory

The ZPD functions on the premise of collaboration and outside support. The ZFI calls for teachers to build their capacity to be innovative when engaging with curriculum. The Engagement theory asserts that through collaborative team work meaningful, purposeful and authentic learning can occur.

2.14. Vygotsky's Zone of Proximal Development

Vygotsky's ZPD is defined as "the distance between a person's (in my work person refers to the practicing teacher) actual development level as determined by independent problem solving, and the higher level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Wertsch, 1985, p. 60).

Donald, Lazarus and Lolwana (2002) state that Vygotsky's ZPD may be defined as that space that lies just beyond a person's present understanding. It is that critical space where someone cannot quite understand something alone, but has the potential to do so through proximal interaction with another person who has the requisite capacity.

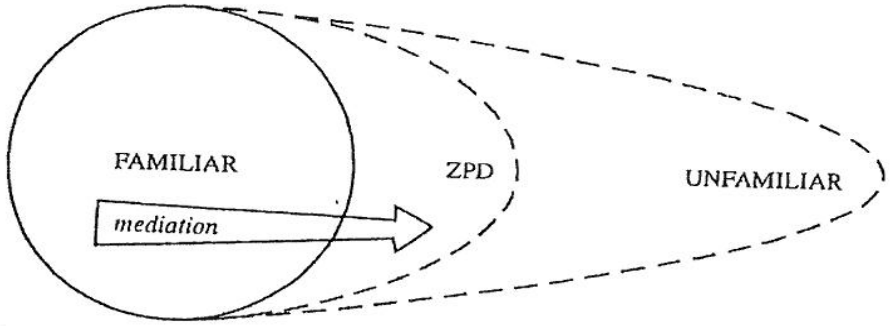


Figure 10 – Zone of proximal development (ZPD) (Donald *et al.*, 2002, p.71).

Donald *et al*. (2002) state that Vygotsky's ZPD (figure 10) is the critical space in a persons' current understanding where, through face-to-face mediation a new level of understanding can be fashioned. The ZPD is this critical space where potential development of knowledge can occur (Donald *et al*., 2002). Kinginger (2002) supports the use of Vygotsky's ZPD in educational situations. She argues that "the ZPD is a tool capturing the emergence of cognitive development within social interaction, when a person is provided with assistance from more-competent others (peers or lecturers) as they engage in learning activity" (Kinginger, 2000, p.240). Her argument for the advocacy of the ZPD is that it encourages learning. Rogan adapted Vygostky's ZPD to develop the ZFI.

2.15. Rogan's Zone of Feasible Innovation

Central to the ZFI are the following three constructs: Profile of implementation, Capacity to innovate, and Outside influences (Rogan & Aldous, 2005).

Profile of Implementation

Rogan and Aldous (2005) explain that this construct is the actual implementation phase of innovative teaching. This construct can "help understand, analyse and express the extent to which the ideals of a curriculum are being put into practice" (Rogan & Aldous, 2005, p. 315). This construct recognises that a new curriculum that is being implemented is not an all or nothing process, but implementation of a new curriculum must occur in phases over a period of time (Rogan & Aldous, 2005). They add that this construct affords curriculum implementers at a school level the opportunity to evaluate implementation of a new curriculum by focusing on the context and capacity of the school. Nsengimana, Ozawa and Chikamori (2014) characterise the profile of implementation as the types of activities that occur during the lesson, the capacity to innovate as the opportunities the school has to support or achieve implementation of the new curriculum, and outside influence as the policies schools can engage with, and the external support that a particular school can draw on.

In their study of the implementation of a new science curriculum in Rwanda, Nsengimana *et al*. (2014) found that there was a distinct absence of consideration of a link between the capacity of the school to innovate, and the school's level of curriculum implementation. For a school to exhibit high levels of implementation of a new curriculum there must be evidence of a link between the implementation of curriculum and the school's capacity to be innovative (Rogan & Grayson, 2003). Nsengimana *et al*. (2014) found that because certain schools lacked the capacity to support innovation, teachers withdrew to the security of a more traditional method of teaching. This indicates that teachers do not feel confident implementing a new curriculum, if they do not receive adequate levels of support from the school itself. (This aspect of "profile of implementation" is not located under "capacity to innovate" because it explains why teachers taught in certain ways).

Altinyelken (2010, p. 152) states that the profile of implementation "assists in understanding, analysing and expressing the extent to which the objectives of the reform programme are put into practice". She adds that implementation can occur in different ways in different schools.

Capacity to Innovate

According to Rogan and Aldous (2005) this construct consists of four sub-constructs:

- Physical resources (e.g., school buildings, furniture, school grounds, community facilities)
- School ethos and management
- Teacher factors
- Learner factors

Rogan and Aldous (2005, p. 317) state that this construct "is an attempt to understand and elaborate on the school-based factors that are able to support, or hinder, the implementation of new ideas and practices". They add that it must be noted that not all schools possess the capacity to implement an innovation at the same level and with the same intensity. The sub-constructs of this construct make it very dynamic in nature due to the fact that they can change over time and are dependent on the level of the school and the phase of implementation (Rogan & Aldous, 2005).

Further elaboration on the construct of the capacity to support innovation is provided by Altinyelken (2010). She states that the capacity to support innovation is made of "factors likely to hinder or support implementation of new ideas and practices in the new curriculum" (p. 152). Altinyelken (2010) adds that it is crucial to recognise that every school will differ in their capacity to implement innovations. For her, such factors encompass:

1) Physical resources:

These include the physical condition of the school, and whether or not the school is well-resourced. The resources of the school affect its capacity to support innovation. Poor conditions and limited resources limit the performance of both teachers and learners in the school.

2) School ethos and management:

A school that is well managed will affect the capacity of the school to support innovation. Poor management within the school creates an environment where innovation can no longer be sustained. The leadership within the school is vital to sustainable innovation. There is a need for positive leadership within the school so that innovation can be supported. Positive

school leadership will affect teacher motivation, influence teachers' capacity to be innovative, and affect teachers' attitudes and their willingness to implement change.

3) Teacher factors:

Teacher factors are closely linked to school ethos and management. If teachers are supported and allowed to be innovative, then change will not be a challenge for them. Support from the school will increase the motivation of teachers to be innovative, their attitudes will change and they will be willing to implement change.

4) Learner factors:

This sub-construct consists of a range of issues namely, the home environments of the learner, the level of parental commitment to the education of the learner, the quality of health and nutrition of the learner and the level of proficiency of a learner in the language of instruction in the classroom (e.g. English).

Outside Support

There are various sub-constructs that constitute this construct (Rogan & Aldous, 2005), namely:

- Physical resources (e.g., teaching material, worksheets, computers)
- Change forces
- Monitoring
- Support to learners
- Professional development of teachers

This construct describes factors which are external to the school but which influence practices which occur within the school (Rogan & Aldous, 2005). This construct reflects the various levels of support/resistance offered by organisations to the school to affect change (Rogan & Aldous, 2005). The sub-constructs are further divided into two themes namely, material support and non-material support. Material support includes the school buildings, books, and apparatus and the support given to learners. Non-material support comprises the professional development of teachers (*ibid*). Professional development of teachers is the most common measure employed by outside agencies to bring about change in schools according to Rogan and Aldous (2005). Professional development as a component of outside support is privileged in this thesis. The construct of outside support promotes effective professional

development of teachers by focusing on implementing change rather than it being a mere workshop for teachers (Rogan & Aldous, 2005). Professional development for teachers seeks to give teachers ownership of their development and to ensure that teachers are engaged in continuous professional development and not just one-off workshops (*ibid*).

Altinyelken (2010) states that the outside support can come from different support agencies:

- Department of education (with regards to the textbooks and educational material provided to schools)
- Non-governmental organisations

Altinyelken (2010) states that the perspectives of teachers are crucial in any curriculum reform initiative. In a study conducted in Uganda on curriculum reforms from the, Altinyelken (2010) categorises the responses of teachers according to the three constructs of Rogan and Aldous (2005). This study looked at the training of teachers through workshops with the goal of implementing a new curriculum in the Ugandan educational system.

1) Support from outside agencies:

In her study Altinyelken (2010) found that teachers believed the training (professional development) that they received was hurried and this created a negative attitude towards the new curriculum. These teachers did not feel well equipped to implement the new curriculum. They felt more confused after the training and questioned the benefits of the new curriculum. Interestingly, experienced teachers commented that novice teachers would have real difficulty implementing the new curriculum. An important finding evident in her study was that the resources were not equally distributed to all schools and this was a major hurdle for many teachers (Altinyelken, 2010). Teachers reported that the purchasing of resources was very expensive (purchases made by the teachers themselves) and this did little to assist teachers with the implementation of the new curriculum. Each teacher had different experiences of monitoring and supervision from education department officials and initial visits from department officials were experienced in certain schools, although there was no evidence of follow-up supervision (Altinyelken, 2010).

2) Capacity to support the innovation
    a) Physical resources

From her study (Altinyelken, 2010) found that teachers were excited about using different resources, that they themselves had to develop, in their teaching of the new curriculum. But unfortunately many teachers complained of the lack of resources provided to them by the education department. Some teachers complained that resources that they did receive were inadequate. Due to the lack of resources teachers had to create their own resources, but this was limited by their creativity, time and materials available to teachers (Altinyelken, 2010).

b) School ethos and management

The advent of a new curriculum created excitement for both teachers and the school's management team. Although there was excitement surrounding the new curriculum, many of the management teams at schools complained that they receive no support from the education department regarding other issues such as, high drop-out rate of learners and assistance in improving proficiency of learners in literacy and mathematics (Altinyelken, 2010).

c) Teacher factors

Teachers in the study emphasised that they had received insufficient training to implement the new curriculum which created a lack of motivation/morale amongst them (Altinyelken, 2010). This lack of motivation was highlighted by teachers stressing how low their salaries were and that they were not prepared to put in more time and effort that the new curriculum required, without monetary incentives (Altinyelken, 2010).

d) Learner factors

Overcrowded classrooms restricted new teaching methods proposed by the new curriculum (e.g. group work). Due to large class sizes teachers experienced major discipline concerns in classrooms which restricted opportunities for innovation (Altinyelken, 2010). Teachers reported that due to classrooms being overcrowded spread of disease and sickness became common amongst learners (Altinyelken, 2010). Learners had very poor handwriting and lack of proficiency in English of learner's hindered teachers from being innovative. Due to learners' lack of proficiency in English, learners required individual attention and this slowed down the completion of syllabus. The different learning abilities of learners were a hurdle for teachers and resulted in some teachers abandoning innovation (Altinyelken, 2010).

3) Profile of implementation

Altinyelken (2010) found that teachers experienced a variety of challenges when they attempted to implement a new curriculum and to be innovative in their teaching. Teachers noted that the new curriculum required more teaching time to complete. Assessment and activities consumed a lot of teaching time. She found that learner proficiency in English hindered implementation of the new curriculum. The new curriculum requires learners to be more responsible for their learning, but the ability of learners to manage this responsibility varied. Assessment was highlighted by the new curriculum, but teachers revealed that they received little on how to practice assessment in their training workshops (Altinyelken, 2010). It is for this reason some teachers ignored certain assessment tasks in the assessment programme. The new curriculum also came with new formats for learners' progress reports (Altinyelken, 2010). Teachers complained that these new reports created confusion for both learners and parents as they did not understand how to read these new reports. Some parents even transferred their children to private schools where the new curriculum was delayed.

From the study conducted by Altinyelken (2010) there are challenges teachers face that seem to overlap across different constructs. This illustrates that with curriculum reform there are certain challenges that will exist in whichever country the reform takes place. Bantwini (2010, p.90) states that "all reforms will face challenges, whether contextual, cognitive or otherwise."

Role of ZFI in Innovation

Rogan (2007) argues that changes in educational systems are necessary, however he contends that capacity to bring about change and the ability to sustain the change is lacking in developing countries. This is the case in South Africa because we are a developing nation (Reddy, 2011). Rogan (2007) proposes that the ZFI can be used to facilitate innovation (change). Innovation in this study refers to the implementation of the new curriculum together with the new practices in environment and sustainability education. Rogan (2007, p.444) states that the ZFI "is an attempt to bring an element of direction and continuity to the decision-making process".

Literature emphasises that professional development for teachers is a complex process (Frost, 2012). Integration of environmental education into the curriculum requires a multi-pronged

approach. The need for innovation and outside support (professional development) is therefore critical. Rogan's ZFI is therefore useful, because the Fundisa for Change is a professional learning community which can offer outside support to practicing teachers, and this outside support was used to a limited extent in my study. If practicing teachers engage with this outside support they can build capacity for change. Rogan (2007) asserts that the ZFI functions on the capacity available to support the innovation. The Fundisa for Change professional learning community aims to increase the teaching capacity of teachers so that the innovation (successful teaching of environment and sustainability education) can occur. Rogan (2007, p. 457) calls for "outside support" that is needed for progress of change to occur.

Rogan (2007) refers to the ZFI existing in a continuum of practice. In a continuum of practice there is a move from routine practice to more ideal practices, the ZFI will widen as the capacity to support the innovation increases (Rogan, 2007). The ZFI is the area where practicing teachers will engage with new practices (e.g., activities from Fundisa for Change) that are beyond the normal routine practice. These new practices enhance the professional development of teachers and move the ZFI closer to the ideal practice. Figure 11 suggests practices that are beyond the routine (current practices), but not practices that are beyond what is feasible in time. "The ZFI assumes an acceptance of the final goal (ideal practices) and regards teacher's decision making as a series of graded steps towards this ultimate goal (ideal practices), phased in over a number of years if necessary" (Rogan, 2007, p.441). Rogan adds that the ZFI highlights change occurring gradually, over time, without it being a rapid process.

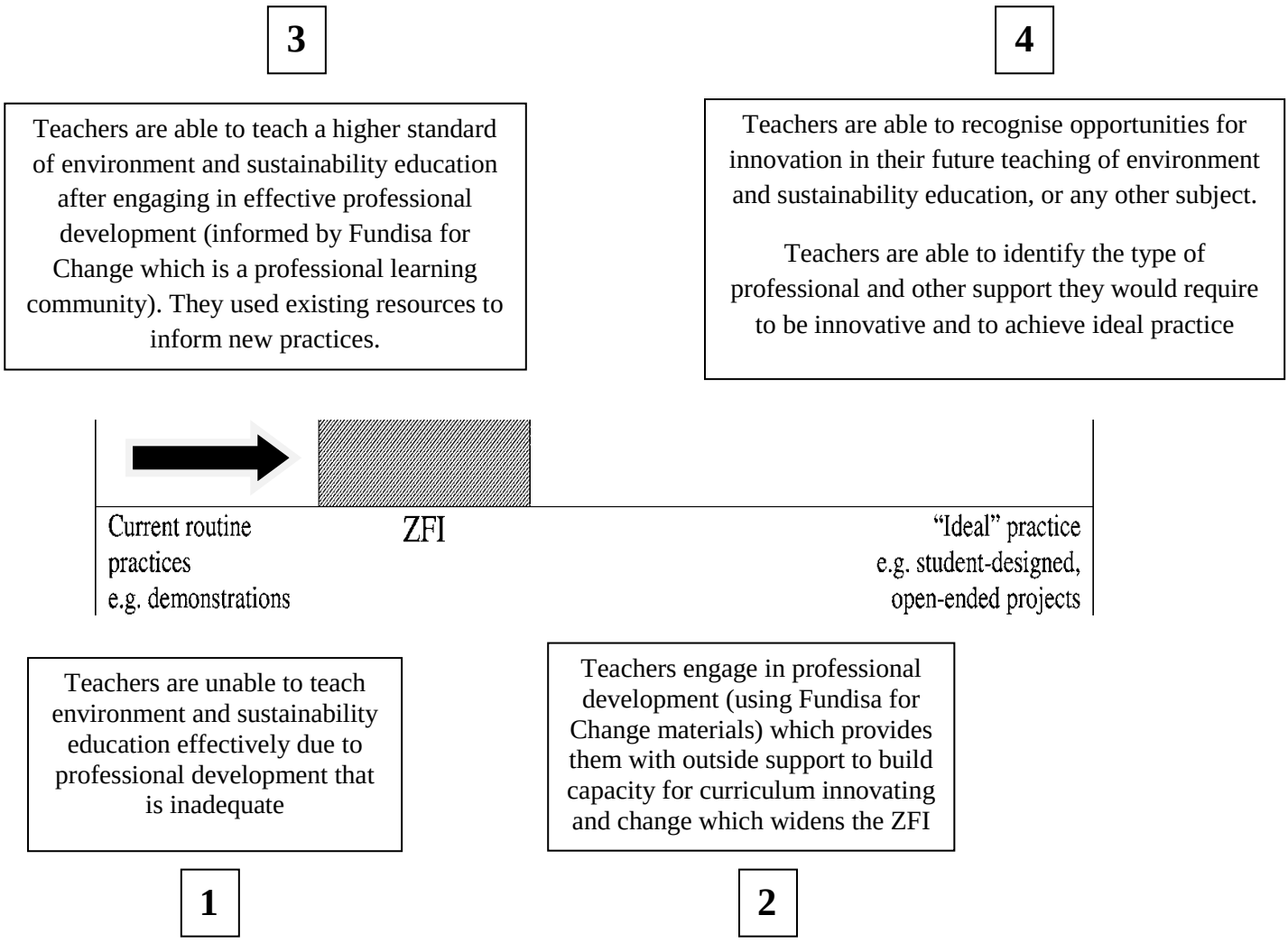


Figure 11 – The location of the ZFI on a continuum of practice for teaching environment and sustainability education (adapted from Rogan, 2007, p.450).

2.16. Vygotsky's Engagement Theory

Maloshonok (2014) states that the engagement theory places emphasis on the role of the environment in learning. Miliszewska and Horwood (2004, p. 3) assert the basis of the engagement theory is the "idea of creating successful collaborative teams that work on tasks that are meaningful to someone outside the classroom". They add that a major premise of the engagement theory is in order for effective learning to take place learners must be engaged with their work. Miliszewska and Horwood (2004) state three fundamental avenues for engagement to occur, these are collaborative efforts of learners, project-based assignment and non-academic focuses. These fundamental avenues of engagement are viewed as methods that can be used so that creative, meaningful and authentic learning can occur (Miliszewska

& Horwood, 2004). The engagement theory comprises of core principles which are, relate, create and donate (Miliszewska & Horwood, 2004). Relate refers to the communication and social skills that must exist in a team effort. Create, which regards learning as a creative, purposeful activity, and donate which focuses on learning whilst bearing in mind the wider community (Miliszewska & Horwood, 2004). This theory will inform the recommendation that I will propose in chapter five.

2.17. Link between theoretical constructs and this study

Currently in science classrooms teachers are experiencing challenges related to being able to effectively teach and assess environment and sustainability education. As a consequence of this learners in science classrooms are experiencing difficulties in understanding environment and sustainability education (Nsengimana *et al.*, 2014). Rogan's ZFI, Vygotsky's ZPD and Vygotsky's Engagement theory, when fused illuminate the way towards a renewed approach to the teaching and learning of environment and sustainability education. This fusion of theories is applicable to my study because it calls for curriculum innovating and effective professional development as the foundation to effective teaching and learning of environment and sustainability education. Curriculum innovating and effective professional development, when considering the context, can provide teachers with the requisite skills and knowledge to be effective teachers of environment and sustainability education. In turn, this will positively affect and address the difficulties learners face as they are taught environment and sustainability education.

2.18. Conclusion

The literature reveals that change in curriculum precipitates challenges for teachers. Resistance to educational change is common amongst teachers due to, among other reasons, the fact that teachers play a minimal role in the construction of these educational changes, but are required to implement the changed curriculum. Findings from previous studies which have been mentioned in this review suggest that one of the main reasons why educational changes are unsuccessful is because teachers are invisible in the formulation of these changes. This makes visible the DBE's positioning of teachers as technician in the classroom

rather than as creative, innovative individuals. Studies which were reviewed indicate that if teachers are not included in the planning of any educational change they will not take ownership of it and will not implement the envisaged change. There is a call for teachers to be more involved in future educational changes in South Africa to ensure that the changes are appropriate for the implementation at grassroots level. The teacher should be viewed as an agent of change and be given the opportunity to fully extend in this role. There is an abundance of literature advocating for teachers to be seen as crucial to the development and implementation phase of educational change because they are at the curriculum implementation-learner interface.

South Africa's basic education curriculum has undergone numerous changes over the years and with the introduction of the CAPS curriculum which emphasises environment and sustainability education as part of the Natural Sciences and Life Sciences curriculum, teachers are experiencing personal and professional challenges in effectively teaching environment and sustainability education content. These challenges are in the form of a lack of motivation and determination; a lack of content knowledge; a lack of school resources and poor work ethic of learners, as teachers are tasked with teaching a content-rich section of the curriculum. Previous studies which were reviewed reveal that a lack of effective professional development is one of the key factors that contributes to the negative attitudes of teachers towards environment and sustainability education. The learners are also affected by this and they encounter their own difficulties as they are taught environment and sustainability education. Literature reveals that learners experience a lack of understanding when they are taught due to teachers not having exciting and innovative methods enhancing relevance of what is taught.

The teaching and learning of environment and sustainability requires a shift in practice. Literature calls for a renewed and refreshed way of teaching environment and sustainability education; curriculum innovating can be a vehicle for effective teaching and learning of environment and sustainability education. A review of literature has identified that there existed a divide between the expectations of curriculum developers and teachers' capacity to be innovative.

Effective professional development, referred to as a constituent of outside support by Rogan (2007), is the cornerstone of teachers' potential to enhance their capacity to a level which allows them to innovate as they teach. Teachers who have the capacity to innovate when

they teach environment and sustainability education are more likely to grasp the attention of the learner and be able to teach effectively. A review of literature reveals that teachers who are not engaged with effective professional development have a limited capacity to innovate when they teach environment and sustainability education.

The review of literature and relevant theories supported the research design, analysis, findings and recommendations in this study. The next chapter will focus on a discussion of the research design and methodology which was selected for this study.

CHAPTER 3

Research Methodology

CONTENTS	PAGE
3.1. Introduction	64
3.2. Context of the study	64
3.3. Paradigm	65
3.4. Approach	66
3.5. Design	67
3.6. Sample	69
3.7. Data generation	72
3.8. Triangulation	79
3.9. Data generation methods fit for purpose	80
3.10. Pilot study	82
3.11. Data analysis	83
3.12. Rigor of the research	86
3.13. Ethical issues	88
3.14. Limitations of the study	90
3.15. Conclusion	90

3.1. Introduction

In this chapter I describe and explain the research methodology selected for this study. I begin by setting the scene and establishing the context of this study. The research methodology, which adopts a qualitative approach, is described, along with the selected paradigm, which is the critical paradigm. Purposive sampling, the strategy selected for this study, is described and an explanation for the chosen sampling technique is advocated for. The different types of case studies are discussed prior to making a case for a combination of a descriptive and interpretive case study. I motivate for the choice of research design and explain why this type of design is best suited for answering the research questions. The data generation methods, which include interviews, portfolios, reflections and photo-narratives, are elaborated on, and the methodology underpinning these choices is discussed. Justification for the use of the research instruments is presented with a view to ensuring trustworthiness of data. Finally, I elaborate on the ethical issues and limitations of this study, which form the concluding segments to this chapter.

3.2. Context of the study

This study focused on how teachers who have engaged in professional development enact curriculum innovating in environment and sustainability education. In doing this the study endeavoured to illuminate ways in which teachers' knowledge of innovation in environment and sustainability issues could be addressed through professional development. This study was conducted at a teacher education institution in KwaZulu – Natal. The participants in this study were 10 practicing science teachers who were registered at the institution for a Bachelor of Education Honours programme in Science and Mathematics education. This programme is a two year part time qualification which prepares teachers for further postgraduate study by developing research related skills and also contributes to their professional development in Science and Mathematics education. The Bachelor of Education Honours programme comprises five compulsory modules which are *Assessment in Science and Mathematics education, Issues in Science and Mathematics education, Teaching and Learning in Science and Mathematics education one, Teaching and Learning in Science and Mathematics education two and Curriculum Development in Science and Mathematics education.* The module which was central to this study was Curriculum Development in Science and Mathematics Education. The Bachelor of Education Honours programme in Science and Mathematics Education is studied by teachers who teach Natural Sciences,

Physical Sciences, Life Sciences and Mathematics. In this study I engaged teachers who teach in the Life Sciences and Natural Sciences disciplines. The reason for selecting practicing Life Sciences and Natural Sciences teachers was because I intended to explore curriculum innovating as it relates to implementation of the Life Sciences and Natural Sciences curriculum in environment and sustainability education.

3.3. Paradigm

Cohen, Manion and Morrison (2011, p. 23) describe a paradigm as the "philosophical intent or motivation for undertaking a study". Mackenzie and Knipe (2006, p. 193) further expound that, "It is the choice of paradigm that sets down the intent, motivation and expectations for the research". In order for accurate decisions to be made regarding methodology, literature, methods or research design, the paradigm selection must be conducted during the initial stages of the study (Mackenzie & Knipe, 2006). Some of the paradigms that are discussed in literature are the positivist, interpretive and critical paradigms. Fundamentally these paradigms view phenomena through different lenses (Cohen *et al.*, 2011). "Positivism strives for objectivity, measurability, predictability, controllability, patterning and the construction of laws and rules of behaviour. The interpretive paradigms strive to understand and interpret the world in terms of its actors" (Cohen *et al.*, 2011, p. 31).

Cohen *et al.* (2011) mention that the critical paradigm focuses on change, empowerment, transformation and emancipation. The paradigm which framed this study was the critical paradigm. Cohen *et al.* (2011) argue that the main aim of critical research is to transform and change individuals. In my study positive changes in teacher practices was effected, and was evidenced by transformed teaching and learning of environment and sustainability education in the science classroom. The focus was not only on curriculum change but also how the practices of teachers changed in order to implement a new curriculum. Curriculum change is a learning process that requires teachers to also change (transform) in order for implementation to be successful. Change in the practice of teachers is necessary because sometimes the diminished capacity of a teacher restricts the implementation of curriculum change (innovation). Robson (2011, p. 39) contends that the purpose of the critical paradigm "is not only to explore, describe or explain but also to facilitate action, to help change or make improvements, to influence policy or practices". This study explored the experiences and challenges of teachers as they taught a changed science curriculum. It revealed how

teachers transitioned from traditional to new improved practices which enhanced learner enthusiasm and performance. This study also aimed to critically evaluate the use of an outside support structure (effective professional development) to transform the current teaching practices of teachers through their engagement with curriculum innovating that resulted in creative teaching of environment and sustainability education.

3.4. Approach

Corbin and Strauss (2015) state that qualitative researchers aim to explore inner experiences of participants and how meaning is formed. For this study, the methodological approach selected was qualitative. "Qualitative research is research that attempts to collect rich descriptive data in respect of a particular phenomenon or context with the intention of developing an understanding of what is being observed or studied" (Nieuwenhuis, 2007a, p. 50). Qualitative research focuses on techniques associated with the collection of in-depth data that relies heavily on narrative, nonnumeric analysis, interpretation and presentation (Mertens, 1998; Mertler & Charles, 2008; Teddlie & Tashakkori, 2009). I wanted to obtain thick detailed descriptions about the challenges and experiences by participants as they engaged in curriculum innovating. I also wanted to understand the effect that the professional development had on participants.

Mertler and Charles (2008) describe qualitative research as having the following fundamental characteristics:

- Qualitative research tends to occur in a natural setting where the researcher collects their data from a particular setting.
- Data collected through qualitative research is descriptive and is presented in the form of words rather than numbers.
- Qualitative research is not only concerned with the outcomes of research but also with how and why things occur the way they do during the research.
- In qualitative research the thinking of the participant and the reasons for that thinking is given emphasis.

A quantitative research approach can be defined as "the techniques associated with the gathering, analysis, interpretation and presentation of numerical information" (Teddlie &

Tashakkori, 2009, p. 5). This approach emphasises the clarifying of a problem in the form of a question or hypothesis, with the specification of the variables associated with the problem, and then the identification of the relationship between the variables, so that research can be conducted towards answering the initial question (Ary, Jacobs & Razavieh, 2002). For this study a quantitative approach was not adopted because the meanings derived from this work were not "experimentally examined or measured in terms of quantity, amount, intensity or frequency" (Denzin & Lincoln, 2005, p. 10).

Qualitative research incorporates the following keywords: complexity, contextual, exploration and inductive logic (Mertens, 2009). By adopting an inductive approach, the researcher can make sense of a situation without imposing any bias on the phenomenon under study (*ibid*). This inductive study focused on the phenomenon of curriculum innovating in environment and sustainability education and it sought to explore the reasons as to how and why participants engage in curriculum innovating. It also took into consideration the unique context and setting of each participant as they engaged in curriculum innovating. This was done without any bias towards a predetermined result or outcome.

It is thus on the basis of the aforementioned characteristics of a qualitative research approach that this study is framed. By using a qualitative approach, I was able to obtain rich and in-depth understanding of how teachers who engaged in professional development could enact curriculum innovating when they taught environment and sustainability education.

3.5. Design

"Qualitative case study is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood" (Baxter & Jack, 2008). The design for this research was a case study. Case studies have a definite purpose "to portray, analyse and interpret the uniqueness of real individuals and situations through accessible accounts" (Cohen, Manion & Morrison, 2007, p. 85). Yin (2003, pp.13-14) defines case study research as an "empirical inquiry that investigates a contemporary phenomenon within its real life context in which multiple sources of evidence are used". A case study is an in-depth study of one particular case, where the case may be a person or group of people, such as teachers

(Opie, 2004; Robson, 2011). The case in this study was 10 practicing Life Sciences/Natural Sciences teachers who were enrolled for an Honours module in education at a tertiary institution. Baxter and Jack (2008, p. 556) assert that a "case study is an excellent opportunity to gain tremendous insight into a case. It enables the researcher to gather data from a variety of sources and to converge the data to illuminate the case". This study sought to explore the in-depth experiences of participants as they engaged in curriculum innovating in environment and sustainability education. A case study provides a platform for detailed, descriptive responses from participants "with narrow focus, combining subjective and objective data" (Cohen *et al.*, 2007, p. 254). Moreover, the critical factors that enabled or restricted participants' attempt to engage with curriculum innovating were explored and analysed. This resonates with Nieuwenhuis's (2007b, p. 75) view that case study research aims at "gaining greater insight and deeper understanding of the dynamics of a specific situation". This data was gathered through individual interviews, document analysis, reflections and photo narratives.

Merriam (1998) states that case studies can be categorised according to their unique features. Case studies can be:

- Particularistic, meaning the focus is specifically on particular event or phenomenon,
- Descriptive, meaning the result of a case study provides and in-depth, rich description of the phenomenon that was studied, and
- Heuristic, meaning the case study enhances the understanding of the reader regarding the phenomenon that was studied.

Case studies can be described according to the overall intent of the study (Merriam, 1998). An explanation of the different types of case studies is provided by Merriam (1998):

- A descriptive case study which provides a detailed account of the studied phenomenon.
- An interpretive case study which not only provides a thick description of the phenomenon that was studied but also allows for the development of conceptual categories that can be used to support or challenge theoretical assumptions that were assembled prior to the study being conducted.
- An evaluative case study which provides a description, an explanation and a judgement regarding the data that was gathered.

"Some case studies are purely descriptive; many more are a combination of description and interpretation…" (Merriam, 1998, p. 40). My study displays elements of both a descriptive and interpretive case study. My study provides a detailed account of participants who engaged in curriculum innovating as they taught environment and sustainability education. It also provides a rich and in-depth explanation of the use of outside support (professional development) to build teachers' capacity to innovate. Moreover, my study supports the theoretical assumption put forward by Rogan's (2007) ZFI that highlights the use of effective outside support to help teachers engage in curriculum innovating.

3.6. Sample

Mertens (2010, p. 309) defines sampling as a "method used to select a given number or people from a population". Gay, Mills & Airasian (2009, p. 113) add that in qualitative sampling a few individuals who serve as suitable key informants are selected to deepen the researchers understanding of the phenomenon under investigation. The participants in this study were 10 practicing Life Sciences/Natural Sciences teachers, who were volunteers from a Science and Mathematics Education Honours programme. The reason for selecting 10 practicing Life Sciences/Natural Sciences teachers as participants was because it was a manageable number to work with. Purposive sampling was used to select 10 practicing teachers who taught Life Sciences/Natural Sciences. In purposive sampling, researchers "hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought" (Cohen, Manion & Morrison, 2009, p. 156). McMillan and Schumacher (2010) mention that in purposive sampling specific characteristics of the population which would enhance understanding of the phenomenon are sought. The criteria for selection of participants was, first, that they were practicing teachers who taught Life Sciences and or Natural Sciences, second, they were fully qualified to teach science and third, that they were registered to study the Curriculum Development in Science and Mathematics Education (Honours) module. Patton (2002) explains that the advantage of purposive sampling is that similar patterns which emerge from a variety of data sources and participants are valuable because they capture the essence of the experience of participants in a particular context. The commonality among the selected participants was that they all had the task of engaging in curriculum innovating when they taught environment and sustainability education. In convenience sampling, the researcher has ease of access to participants (Cohen *et al.*, 2011). Convenience sampling was also used

because all the participants were based at the university where the study was conducted and were easily accessible. The fundamental method of sampling for this study was purposive sampling, but convenience sampling was used to a lesser extent. The decision for the sampling techniques for this study was underpinned by the aim of collecting rich, high quality data that enabled me to answer the research questions.

Table two provides a descriptive summary of participants.
P1 to P10 represents participants 1 to 10.

Table 2: Summary of participants indicating the subjects they were teaching, years of teaching experience and the type of area the school serve.

	Race	**Gender**	**Subjects being taught**	**No of years teaching Life Sciences and or Natural Sciences**	**Community which school served**
P1	African	Female	Life Sciences and Natural Sciences	3	Middle class socio-economic community.
P2	Indian	Female	Life Sciences and Natural Sciences	2	Lower to middle class socio-economic community. Some learners came from townships.
P3	African	Male	Information Technology and Natural Sciences	1½	Lower socio-economic community. Most learners came from townships and underprivileged backgrounds.
P4	Indian	Female	Life Sciences and Natural Sciences	8	Lower to middle class socio-economic community. Some learners emerged from townships and underprivileged backgrounds.

P5	Indian	Female	Life Sciences and English	1	Lower to middle class socio-economic community. Some learners emerged from townships and surrounding area.
P6	African	Female	Physical Sciences and Natural Sciences	19	Lower socio-economic community. Most learners were from townships and underprivileged backgrounds
P7	African	Male	Physical Sciences and Natural Sciences	3	Affluent community
P8	Indian	Male	Natural Sciences and Life Sciences	1	Lower to middle class socio-economic community. Some learners were from townships and underprivileged backgrounds.
P9	Indian	Male	Natural Sciences and Physical Sciences	25	Lower to middle class socio-economic community. Some learners were from townships and underprivileged backgrounds.
P10	Indian	Male	Natural Sciences and Mathematics	7	Lower to middle class socio-economic community. Some learners came from townships and underprivileged backgrounds.

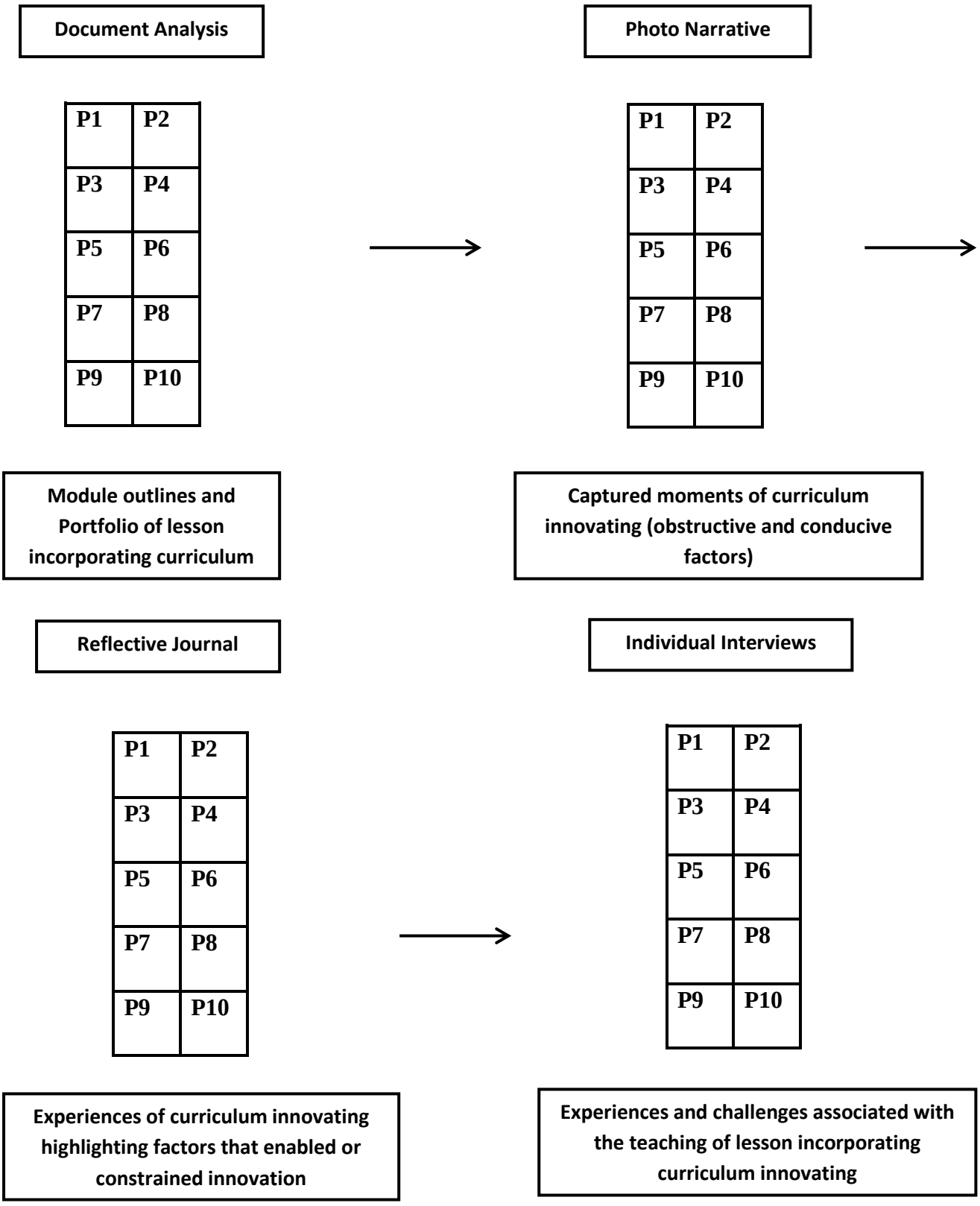
The sample in this study comprised five female and five male participants. Each participant had a four-year teaching degree with a specialisation in Life Sciences and/or Natural Sciences. In terms of racial demographics, four participants were of African descent and six were of Indian descent. The participants taught in diverse socio-economic settings, ranging from affluent communities to lower socio-economic communities. Each participant had less than ten years of teaching experience, with the exception of participants six and nine.

3.7. Data generation

Generating data for a qualitative inquiry involves the use of different techniques and methods (Denzin & Lincoln, 2000). According to Cohen *et al*. (2011), qualitative data stems from many sources such as interviews, observations, documents and diaries.

3.7.1. Data generation methods and instruments

This study employed four methods of collecting data, namely: Document Analysis (B.Ed Honours module outlines and portfolios), Photo Narratives, Journaling and Individual Interviews. The process of data generation occurred in stages. Stage one incorporated an analysis of module outlines and lesson plans developed by participants. Stage two focused on the analysis of the photo-narrative created by participants. Following this was the analysis of participants' reflective journals which was stage three. The fourth and final stage was analysis of the individual interviews conducted with participants.



*****P - represents Participant

Figure 12 - Diagrammatic representation of data generation.

Nieuwenhuis (2007b) mentions that there is a complementary relationship between interviews, reflections and document analysis, which enhances the trustworthiness and crystallization of findings. "Crystallization therefore provides us with a complex and deeper understanding of the phenomenon" (Nieuwenhuis, 2007b, p.81). The intention underlying the use of multiple methods for data generation was to attain an in-depth understanding, in order to answer the critical research questions from different angles, thereby generating triangulated data.

Document Analysis

Ritchie (2003) mentions that document analysis involves a careful study of documents in order to deeply understand the meaning conveyed by the content. In addition documents can provide information which supports details from other sources (Yin, 2009).

According to Cohen *et al.* (2011) and Mogalakwe (2006) primary documents and secondary documents are the two types of documents used in documentary study. "Secondary documents whose authors are not eye witnesses but people who compile the information in the document from interviewing eye witnesses or reading primary documents" (Bailey, 1994, p.319). Mogalakwe (2006, p. 222) states that "primary documents refer to eye-witness accounts produced by people who experience the particular event or behaviour we want to study".

In this study primary documents were analysed. Five module outlines from a Bachelor of Education Honours programme were used to gain insight into what professional development related to innovating in environment and sustainability education was being offered at the higher education institution where the study was located. In addition analysis of participants' portfolios containing a unit of learning in environment and sustainability education lesson plans, professional biography of the teacher, and the context of schools, was conducted. These portfolios were developed as part of the assessment programme in the Honours module "Curriculum Development in Science and Mathematics Education". Some of the aspects included in the document analysis schedule were (see Appendix 6):

- Do the module outlines incorporate curriculum innovating in environment and sustainability education?

- Which features relate to curriculum innovating in environment and sustainability education? Do these relate to content/teaching methodology/both?

The lesson plans of participants were also analysed. Some of the aspects included in the document analysis schedule, relating to the lesson plans were (see Appendix 6):

- Does the lesson plan incorporate curriculum innovating in environment and sustainability education?
- What innovative teaching methods are incorporated in the lesson plan?
- How is innovation planned and enacted in terms of the capacity to innovate/outside influences and profile of implementation?

Document analysis has both advantages and limitations as described by Bowen (2009, p.31). Document analysis has the following advantages:

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

Bowen (2009) suggests that document analysis as a method is limited by the lack of detail in documents, to enable deep responses to research questions. However, Bowen argues that insufficient detail is a minor limitation which is outweighed by advantages of document analysis, the latter which include the fact that this method is not prohibitively expensive, and is highly effective. In this study multiple methods of data generation were used to answer the research questions. Documents were not used in isolation and this facilitated the attainment of sufficient in-depth data for a detailed response to each research question.

Photo Narrative

Visual data (photographs) capture a particular moment or event (Cohen *et al.*, 2011). Furthermore visual data convey deep meanings of real life situations. Thus Cohen *et al.* (2011, p.529) argue that visual data tell a story rather than being a "singular objective reality". In this study participants photographed moments of innovation during their lesson on environment and sustainability education. The participants were required to take ten photographs which were organised to illustrate the chronological unfolding of their lesson

presentations in environment and sustainability education. In addition the participants provided a brief written explanation of the learning interactions for each photograph. Cohen *et al.* (2011) emphasise the importance of including written texts (narratives) because this text tells a selective story. Participants were requested to incorporate the factors that enabled or constrained curriculum innovating in their narratives. These could include the following: Support from peers, professional development, monitoring/assistance from HOD's/subject advisors, physical resources, teacher capacity, learners capacity and the ethos and management of the school (see Appendix 7).

Reflective Journals

Phelps (2005) mentions that journals can be used as a method of collecting qualitative data. Keke (2008) adds that a reflective journal is a tool that allows people to give a greater and in-depth understanding of their experiences. "A reflective journal is an instrument for participants' self-evaluation" (Yildrim, Akar, Haller, Freitag, List-Ivankovic, Brodigan & Dincelek-Letinga, 2007, p. 4). These authors add that reflective journals provide participants with the opportunity to critically reflect on an isolated learning experience that is to be studied. The participants in this study reflected on their experiences of engaging with a professional development Honours module, and their enactment of curriculum innovating in environment and sustainability education, according to the constructs of the Zone of Feasible Innovation.

The participants were given a template which they used to document reflections based on introspection of curriculum innovating (see Appendix 9). Some of the aspects participants reflected on were framed as questions, and included the following:

- Was your personal capacity as a teacher enhanced when you engaged with this professional development?
- Were you actively engaged during this professional development?
- Did you collaborate with your peers during the course of this professional development?
- Do you now have increased confidence of how to teach content on environment and sustainability education?
- After this professional development, do you feel that you have undergone a transformation as a science teacher?

Reflective journals have both advantages and disadvantages as described by Yildrim *et al.* (2007) and Phelps (2005).

Reflective journals have the following advantages:

- Provide an in-depth insight into the process of learning
- Have the ability to facilitate reflective learning

Reflective journals have the following disadvantages:

- Require discipline and time to record reflections on a regular basis
- The capacity and the readiness of participants to engage deeply in the reflective practice influences the quality of the reflection
- The ability to share personal feelings with others may not come naturally to every participant

This study overcame the aforementioned disadvantages by emphasising the value of reflection as a tool for learning to teach. This study utilised multiple methods of data generation and reflective journals were not used in isolation. This allowed me to accrue rich in-depth data in order to successfully answer each research question.

Individual Interviews

Cohen *et al.* (2007, p.349) define an interview as an "interchange of views between people on topics of mutual interest that may assist in answering the research questions". The most commonly selected method of data collection for qualitative research is interviewing (Greeff, 2002; Robson, 2011). This study adopted a qualitative approach, and individual face-to-face interviews were conducted with 10 practicing Life Sciences/Natural Sciences teachers. Face-to-face interviews are useful because they allow opportunities for the researcher to encourage the participants and for the researcher to note non-verbal cues which accompany the verbal responses (McMillan & Schumacher, 2010).

Robson (2011) explains that there are three types of interviews namely, structured, semi-structured and unstructured. Robson (2011) and Opie (2004) elaborate further on these three types:

- Structured interview – This type of interview is controlled by the interviewer and contains predetermined questions that have fixed wording in a specific order.

- Semi-structured interview – The interviewer utilises an interview schedule that guides the interview. The addition of unplanned follow-up questions (probes) is allowed. This type of interview is less controlled by the interviewer.
- Unstructured interview – This type of interview in very flexible and informal in nature with the interviewer having a general area of interest, but allows the conversation to develop.

For my study I chose to use semi-structured face-to-face interviews which were audio-recorded. I chose this type of interview because it afforded adequate flexibility to ensure participants' responses addressed my research questions. In this way I was able to gain a rich and in-depth understanding of participants' experiences of curriculum innovating in environment and sustainability education, their experiences of engaging with the professional development, and how this professional development contributed to their capacity for curriculum innovating. Semi-structured interviews allowed me to probe more deeply and to seek clarity on certain issues (Maree, 2009). This resonates with Henning's (2004) view that through interviews, detailed information about a phenomenon can be elicited. A semi-structured interview schedule (see Appendix 8) was used to guide the interview process.

Wilkinson and Birmingham (2003) expand on the advantages and disadvantages of interviews. The following are some of the advantages of interviews:

- It gives the researcher the freedom to add follow-up questions during the interview.
- The researcher is able to 'hear' more than just the 'response' from the participant. The researcher has the opportunity to observe the participant's body language.
- An interview can be an outlet for participants to give their views or vent their feeling and emotions.
- More often than not interviews provide the researcher with useful, rich data for analysis.

The following are some of the disadvantages of interviews:

- An interview can be seen as time-consuming, as time should also be allocated for transcription of the interview.
- Analysing data can prove to be problematic.
- If an interview is not strictly controlled, there may be deviation away from the point of focus.

In my study I was able to overcome the aforementioned disadvantages by allocating sufficient time for the interviews, transcription and analysis of data. The use of a carefully designed semi-structured interview schedule ensured the interviews did not deviate from the central focus of the study. I generated the data personally, and I was always mindful of the critical questions which governed the study, therefore I did not stray from the focus of this work. The main intentions of conducting the individual semi-structured interviews were to triangulate data, and to elucidate and elaborate on responses from participants in their reflective journals.

3.8. Triangulation

"Triangulation is defined as the use of two or more methods of data collection in the study in the attempt to find a single answer for a single purpose" (Cohen *et al*., 2007, p. 141). According to Lichtman (2011, p. 116) triangulation involves various data sources such as reflective journals, interviews and document reviews. Hence through triangulation qualitative research can become more objective (*Ibid*). Creswell (2012) mentions that by triangulating among various data sources, the accuracy of information can be heightened. What this implies is that all the data are mapped at different perspectives and will converge and be analysed to construct a text. Patton (2002) supports the use of triangulation by arguing that triangulation by using multiple methods enhances rigour of a study. Moreover, "triangulation is seen as a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (Creswell & Miller, 2000, p. 126).

A variety of triangulation methods exist. Methodological triangulation encompasses the use of different data collection methods on the same object of study (Cohen *et al.*, 2007; Willis, 2007). There are two types of methodological triangulation, namely, "within methods" triangulation and "between methods" triangulation (Cohen *et al.,* 2007). "Within methods triangulation is when a study is replicated and reliability is being confirmed and between methods triangulation involves the use of more than one method in the study in order to gain validity" (Cohen *et al*., 2007, p. 143). This case study advocated the "between methods" triangulation in its design. This method embraces the "notion of convergence between independent measures of the same objective" (Cohen *et al*., 2007, p. 143). This qualitative

case study made use of multiple data generating methods that served to triangulate the data, thereby answering the research questions, which enhanced the trustworthiness of my study.

3.9. Data generation methods fit for purpose

Table three presents a summary of the methods that were used to generate data and the justification for each method as it relates to each critical question.

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

Data Generating Method	Purpose	Research Question	Justification for Method
Journaling	Life Sciences/Natural Sciences teachers reflected on their experiences of innovating in environment and sustainability education. The purpose was for practicing Life Sciences and Natural Sciences teachers to introspect on their experiences of engaging with a professional development module and their experiences of curriculum innovating in environment and sustainability education	Research questions 3.1; 3.2 & 4	"...means of enabling teachers to conceptualize the nature of their own professional development ..." (Moon, 2001, p. 368).
Photo Narrative	Life Sciences and Natural Sciences teachers photographed moments of curriculum innovation in their lessons. These photographs were accompanied by narrative descriptions. This provided data on the factors that enabled teachers to be innovative in their lessons together with the types of innovative teaching strategies used in their lessons.	Research questions 3.1, 3.2 & 4	"...method by which people create photographs as a means of catalysing personal change" (Wang, Yi, Tao, Carovano, 1998, p. 75).

Individual Interviews	Individual face to face interviews were conducted with 10 Life Sciences/Natural Sciences teachers about their experiences on curriculum innovating in environment and sustainability education. These interviews focused on whether professional development related to innovating in environment and sustainability education was offered in the Honours degree, how these teachers enacted the curriculum after engaging in professional development activities, the types of strategies used when innovating in environment and sustainability education and the factors that were conducive or obstructive to curriculum innovating.	Research questions 1; 2; 3.1; 3.2 & 4	"...logical gaps in data can be anticipated and closed" (Cohen *et al*., 2007, p. 353).
Document Analysis	The module outlines for the Bachelor of Education Honours programme were analysed to gain insight into what professional development in innovating in environment and sustainability education was being incorporated. In addition analysis of participants' portfolios containing a unit of learning in environment and sustainability education lesson plans, professional biography of teacher and context of schools, was done. These portfolios were developed as part of the assessment programme in one Honours module.	Research question 1; 2, 3.1. & 3.2.	"...it focuses on language and linguistic features, meaning in context, is systematic and verifiable (e.g., in its use of codes and categories" (Cohen *et al*., 2007, p. 475).

3.10. Pilot study

Robson (2002) describes a pilot study as the version which precedes the actual research, and is useful to determine the feasibility of the research. A pilot study helps in determining whether the data generating tools measure what is purposed to be measured, and thereby enhances validity. A pilot study is a small scale study, in which research instruments and methods can be tested (van Teijlingen & Hundley, 2002).

A pilot study was conducted in the year 2014 with five practicing Life Sciences/Natural Sciences teachers who were part of the Science and Mathematics Honours in Education programme at the university where my study was located. The pilot study enabled me to amend questions in the individual interview and reflective journal schedules. In addition, administering a pilot study enabled me to eliminate equivocal questions and refine questions to acquire in-depth data and understanding of each participant. The culmination of the pilot study in 2014 revealed that participants misunderstood two questions in the individual interview schedule, and one question in the reflective journal schedule. A question asking participants if they were able to identify the need to for innovation was included in my initial individual interview schedule. The question was, *Were you able to identify the need for innovation in environment and sustainability education?* The pilot study revealed that participants displayed a sense of confusion in answering this question. The question was revised into three parts. The revised question was, *Were you able to identify the need for innovation in environment and sustainability education? Is innovating a curriculum policy requirement? Do you have to be innovative when teaching this content or can you teach it in a traditional manner?* These modified questions enabled me to elicit responses from the participants which were richer and in depth. Another question from the individual interview schedule asked participants to provide responses regarding a transformation or change they had undergone with respect to their teaching. The question was, *Did your current teaching practice of environment and sustainability education change after you studied the curriculum development Honours module? Please explain.* This question was vague and I was not able to extract deep responses from participants and an additional question had to be added, to elicit deeper responses from participants. The question added was, *Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?* By adding these questions participants were asked to delve deeper into their experiences and thus offer rich responses.

While administering pilot study participants revealed misunderstanding regarding a question from the initial reflective journal schedule. The question asked participants about the change or transformation that they had experienced. The question was, *Did the professional development bring about any change/transformation in your teaching of environment and sustainability education?* The pilot study revealed that participants gave very vague and superficial answers to this question. An additional part to the question was included. The revised question was, *Did the professional development bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.* The modified question enabled me to solicit deeper responses from participants.

3.11. Data analysis

Data analysis refers to the meaning-making from data sets (Merriam, 1998). Ezzy (2002, p. 83) defines data analysis as "reviewing each unit of analysis and categorising it according to the predefined categories". The data in my study was analysed using qualitative data analysis.

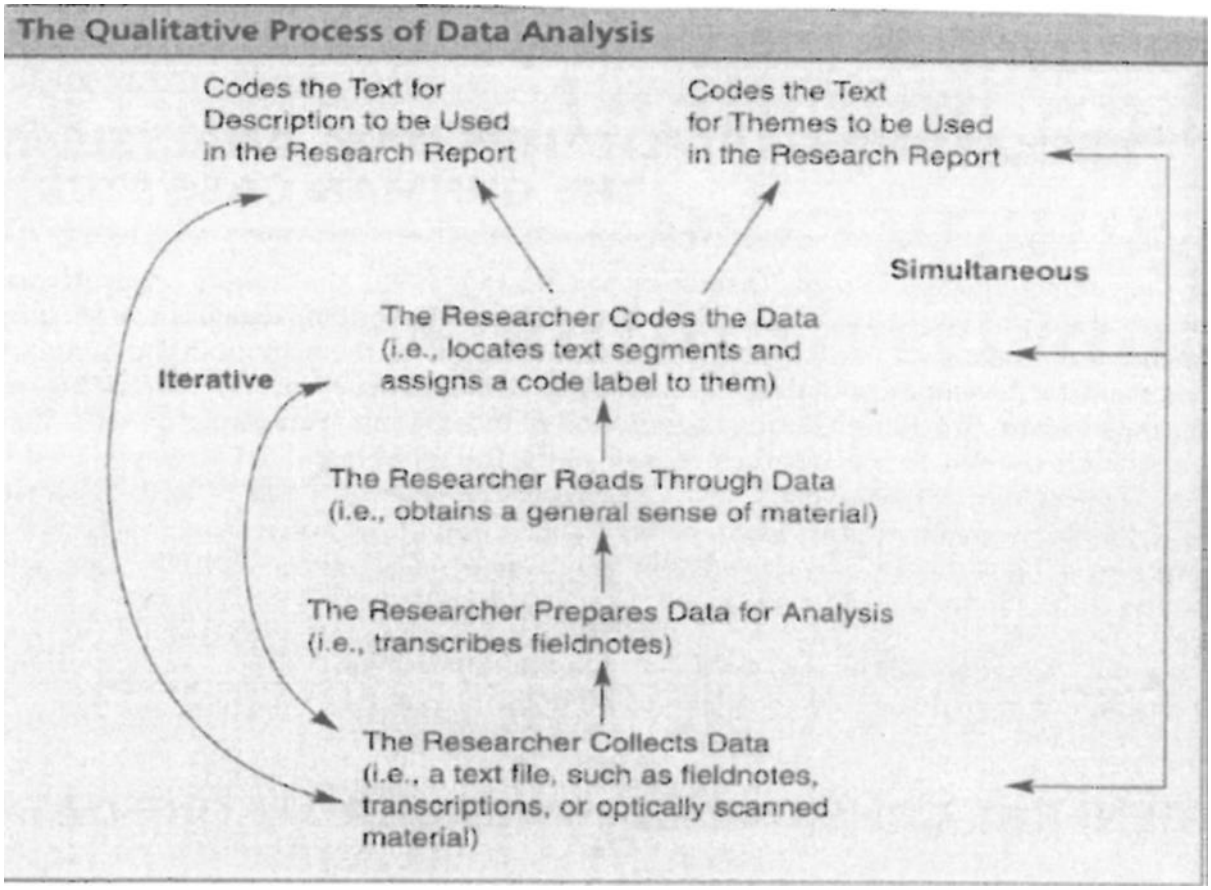


Figure 13 - Diagrammatic representation of data analysis (adapted from Creswell, 2012, p. 137).

Figure 13 reveals that the analysis of qualitative data is not a linear, but is a cyclic process. This concurs with Siedel's (1998) assertion that qualitative data analysis is not merely a process of noticing, collecting and thinking about things, but it is a process that follows particular characteristics. Firstly, the process is iterative and progressive because it is a cycle that is continuous. Secondly, it is recursive because one part can refer the researcher back to a previous part. Thirdly, the process of qualitative data analysis is holographic because each step in the process encompasses the entire process. In my study, as I analysed data from the interviews with participants I began to notice new trends and patterns that appeared in the reflective journals, making the process iterative and progressive. When I had analysed the photo narratives, my thought reverted to what participants had written in their reflective journals, and I was able to find a convergence between the two. In this way my analysis was recursive. As I read through the reflective journals of participants I made notes of possible questions that I could include in the interviews, thus making my data analysis holographic.

The data generated through individual interviews were analysed by listening to audio-recorded interviews. Each interview was transcribed verbatim and transcripts were developed. Thereafter each interview transcript was read and re-read several times. This enabled me to immerse myself in the details in order to gain a deep understanding of each participant (De Vos, 2004). Furthermore, the reflective journals and photo narratives were read and re-read to get a "sense of the participants as a whole before breaking it into parts" (De Vos, 2004, p. 343).

In my study I employed content analysis. Content analysis can be described as "an approach to documents that emphasises the role of the investigator in the construction of the meaning of and in texts. There is an emphasis on allowing categories to emerge out of the data and on recognising the significance for understanding the meaning of the context in which an item being analysed (and the categories derived from it) appeared" (Bryman, 2004, p.542). According to Ezzy (2002) content analysis involves the organisation of the data into categories. In my study coding was used to categorise the data that was collected from the reflective journals, individual interviews, photo narratives and lesson plan of participants. "Coding is the process of identifying themes or concepts that are in the data" (Ezzy, 2002, p. 86). De Vos (2002, p. 344) mentions that the process of coding "involves noting regularities in the setting or people chosen for the study".

There are three types of coding: open coding, axial coding and selective coding. De Vos (2002, pp.345-346) describes these three types:

- Open coding: "the process of breaking down, examining, comparing, conceptualising and characterising data",
- Axial coding: "a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories, utilising a code paradigm involving conditions, context, action or interactional strategies and consequences", and
- Selective coding: "the process of selecting the core category, systematically relating it to other categories, validating those relationships and filling in categories that need further refinement and development".

These three types of coding were used in my study. (De Vos, 2002).

Firstly, I observed consistencies, and codes that emerged inductively from the data. Open coding was used where I assigned a term or phrase that describes the meaning of the text or segment (Nieuwenhuis, 2012). I searched for those that have "internal convergence and external divergence" thus each code was consistent but distinct from one another (De Vos, 2004, p. 344).

Secondly, following rigorous, systemic, repetitive reading and coding of transcripts, key themes were developed. Transcripts were also read "horizontally, which involved grouping segments of text by theme" (Marshall, 1999, p. 165). Major themes were condensed into sub-themes so that they would be convenient to analyse. For example, *the theme of the challenges experienced by practicing science teachers when they taught environment and sustainability education (before engaging with Curriculum Development in Science and Mathematics education module)* was divided into two sub-themes namely, *professional challenges*; and *contextual challenges*.

Finally, I interpreted and deepened my understanding of the data (De Vos, 2002). The data were engaged with critically and links within the data were established. During interpretation "researchers step back and form larger opinions of what is going on in the situation" (*Ibid*). Diverse explanations of Life Sciences and Natural Sciences teachers' experiences and views of curriculum innovating in environment and sustainability education were analysed. Participants' capacity to innovate, after engaging with effective professional development, was also analysed. This analysis brought about the demonstration of the most credible explanations of the factors that were obstructive or conducive to participants being able to engage in curriculum innovating. It also demonstrated the direct consequence of effective professional development on the participants' individual capacity to innovate.

3.12. Rigor of the research

Measures to ensure Trustworthiness

According to Lincoln and Guba (1985) central to trustworthiness is the ability to convince oneself and the readers of one's work that the findings are significant. The credibility, transferability, dependability and confirmability of a qualitative study determine the meticulousness of the research (Cohen *et al.*, 2007; Lincoln & Guba, 1985).

Credibility

Credibility deals with "the question of how research findings match reality…How congruent are the findings with reality" (Merriam, 1998, p. 201). The credibility of the findings of this study was enhanced by the triangulation of data. Multiple data collection methods were used to enhance credibility. Cohen *et al.* (2011) add that a study incorporating two or more methods of data collection displays triangulation. Prior to the study being conducted I engaged with module outlines of the Honours programme that increased familiarity with the culture of the participants (Shenton, 2004). To enhance credibility in this study member checks were used, as supported by Lincoln and Guba (1985) and Shenton (2004). Participants were given the opportunity to read individual interview transcripts to ensure data was captured correctly. The credibility of this study was further enhanced as I engaged in frequent debriefing sessions with my supervisor (Shenton, 2004). This afforded me the opportunity to clarify any misconceptions that arose during the study. By including anonymous copies of individual interview transcripts and reflective journals (see Appendix 10 and 11) reference adequacy was adhered to (Lincoln & Guba, 1985).

Transferability

Merriam (1998, p. 207) describes transferability as "the extent to which the findings of one study can be applied to other situations (contexts)". This study did not aim to generalise that effective teaching of environment and sustainability education can only be accomplished through curriculum innovating. Notwithstanding, Shenton (2004, p. 69) cautions that "since the findings of a qualitative project are specific to a small number of particular environments and individuals, it is impossible to demonstrate that the findings and conclusions are applicable to other situations and populations". Shenton (2004) and Gobo (2009) argue that readers must determine for themselves the degree to which the results and conclusions of a qualitative study apply to their current context. This is further supported by Seale's (1999, p. 468) argument that "transferability is achieved by providing a detailed, rich description of the settings studied to provide the reader with sufficient information to be able to judge the applicability of the findings to other settings that they know". In my study, rich descriptions of the context and research design were provided to enhance transferability.

Dependability

Gasson (2004, p. 94) states that dependability "deals with the way in which a study is conducted should be consistent across time, researchers and analysis techniques".

Dependability is achieved through the researcher detailing the research design and process so that potential researchers can follow a similar framework. This contention is supported by Shenton's (2004, p. 71) view that "the processes within the study should be reported in detail, thereby enabling a future researcher to repeat the work, if not necessarily to gain the same result". Likewise, in addition to documentation of the research processes, the use of triangulation can further enhance a study's dependability (Lincoln & Guba, 1985). In my study, I ensured that detailed accounts were provided about the context, methods and methodology, sampling strategies and considerations related to analysis.

Confirmability

Tobin and Begley (2004, p. 392) explain confirmability to be "concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but are clearly derived from the data". Shenton (2004) highlights the use of an audit trail to enhance the confirmability of a study. My audit trail consisted of primary findings derived from a pilot study and the subsequent development of themes and sub-themes related to participants engaging curriculum innovating in environment and sustainability education. In addition, I presented my findings to my supervisor and to critical academic audiences to ensure rigour of interpretation of data. The modified triangulation of data proved a corroborative instrument, according to Lincoln and Guba (1985), is crucial in confirmability.

3.13. Ethical issues

Merriam (1998) mentions that there are ethical quandaries that arise with regard to the collection of data and in the dissemination of findings, in qualitative studies. She adds that crucial to both the generation of data and the dissemination of findings, is the relationship between the researcher and the participant. "For example, this relationship and the research purpose determine how much the researcher reveals about the actual purpose of the study, how informed the consent can actually be and how much privacy and protection from harm is afforded the participants" (Merriam, 1998, p. 213). According to Resnik (2015) the code of ethics supplies the participants with details about what is intended to be done with the information that is given and it shows the intention to treat both the participants and the information with respect and honesty. Sikes (2004) emphasises that ethical issues apply throughout the research process and no research can be put into practice without a careful

consideration of ethical issues. There were a number of ethical issues that were taken into consideration during this research.

Gatekeeper permission

When conducting research in an educational setting gatekeeper permission to the research site is compulsory (Wiersma and Jurs, 2009). A formal application was approved by the Human and Social Sciences Ethics Committee of the university where I had registered for my degree (see Appendix 1). A letter was written to the Head of the School of Education and the Cluster Leader of the Science Education department to grant permission for the research (see Appendix 2 and 3). Permission was also obtained from principals of the schools where the participants worked (see Appendix 5).

Informed consent from participants

Informed consent refers to a decision made to participate in a particular activity after full evidence regarding the purpose and process, which may influence the decision itself, which is given to the deciding participant (Cohen *et al*., 2007). Informed consent was attained from each Life Sciences/Natural Sciences teacher participant in writing with a clear indication that they could at any stage request withdrawal from the research (see Appendix 4). Permission for this study was sought from the principals of the schools (see Appendix 5). Participants were informed at the outset that participation in this study was voluntary.

Privacy and confidentiality (Protection from harm)

Christians (2005, p. 144) argues that the "code of ethics insist on safeguards to protect people's identities and those of the research locations". Welman, Kruger, and Mitchell (2005) mention that participants should be assured that they will be protected from physical or psychological harm. Anonymity and confidentiality was assured in letters of informed consent. Pseudonyms were used in the write up of this study. All responses were treated in a confidential manner. The participants were not exposed to questions which were traumatic or offensive, or to procedures which might have had an unpleasant or harmful side effect.

Accuracy

"Ensuring that data are accurate is a cardinal principle in research" (Christians, 2005, p. 145). Fabricating data, the use of fraudulent materials, omitting information and contrivance is regarded as unethical and non-scientific (*ibid*). In this study all data that was obtained and

presented was done without fabrications or omissions and is a reflection of true data. Verbatim quotes were used in the write up of the study.

Data use and disposal

Participants and gatekeepers were assured, in writing, that the findings of the research would not be used for any other purpose, other than for the Doctoral dissertation and scholarly publications. They were also informed that the data would be stored for five years at the university and thereafter disposed of. Interview transcripts, reflections and photographs would be shredded and audio tapes would be incinerated.

3.14 Limitations of the study

The study of a single lesson being taught over a short period of time is a limitation in itself. This was addressed by making use of reflective journals and individual interviews which allowed Life Sciences and Natural Sciences teachers the opportunity to introspect on their experiences and challenges of curriculum innovating in environment and sustainability education. Another limitation was that participants had initially agreed to be a part of the study, but then rescinded their participation. This resulted in me having to solicit other willing participants. This study privileged one module in the tertiary education institution and the findings are context specific.

3.15. Conclusion

In this chapter I described and discussed the qualitative research methodology that I selected for this study. This chapter elaborated on the data generation instruments and methods that were selected which were in alignment with the fundamentals of a qualitative research approach. The critical paradigm, case study approach and design for the study were discussed together with an explanation and rationale for my choices. The measures to ensure trustworthiness of the gathered data were elaborated and explained, with the chapter drawing to a conclusion with a discussion of the ethical considerations and limitations of the study. The next chapter will focus on the presentation and analysis of data and major findings which emerged from the study.

CHAPTER 4

Data Presentation and Analysis

CONTENTS **PAGE**

4.1. Introduction 93

4.2. Data analysis and presentation of findings 93

4.3. **Research question one** 96

4.3.1 Theme one: Lack of content related innovation in environment and sustainability education in the Science and Mathematics Honours degree 98

4.3.2 Theme two: A call for more innovation in environment and sustainability education to be included in the Science and Mathematics Honours degree 100

4.4 **Research question two** 102

4.4.1. Theme one: Professional challenges 103

4.4.2. Theme two: Contextual challenges 107

4.5. **Research question 3** 114

4.5.1. **Research question 3.1.** 114

4.5.1.1. Theme one: Teaching strategies used by participants when innovating in environment and sustainability education 114

4.5.1.2. Theme two: Assessment strategies used by participants when innovating in environment and sustainability education 119

4.5.2. **Research question 3.2.** 121

4.5.2.1. Theme one: Teachers' enablement through the Honours professional development programme 121

4.5.2.2. Theme two: Enhanced teacher motivation based on improved learner responses and performance 126
4.5.2.3. Theme three: Deeper teacher understanding of the benefits of technology to enhance curriculum implementation 135
4.5.2.4. Theme four: School-based factors that enabled curriculum innovating in environment and sustainability education 141
4.6. **Research question four** 145
4.6.1. Theme one: School-based factors that restricted curriculum innovating in environment and sustainability education 145
4.6.2. Theme two: Overcoming challenges: Creating spaces for innovating 153
4.7. Conclusion 163

4.1. Introduction

In this chapter the qualitative data generated through individual interviews, reflective journals, document analysis and photo narratives are analysed and presented. In order to explore how science teachers who studied towards an Honours qualification engaged in curriculum innovating in environment and sustainability education, responses that are related to the research questions are analysed.

4.2. Data analysis and presentation of findings

In order to provide a rich description of how science teachers engaged in curriculum innovating in environment and sustainability education, the data was analysed inductively and themes were derived. Direct quotations from science teachers' responses are presented in verification of the emerging themes. The literature review and associated theoretical constructs are presented in support of the emerging themes. The classification of the themes according to the specific research questions follows. Research question one is: *What professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution?* The themes which emerged are:

- Lack of content related to innovation in environment and sustainability education in the Science and Mathematics Honours degree.
- A call for more content about innovation in environment and sustainability education in the Science and Mathematics Honours degree.

Two themes emerged based on research question two, which is: *What challenges did teachers encounter when working with environment and sustainability education before they engaged with the professional development programme at the higher education institution and did teachers display a transformation in their teaching after engaging with the professional development module?* The themes are:

- Professional challenges.
- Contextual challenges.

Research question two has been included in this study for the following fundamental reasons. First, to enhance understanding that professional development is not a panacea to inadequate teacher knowledge. Second, to emphasise that the reasons for scheduling teacher professional development must be substantive. Third, to emphasise that teacher attendance to professional development programmes for the sake of compliance is usually ineffective. Lastly to provide insight into teachers' valuing of professional development.

For research question three, *How do science teachers who have engaged in professional development activities enact the curriculum by innovating environment and sustainability education*, there two sub-questions.

Three themes emerged based on research sub-question 3.1, which is: *What types of strategies do science teachers use when innovating in environment and sustainability education?* The themes are:

- Teaching strategies used by participants when innovating in environment and sustainability education.
- Assessment strategies used by participants when innovating in environment and sustainability education.

Four themes emerged based on research sub-question 3.2, which is: *Why do science teachers choose to use these strategies?* The themes are:

- Teachers' enablement through the Honours professional development programme.
- Enhanced teacher motivation based on improved learner responses and performance.
- Deeper teacher understanding of the benefits of technology to enhance curriculum implementation.
- School-based factors that enabled curriculum innovating in environment and sustainability education.

Three themes emerged based on research question four, which is: *What factors are obstructive to curriculum innovating in environment and sustainability education? How do science teachers respond to these factors?* The themes are:

- School-based factors that restricted curriculum innovating in environment and sustainability education.
- Overcoming challenges: Creating spaces for innovating.

- Effective professional development: Creating progressive teachers through the Zone of Feasible Innovation.

The table below provides a summary of the research questions and the themes related to each question.

Table 4: Summary of research questions and themes

Research Questions	Emerging Themes
Research question one: What professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution?	• Lack of content related to innovation in environment and sustainability education in the Science and Mathematics Honours degree. • A call for more content about innovation in environment and sustainability education in the Science and Mathematics Honours degree.
Research question two: What challenges did teachers encounter when working with environment and sustainability education before they engaged with the professional development programme at the higher education institution and did teachers display a transformation in their teaching after engaging with the professional development programme?	• Professional challenges • Contextual challenges
Research question three: How do science teachers who have engaged in professional development activities enact the curriculum by innovating environment and sustainability education?	
Research sub-question 3.1: What types of strategies do science teachers use when	• Teaching strategies used by participants when innovating in environment and

innovating in environment and sustainability education?	sustainability education • Assessment strategies used by participants when innovating in environment and sustainability education
Research sub-question 3.2: Why do science teachers choose to use these strategies?	• Teachers' self-perception as drivers of innovative teaching in environment and sustainability education • Deeper teacher understanding of benefits of technology to enhance curriculum implementation • Factors that enabled curriculum innovating in environment and sustainability education
Research question four: What factors are obstructive to curriculum innovating in environment and sustainability education? How do science teachers respond to these factors?	• Factors that restricted curriculum innovating in environment and sustainability education • Overcoming challenges: Creating spaces for innovating • Effective professional development: Creating progressive teachers through the Zone of Feasible Innovation

Analysis of data

4.3. Research question 1: What professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution?

Data which emerged from the analysis of documents and teacher interviews are presented in lieu of question one.

The Science and Mathematics Honours programme comprises five specialisation modules which are:

- Teaching and learning in Science and Mathematics education 1
- Teaching and learning in Science and Mathematics education 2
- Assessment in Science and Mathematics education
- Issues in Science and Mathematics education
- Curriculum development in Science and Mathematics education

A document analysis of the module outlines for *Teaching and learning in Science and Mathematics education 1* and *Teaching and learning in Science and Mathematics education 2* revealed that science teachers are educated on learning theories, classroom environment, effective practices, practical work, communication and problem solving. The module *Assessment in Science and Mathematics education* emphasised the fundamental criteria underpinning assessment, various methods of assessment and the basics of statistics. The module *Issues in Science and Mathematics education* presented science teachers with concepts on the nature of Science and Mathematics, as well as indigenous knowledge systems, and controversial matters surrounding Science and Mathematics such as evolution and cloning.

The *Curriculum Development in Science and Mathematics Education* module was designed to enable students to critically reflect on their beliefs and practices. These skills were envisaged to enhance their capacity to problematize and critically address relevant issues in education and improve their professional and academic practice. A common purpose of all these modules was to ensure that the teachers of Science and Mathematics are able to carry out research competently and to contribute to the ongoing development of this field of study.

Document Analysis of modules revealed that innovation formed part of one module, namely, *Curriculum Development in Science and Mathematics Education*. This module aimed to educate science teachers on the approaches, implementation, evaluation, aims and purposes of curriculum development in Science and Mathematics education. This module was the focus of this study as innovation formed part of it.

The analysis of the module outlines provided a foundation for the entire process of data analysis. The analysis will now focus on the data generated through the interviews, reflective journals, photo-narratives and lesson plans.

The following abbreviations will be used to distinguish data from each participant (science teacher:

- Participant 1 – P1
- Participant 2 – P2
- Participant 3 – P3
- Participant 4 – P4
- Participant 5 – P5
- Participant 6 – P6
- Participant 7 – P7
- Participant 8 – P8
- Participant 9 – P9
- Participant 10 – P10

Views from the ten science teacher participants were solicited using individual interviews (II), reflective journals (RJ) and photo-narratives (PN).

Science teachers expressed two views regarding the professional development related to innovating in environment and sustainability education being offered as they studied towards their Honours degree.

These two themes are discussed below.

4.3.1. Theme 1: Lack of content related to innovation in environment and sustainability education in the Science and Mathematics Honours degree.

All 10 of the participants indicated that there was a lack of content related to innovation in environment and sustainability education in the Science and Mathematics Honours in Education degree.

All of responses from the participants clearly indicated that innovation in environment and sustainability education was only present in one module of their Honours degree. All responses from participants showed that they would have preferred content and pedagogy topics related to innovating in environment and sustainability education to have been included in all the modules of the Science and Mathematics Honours qualification. This indicated that participants believed that the professional development related to knowledge

about innovating in environment and sustainability education that they had received was insufficient, and this had a deleterious effect on their teaching.

A review of the CAPS document for both Natural Sciences and Life Sciences indicated that the words *innovating* or *innovation* do not appear. The word creativity, which is closely associated with innovation or innovating, appears only once. This indicates that the CAPS curriculum appears to aim to engage teachers as technicians in the classroom rather than as innovators of curriculum. It is possible that because this Honours professional development programme, to some extent trains teachers to teach to the CAPS curriculum, a lack of content related to innovating in the CAPS curriculum is echoed in the content and design of the Honours professional development programme.

The following views emerged from the analysis of individual interviews:

> *We only did innovation in one module…curriculum development.* (P2 – II)

> *In the Honours degree we had to complete five modules for Science and Mathematics, out of those five modules only one module included innovating.* (P6 – II)

The following journal entries further reinforced the individual interview responses:

> *Only one module included innovation, which I feel was not enough.* (P2 – RJ – Oct 2015)

> *In the Honours programme only the curriculum development module incorporated innovation… I am not sure if it was by choice.* (P3 –RJ – Nov 2015)

Each of the 10 participants indicated innovation in environment and sustainability education was part of only one module. From the preceding responses it is evident that participants believe that the science cluster (faculty) at the university determines what content should be included or excluded in the modules. This resonates with Odora Hoppers' (2001) findings that tertiary institutions exercise their power to add or subtract whatever content they choose regardless of the effect it might have on the student.

The following view arose from the individual interview:

> *Maybe they could have included innovation in another module.* (P1 – II)

The following journal entry affirmed the above response:

> *I think there needs to be a review of the course because the university is not helping us by only including innovation only in the one module…* (P8 – RJ – Oct 2015)

Participants viewed the dearth of content and pedagogy related to innovation in environment and sustainability as critical and placed some of the responsibility for this on the university which offers the professional development programme. This articulates with Frost's (2012) assertion that professional development can be perceived as the engine that drives innovation.

4.3.2. Theme 2: A call for more innovation in environment and sustainability education to be included in the Science and Mathematics Honours degree.

The responses of all participants indicated that there should be more content and pedagogy related to innovation in environment and sustainability in the Honours degree. The following views emerged from the individual interviews:

> *Like we did Teaching and Learning 2, where we did practical work maybe innovation should have been included.* (P1 – II)

> *Learning about innovation was helpful to me but it would have been more beneficial to learn about it in more modules…* (P6 – II)

The following journal entries affirmed the above responses:

> *I would have liked to learn about innovation in other modules because it is really useful in teaching science.* (P1 – RJ – Aug 2015)

> *But if innovation was in other modules it would help my teaching as I would be more exposed to innovation and I could then gain knowledge and skills to be a more effective science teacher.* (P6 – RJ – Sept 2015)

The preceding responses indicated that participants had a vision of how innovation could have been included in other modules of the Honours programme. It is apparent that there was space available for innovation in the practical work aspect of science education. This resonates with Millar's (2009) assertion that a majority of science teachers view practical work as the most productive area for learning to occur because learners have direct experiences of scientific phenomena when they do practical work. This enhanced space for learning that practical work creates can be filled with innovative practical tasks and activities

that participants could be engaged with during other modules of this professional development programme.

The responses of participants indicated that they perceived knowledge and skills related to innovation in the teaching and learning of science as being necessary. This resonates with the assertion by Ferrari *et al.* (2009) that innovation must not only be viewed as an opportunity, but it must be seen as a necessity. Kärkkäinen (2012) provides a more holistic view on the need for innovation because he states that in order to improve the quality of education, entire education systems need to become more innovative. Participants in this study expressed the view that the science cluster at the university should review the modules that do not include innovation.

The following views emerged from individual interviews:

> *Maybe they must review the modules and include innovation. I did write that in my module evaluation.* (P7 – II)

The preceding views were supported by journal entries. The following excerpt attests to this:

> *After going through all the modules I feel that maybe the lecturers must change the course next year, innovation should be in more modules. I stated that on the module evaluation.* (P7 – RJ – Nov 2015)

A majority of participants expressed the view that the B.Ed Honours programme should be reviewed, with a view to revision. The responses of many participants reflected a call for the inclusion of more content and pedagogical knowledge related to innovation in other Honours modules. This call was expressed in both data sets, the individual interview transcripts as well as the reflective journals, and indicated that it was a strong view that participants possessed. The preceding responses highlight the importance of student feedback or evaluation of modules for improving the professional development programme. This resonates with Jara's and Mellar's (2010, p.709) assertion that "the collection of student feedback is seen as a central strategy to monitor the quality and standards of teaching and learning in higher education institutions".

Participants also regarded their personal involvement, in the development of the modules as important. This adds credence to the contention by Ferrari *et al.* (2009) that the teacher is the fundamental element in educational innovation. Participants viewed the modules as useful to

their teaching but a majority indicated the need for more content and pedagogy related to innovation in the Honours degree.

4.4. Research Question 2: What challenges did teachers encounter when working with environment and sustainability education before they engaged with the professional development module at the higher education institution and did teachers display a transformation in their teaching after engaging with the professional development programme?

In responding to this question, two themes emerged from the analysis of data. The first is the professional challenges which had been experienced by science teachers when they taught environment and sustainability education, before they had studied the Curriculum Development in Science and Mathematics education module. The second theme relates to the contextual challenges which had been experienced by science teachers when they taught environment and sustainability education, before they had studied the Curriculum Development in Science and Mathematics education module.

The challenges experienced by participants will be explored according to the following sub-themes illustrated in Table four:

Table 5: Challenges prior to engaging in the Honours professional development module experienced by science teachers when they taught environment and sustainability education

A tick indicates that the participant experienced that theme as a challenge.

A cross indicates that the participant did not experience that theme as a challenge.

THEME1 – Professional challenges	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Lack of knowledge and skills related to teaching strategies/methods to innovate when teaching environment and sustainability education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ineffective professional development regarding innovation in science teaching	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
THEME 2 – Contextual challenges										
Lack of support from school management	X	✓	X	X	X	X	X	X	✓	✓

and other stakeholders										
Lack of resources in school	X	✓	X	X	X	✓	X	X	✓	✓

Table five, which illustrates data generated from individual interviews with participants and reflective journals written by participants reveals that all participants experienced some form of challenge, which included the inability to use apposite teaching strategies/methods to innovate when teaching environment and sustainability education. All participants also declared that professional development in four out of five modules of the Honours programme was inadequate, with regards to content related to innovation. Participants two, nine and ten expressed a lack of support from school management as a challenge, and participants two, six, nine and ten all indicated a lack of resources in school as a challenge.

The challenges experienced by participants will be examined according to the following themes:

- Professional challenges:
  - Lack of knowledge and skills related to teaching strategies/methods to innovate when teaching environment and sustainability education
  - Ineffective school-based professional development related to innovation in science teaching
- Contextual challenges:
  - Lack of support from school management
  - Lack of resources in school

4.4.1. Theme 1: Professional challenges:

Lack of knowledge and skills related to teaching strategies/methods to innovate when teaching environment and sustainability education

All participants revealed that prior to their engagement with the Honours module, they did not have sufficient knowledge of teaching strategies or methods of how to innovate when teaching environment and sustainability education.

The following views emerged from the individual interviews:

Before the Honours module I was not confident of teaching environment and sustainability education because I did not know how… (P1 – II)

Environmental education is hard to understand for me even as a teacher… I was not sure how to explain it to learners. (P3 – II)

Teaching it was really challenging because the textbooks were not clear… they have examples that are hard for learners to relate to… (P7 – II)

I was not confident teaching environment and sustainability education to learners because I did not have any method to make it easy for them. (P9 – II)

The subsequent journal entries affirmed the preceding responses:

I did not know how to teach EE before the professional development… (P1 – RJ – Aug 2015)

Previously I rushed through the section on environment and sustainability education just to get through it… (P9 – RJ – Oct 2015)

To teach it (environmental education) is hard, I struggled to find a method that simplified the concepts for learners to understand… (P10 – RJ – Oct 2015)

The responses of participants revealed an indirect awareness that they did not possess the capacity to innovate before the professional development module. It was apparent from the preceding responses that participants found it challenging to teach environment and sustainability education.

Their views indicated that they struggled to find innovative methods and strategies to teach content to learners. This resonates with the view of Dreyer and Loubser (2014) who assert that there have been efforts to integrate environmental education in the formal school curriculum, but there exists a lack of clarity regarding how environmental education can be implemented in the formal school curriculum. The present participants expressed views that indicated an uncertainty of how to teach environment and sustainability education. However, it is also evident from their responses that they were aware of the need for alternative methods to teach environment and sustainability education. This concurs with McFarlane's (2013) assertion that teachers must broaden their horizons to new knowledge that is more relevant than previous knowledge, which they may have perceived as fixed. He adds that

science teachers must understand that some practices and knowledge can become obsolete and must be replaced with new practices and knowledge.

Ineffective professional development

Analysis of the individual interviews and reflective journals of participants revealed that all participants believed that some of the professional development programmes which were offered by the DBE were ineffective.

The following views expressing ineffective school-based professional development emerged in the individual interviews:

> *I have been for once-off workshops that are really not worth my time…* (P2 – II)
>
> *Many workshops I have been for never start on time and the facilitator just reads the CAPS document to us.* (P4 – II)
>
> *I've been for the workshop but I got nothing on how to teach concepts…* (P5 – II)
>
> *Going for workshops are sometimes a waste of my time because I lose out on teaching time and don't even gain anything useful…* (P8 – II)

The following reflective journal entries further reinforced the preceding individual interview responses:

> *Once-off workshops never gave me anything to help me to teach… they just read through the CAPS document.* (P4 – RJ – Oct 2015)
>
> *I think that professional development needs to be more effective…* (P5 – RJ – Nov 2015)

Responses from some participants provided evidence that certain school-based professional development workshops which had been conducted by the DBE were ineffective. Participants revealed that these single workshops in isolation did not in any way increase their knowledge of how to teach environment and sustainability education. This resonates with the assertion by O'Sullivan et al. (n.d) that effective professional development is not a single occurrence. They add that learning requires time and that deep learning cannot be the result of short-term programmes. A majority of participants further revealed that these ineffective single workshops were also time consuming and utilized their teaching time. This correlates with

the assertion by Reddy, Prinsloo, Netshitangani, Moletsane, Juan and Janse van Rensburg (2010) that a large degree of teacher absence from school is due to teachers attending meetings and/or workshops during the time that is intended for teaching. "Curriculum workshops and other training by the various offices of the Department of Education were rated as the main reason for teacher leave taking" (Reddy et al., 2010, p.77). These authors provide a solution to remedy this issue by proposing that these types of activities should be conducted outside of school time if they are deemed necessary (*ibid*).

The following journal entries expressed the ineffective nature of the one-off workshops:

> *Just going for 2 hours for a workshop can't really help me to be a better teacher, all it does is gives me more work when I get back to school to catch up syllabus. If I learnt something useful then I would not mind…* (P9 – RJ – Oct 2015)

> *The workshops never taught me anything and I lost out on time to teach… I asked my Head of Department (HOD) not to ask me to go for the next workshop because I lose out on time to teach as well.* (P10 – RJ – Oct 2015)

The preceding journal entries resonate with Gulamhussein's (2013, p.1) assertion that "the real issue isn't that teachers aren't provided professional development, but that the typical offerings are ineffective at changing teachers' practice and student learning". A majority of participants expressed their frustration about the teaching time lost due to their attendance at ineffective workshops. They viewed attendance at these professional development workshops as a "waste of time". This concurs with the argument by Lessing and de Witt (2007) that the view teachers have of professional development plays a vital role in their willingness to engage in professional development programmes. They add that teachers must view professional development as something worthy of their time and effort because they make sacrifices to attend these programmes. This correlates with Gulamhussein's (2013) contention that the biggest cost for developers of programmes on professional development is purchasing the time of teachers. The preceding responses clearly indicate reluctance from participants to attend further professional development workshops due to their ineffective nature and the inherent loss of valuable teaching time.

4.4.2. Theme 2: Contextual challenges:

Contextual factors included unsupportive school management and a shortage of resources.

Lack of support from school management and other stakeholders

Three out of ten participants indicated that the inadequate support they received from the management in their respective schools presented them with a challenge to teach environment and sustainability education creatively.

The following views emerged from the individual interviews:

> *My HOD doesn't like young teachers giving ideas or new ways to teach so I am reluctant to ask questions or give suggestions.* (P2 – II)
>
> *My HOD is not very approachable he just wants the work to be completed his way… if I could ask for help I would.* (P9 – II)
>
> *The school management is not interested in the way we teach… I would appreciate help.* (P10 –II)

The following journal entries affirmed the preceding responses:

> *…because my HOD is not helpful I just teach it without any help…* (P2 – RJ – Oct 2015)
>
> *It's hard but I don't have support from the management… some help when I am stuck would benefit my teaching.* (P10 – RJ – Oct 2015)

The preceding responses revealed that some participants were teaching environment and sustainability without collaboration with their heads of departments (HODs) or management members in the school. This presented an immense challenge because these participants did not have an expert to guide or monitor their teaching. Dreyer and Loubser (2014) highlight the need for continuous monitoring and support for teachers regarding implementation of curriculum. If the participants are being monitored and supported by HOD's and department subject advisors, then the challenges experienced by them may be addressed. This concurs with the Kirkgöz's (2008) and Tytler's (2007) views that teachers need support and help to adapt and accommodate new strategies and methods into their teaching. It is evident that

participants are not receiving support or monitoring from their HOD's or subject advisors. If this support is lacking then the inspiration to make a change will diminish and so will the innovation (Tytler, 2007). Innovating in their teaching of environment and sustainability education appeared to be absent due to this lack of support. Kärkkäinen (2012) asserts that teachers are sometimes not even aware of the potential for innovation in the curriculum and require support in this regard. Kärkkäinen (2012) calls for support to enable teachers to engage in curriculum innovating, and this study revealed that this support can be given to teachers in the form of effective professional development. This support can come in the form of interaction with a more knowledgeable others, a peer or a subject advisor that can fashion a new level of understanding for a teacher (Donald *et al.*, 2002). Scaffolding of knowledge by a more knowledgeable peer resonates with constructs of the ZPD (Vygotsky, 1978). Stahl (n.d.) extends on Vygotsky's Engagement Theory by stating that this interaction with peers which can occur in a social setting can provide teachers with motivation for acquiring new knowledge. Without this engagement a teacher may not be able to apply new pedagogic content knowledge and new knowledge of teaching and assessment (Stahl, n.d).

The following responses emerged from the reflective journals:

> *I have learnt how to be innovative and I have also identified the need for innovation, but in the school that I am currently teaching there is no room for innovation. The HOD is strict and instructs teachers to teach according to the methods he prescribes. Even if I do want to teach an innovative lesson other teachers are upset as I only did the lesson with my class. So I don't see myself being innovative in the school I am in…* (P9 – RJ – Oct 2015)

> *My school is not functioning, it is declining and majority of the staff do not care. Teachers attend school and walk out without making a difference to learners. I am not allowed to be innovative by the HOD and the staff who believe that our learners are not worth it. I have tried to introduce some innovative methods but with little success… I don't think I will be able to use the knowledge gained in the Honours module…* (P10 – RJ – Oct 2015)

The preceding two responses indicate that some participants have gained valuable knowledge and skills of how to engage in curriculum innovating in environment and sustainability education. This, however useful, did not automatically translate to classroom practice because of the contextual challenges.

Lack of resources in school

The responses from four out of ten participants indicated that they were teaching environment and sustainability education in schools in under-resourced settings. All four of the participants revealed that a shortage of textbooks and unclear explanations in some textbooks intensified the challenge of teaching environment and sustainability education successfully. Two of these four participants highlighted the lack of funds in their school for photocopying of worksheets and other print media as barriers to curriculum innovating.

The following responses alluded to the lack of resources in some of the schools of the participants:

> *At my school we don't have enough textbooks, learners share between 3 sometimes…* (P6 – II)
>
> *We can't run out worksheets for learners due to a lack of funds…* (P9 – II)
>
> *Textbooks are an issue, sometimes the diagrams are wrong or the notes do not make sense.* (P10 – II)

The preceding responses are affirmed by the subsequent journal entries:

> *Teaching without worksheets is difficult because drawing and writing notes is time consuming.* (P6 – RJ – Sept 2015)
>
> *Learners share textbooks so teaching is slow and difficult. One textbook was unclear…* (P9 – RJ – Oct 2015)

Participants were required to photograph moments of curriculum innovating in their lesson as part of a portfolio. This portfolio included the photographs as well as a narrative explanation of the photograph. The photographs are presented, followed by the participants' explanation of the context.

The photographs which follow relate to the challenges associated with the lack of resources.

The following photo narratives affirmed the challenges outlined in the preceding journal entries:

Photograph 1

Learners are forced to arrange themselves in uncomfortable positions in order to get a glimpse of a textbook. This does not help learners with understanding of concepts, but teachers have no option but to arrange learners in this manner to complete the syllabus within the prescribed time allocated by the CAPS document.

Photograph 2

Outdated scientific equipment due to a lack of funding disadvantages learners as they are not able to conduct experiments effectively. This is highlighted when learners are expected to write external exam papers set by the DBE, based on experiments they were required to conduct at their schools. This has implications for the pass rate of learners in science-based subjects.

The preceding responses indicated that some participants were struggling to teach due to a lack of resources in their respective schools. A lack of resources can be a demotivating factor in teachers' capacity building process to support innovative teaching. This concurs with Kirkgöz's (2008) assertion that every school is different and not all schools possess the relevant resources required to develop high quality innovations. The other six participants indicated that they taught in well-resourced schools. The resources available to teachers in schools are a crucial determinant of curriculum innovating because it can motivate or demotivate the teacher.

Participants revealed an acute awareness of the importance of resources for curriculum innovating. This lack of resources that they alluded to was a major hurdle for two of the four

participants (P2, P6, P9, and P10). However, the other two participants (P2 and P6) who also experienced a lack of resources at their schools saw this stumbling block as a stepping stone towards innovation and the following excerpts from interviews attest to this:

> *Even though we are not a well-resourced school, I go out and get my own resources; I borrow, make my own and sometimes even purchase my own resources. (P2 – II)*

> *I am in an under-resourced school but I try to get my own resources. I borrow from other teachers. (P6 – II)*

These participants were not dissuaded by the lack of resources at their school. On the contrary, they demonstrated their increased capacity for innovating by creating their own resources to assist them in teaching environment and sustainability education (e.g., furniture). This correlates with Rogan's and Aldous's (2005) assertion that when teachers engage with outside support (e.g. effective professional development) they will be able to move from their current methods of teaching, through the ZFI and into ideal practices of teaching. These ideal practices of teaching are not necessarily impeded by challenges such as a lack of resources, because the teacher now has the capacity to innovate and finds ways to overcome challenges.

Several professional and contextual factors restricted these participants from being innovative. This reminds one of Kirkgöz (2008) argument that there are a number of factors that make curriculum innovation difficult in the classroom. In this study, professional and contextual barriers included teachers' background knowledge and training, a lack of support and the non- availability and poor quality of textbooks. The views of the participants revealed that the context that they had found themselves in created an enormous challenge that was nearly impossible to surpass. Desimone (2011) alludes to an important facet of professional development that is often ignored. She proposes that teachers of the same subject should all be part of the professional development activities together, so that an interactive learning community can be built. This would mean that if three teachers in a school are teaching mathematics, then all three should be part of any professional development programme so that all of them are developing at the same pace without one or two being left behind. This would then create an interactive learning community that would encourage, for example, curriculum innovating (Desimone, 2011). The idea explicated by Desimone correlates with Lave and Wenger's (1991) theory of a community of practice. According to Lave and Wenger (1991) learning should be viewed as a social process of engagement in the form of networking. People in general are involved in a number of communities of practice on a daily

basis in society or at work (Lave & Wenger, 1991). Teachers are involved in "gatherings" at workshops or subject committee meetings. These "gatherings" should place value on the term *networking* and transfer to teachers the importance of forming these networks.

All participants revealed that following their engagement with the professional development (Honours modules) their personal capacity to support innovation had increased.

The following responses emerged from the reflective journals:

> *This professional development gave me the tools I need to be an innovative teacher, in theory anyway…* (P9 – RJ – Oct 2015)

> *I used to teach in one way but now after this Honours module, I can be an innovative teacher, if I was able to do so in my current school…* (P10 – RJ – Oct 2015)

The data represented in Table five (Chapter 4, p. 102) and the preceding journal reflections concur with Rogan's (2007) processes advocated in the ZFI model. Rogan contends that practicing teachers can move from current practice of teaching (traditional style of teaching) to ideal practices of teaching (innovative teaching methods) if they receive effective outside support. The ZFI, as explained by Rogan (2007), is an area between the normal teaching practice of a teacher and the ideal teaching practice of the teacher. Through some sort of outside support (for example the Curriculum development in Science and Mathematics education Honours module), the capacity of the teachers in this study was developed to support curriculum innovating (Rogan, 2007). Once teachers possess the capacity and the support for an innovation they are able to implement it in the classroom.

The demands placed on science teachers evolve and increase with a changing curriculum (Tin, Hean & Leng, 1996). The demands placed on science teachers is not something new or surprising because with advancements in technology and society, science is evolving. Teachers' capacity to meet these demands is crucial. The school management and department officials should be acutely aware of what quintessentially motivates teachers to develop their capacity and become more effective in their teaching (Tin et al., 1996; de Jesus & Lens, 2005).

4.5. Research question 3: How do science teachers who have engaged in professional development activities enact the curriculum by innovating environment and sustainability education?

4.5.1. Research Question 3.1: What types of strategies do science teachers use when innovating in environment and sustainability education?

Participants' responses will be explored in two themes:

- Teaching strategies used when innovating in environment and sustainability education
- Assessment strategies used when innovating in environment and sustainability education

4.5.1.1. Theme 1: Teaching strategies used by participants when innovating in environment and sustainability education

All of the participants planned a lesson from either the Life Sciences or the Natural Sciences curriculum. Each lesson plan was an attempt to enact the curriculum by innovating in environment and sustainability education.

Participants chose topics from different strands of either Life Science or Natural Sciences. Five out of ten participants chose a topic from Life Sciences and the rest of the participants chose a topic from Natural Sciences. These strands were:

- Life Sciences
    - Environmental studies
    - Diversity, change and continuity
- Natural Sciences
    - Life and living
    - Planet earth and beyond

The following analysis is based on the examination of the lesson plans produced by each of the participants.

Table 6: Analysis of lesson plans – Teaching strategies used by participants.

Participant	Lesson topic	Innovative teaching strategies used in lesson
P1	Environmental studies: Biomes	Power-point on biomes, group work
P2	Diversity, change and continuity: Biodiversity and biological keys	Mind map, pictures, group work
P3	Life and living: Energy flow, food chains and food webs	Power-point, video presentation, group work, outdoor learning
P4	Diversity change and continuity: Biodiversity in Durban and ecotourism	Pictures, group work case study on local biodiversity
P5	Diversity change and continuity: Biodiversity and classification	Music video clip, power-point, video presentation, group work
P6	Planet earth and beyond: Layers of the atmosphere and the Greenhouse Effect	Video, group work, charts
P7	Planet earth and beyond: Greenhouse effect and global warming	Power-point, case study, group work
P8	Environmental studies: Human impact on the environment	Video, power-point
P9	Planet earth and beyond: Greenhouse effect and global warming	None
P10	Life and living: Energy flow, food chains and food webs	None

Participants nine and ten did not reflect innovative teaching strategies in their lesson plans. The reasons for the non-inclusion of innovative teaching strategies in these lesson plans will be discussed in the subsequent research question.

Participants one to eight all incorporated innovative teaching strategies in their lesson plans. All eight of these participants chose to include group work as a teaching strategy in their lessons. This resonates with Mayer's and Torracca's (2010) assertion that the use of group

work fosters critical thinking and knowledge acquisition among learners. The responses of all eight participants indicated that they were aware of the benefits of group work as a teaching strategy. Four out of the eight participants aimed to use a power-point presentation in their lessons. Five out of the eight participants proposed the use of audio-visual material in their lessons. This indicated that over 60 percent of participants elected to use audio-visual material. This resonates with the assertion by Akram, Sufiana and Mailk (2012) that the use of audio-visual material is effective because it enhances learner motivation and increases learners' interest levels. They add that the utilization of audio-visual material makes the lesson far more memorable for the learner. Eliciting the services of an audio-visual aid provides a point of focus for the learner (*ibid*). The participants in my study revealed heightened levels of understanding regarding the types of resources that complement curriculum innovating. This concurs with Rogan's ZFI which places importance on the teacher using resources to move through the ZFI to more ideal practices of teaching (Rogan & Aldous, 2005).

Two of the eight participants incorporated a case study and pictures as an innovative strategy for teaching their topics. Outdoor learning, mind maps, charts and samples were only selected by one participant as innovative teaching strategies in the lesson plans. Participant two incorporated the most number of innovative teaching strategies (four) in the lesson plan. This participant planned the lesson on biodiversity and biological keys. In the lesson plan, participant two facilitated a lesson being taught with the use of a mind map to illustrate and explain biodiversity to learners, together with a class discussion of the mind map. Pictures were also used to make learners aware of different organisms. Learners had to identify the characteristics of these organisms. Participant two then planned to teach learners how to use and interpret a dichotomous key.

An original and captivating lesson plan was designed by participant five. The topic was biodiversity and classification. The introduction of this lesson incorporated a dynamic video of David Attenborough narrating the words to the song "What a wonderful world", depicting the diversity of living organisms. The use of technology was evident in this lesson plan because participant five developed the lesson with the use of a power-point presentation and another video clip illustrating the importance of biodiversity to learners. The teaching strategies that this participant had selected demonstrated a distinct and critical awareness of the need for innovation in their teaching. This participant also demonstrated a conscious effort to develop in learners an appreciation for the environment. This concurs with the

contention of Bloom, Holden, Sawey and Weinburgh (2010) that developing awareness in learners of the environment is invaluable.

Participants four and six planned unique and thought-provoking lessons. Their lessons were based on biodiversity in Durban and ecotourism, and layers of the atmosphere and the Greenhouse effect. Both participants incorporated their local context into their teaching. Participant four planned a case study for learners that focused on the biodiversity from a local context of the learners. Participant six also situated the teaching and learning on the local context of the learners by using a video clip of local efforts to combat climate change. These two participants localised science for their learners by immersing scientific concepts into learners' daily life experiences and contexts.

Participant ten and participant three chose the same topic for their lesson plans, namely: energy flow, food chains and food webs. An analysis of both lesson plans however, revealed vast differences. Participant ten, as stated previously, did not include any innovative teaching strategies in the lesson plan. Participant ten planned a simple lesson using traditional methods of teaching (chalk and talk) to facilitate the lesson, with the prescribed textbook. The lesson plan did not seem to include any innovative activities and tasks for learners. However, participant three produced a lesson plan with an array of innovative teaching strategies. This lesson comprised a power-point presentation to demonstrate to learners the concept of energy flow and simple food chains. The design of the lesson revealed that during the course of the power-point presentation questions could be posed to learners and discussion could have emanated from those questions. Participant three then incorporated a video clip to illustrate to learners the feeding relationship in an ecosystem. This video clip used sound and colourful images to show learners the relationship between a predator and its prey. The teaching strategies chosen by the two participants were vastly different. One participant chose traditional, basic teaching strategies while the other participant demonstrated an acute awareness of the need for innovation in the teaching strategies.

Further analysis revealed that participants nine and seven also selected the same topic for their lesson. Both chose to plan a lesson on the topic *Planet earth and beyond: Greenhouse effect and global warming*. Analysis of both participants' lesson plans revealed contrasting strategies of teaching the same topic. Participant nine chose the chalkboard as the main resource for teaching. All explanations and notes were written on the chalkboard for learners to copy in their notebooks. This suggested minimum opportunities for active construction of

knowledge on the part of the learners. The prescribed textbook provided learners with diagrams and discussions around the concepts of the lesson. The lesson plan did not represent an attempt at an innovative lesson. The definition of curriculum innovating for this study is to renew or make new the way education is running or moving (Tytler, Symington & Smith, 2011; & van Laren *et al*., 2012). The lesson plan of participant nine reflected nothing new or different in the teaching and assessment strategies. Participant seven, however displayed a number of innovative teaching strategies. The lesson included the use of a data projector that showed learners a power-point presentation including concepts and images of global warming and the Greenhouse effect. Participant seven developed the lesson by placing learners in groups and administering a case study to be discussed with questions to be answered. Both lessons had the same topic but were planned to be taught in opposing styles. The lesson planned by participant seven was learner centred and was designed to enhance co-operative learning. From the definition of curriculum innovation for this study which is renew teaching practice, it is clear that participant seven displayed new and different methods of teaching and assessment that changed or renewed the way curriculum was being implemented. This contrasts with the common and more familiar methods of teaching and assessment displayed in lessons plan of participant nine.

A deeper analysis of the lesson plans revealed that some participants employed a multiple intelligences approach to inform their choice of teaching and assessment strategies. Pienaar, Nieman and Kamper (2011), referring to Gardener's theory on multiple intelligences, assert that people (learners included) perceive the world by using combinations of eight different but equally important ways. Participants' choices of teaching and assessment strategies reflected the following (Pienaar *et al.*, 2011): linguistically strong learners were stimulated by audio-visual aids such as video clips. Interpersonal intelligence was catered for through group work. Naturalistic intelligence, which involves the understanding of the natural environment through observation, classification and making inferences and predications, was ameliorated through activities outside the classroom. These participants exemplified high levels of awareness of multiple intelligences within their classrooms. This concurs with the assertion of Pienaar *et al.* (2011) that teaching must acknowledge multiple intelligences of learners within the classroom and by showing this awareness teachers can help learners understand content being taught.

4.5.1.2. Theme 2: Assessment strategies used by participants when innovating in environment and sustainability education

The following analysis is based on the examination of the lesson plans produced by each of the participants.

Table 7: Analysis of lesson plans – Assessment strategies used by participants.

Participant	Lesson topic	Innovative assessment strategies used
P1	Environmental studies: Biomes	Group poster presentation
P2	Diversity, change and continuity: Biodiversity and biological keys	Group work activity classifying leaves using a dichotomous key
P3	Life and living: Energy flow, food chains and food webs	Making a model of a food web
P4	Diversity change and continuity: Biodiversity in Durban and ecotourism	Group research presentation
P5	Diversity change and continuity: Biodiversity and classification	Concept map construction, group activity classifying make believe organisms
P6	Planet earth and beyond: Layers of the atmosphere and the Greenhouse Effect	Making a poster
P7	Planet earth and beyond: Greenhouse Effect and global warming	Poster presentation
P8	Environmental studies: Human impact on the environment	Debate, group work
P9	Planet earth and beyond: Greenhouse Effect and global warming	None
P10	Life and living: Energy flow, food chains and food webs	None

All participants except participants nine and ten demonstrated the use of innovative assessment strategies in their lesson plans. Participants nine and ten developed lesson plans

which incorporated worksheets and questions for learners to answer on the chalkboard. Participants one to eight developed lesson plans which included innovative assessment strategies that articulated with their innovative strategies of teaching.

Seven different modes of assessment were selected by participants for their lessons. Three out of the eight participants who incorporated innovative assessment in their lessons, elected to use a poster as a strategy of assessment. Zevenbergen (1999) asserts that this strategy of assessment is an excellent tool for the development of communication skills among learners within a classroom. He adds that this form of assessment is unique because it has the ability to stimulate productive debate regarding educational themes amongst learners.

Two participants chose to assess learners using a group task or activity, with participant eight electing to use a debate as a group activity. The remaining three participants (who used innovative assessment strategies in their lesson) selected a dichotomous key, a model of a food web and a concept map as the strategy of assessment for their planned lessons. The choice of assessment strategies by these four participants can be described as innovative according to Wood (2009). He argues that any activity that increases learners' level of participation, curiosity and motivation can be viewed as innovative. It is important to emphasise that what might be perceived as a routine strategy by one teacher can be perceived as an innovative strategy by another teacher, depending on the context (teacher factors, learner factors, resources, infrastructure, and management ethos, among others). The diverse selection of innovative strategies of assessment displayed by participants indicated that they had identified what would and what would not work in their specific school contexts. This resonates with the assertion by McColskey and O' Sullivan (2000) that once a teacher has a vision of what can be achieved with a specific class of learners, the appropriate innovative assessment tool will be selected. Each participant was able to ascertain the precise outcomes they wanted to achieve from their lesson with their individual classes and made the selection of their assessment tools. The type of assessment selected communicates to learners what is important (McColskey & O' Sullivan, 2000).

A contrast can again be drawn between participants ten and three, as well as between participants nine and seven. Both pairs of participants selected the same topic for their respective lessons, and the chosen assessment strategies demonstrated a distinct lack of innovation (in the case of participant nine and ten), and an awareness of the need for innovative assessment (participant three and seven). Participant ten elected to give learners a

worksheet that required learners to answer questions based on the food chains and food webs. Participant three on the other hand made use of a group activity that required learners construct a model of an actual food web. This resonates with Wood's (2009) view that any activity given to learners that enhances their ability to think and be motivated to work can be viewed as an active learning activity, which can be regarded as an innovative teaching method. The contrast between the choices of assessment strategies by participants nine and seven differed from each other. Participant nine made use of the chalkboard and required learners to answer questions based on global warming and the Greenhouse effect. In contrast, participant seven chose to assess learners as groups who attempted the assessment task. Learners were required to undertake a group research task about the effects of global warming and the Greenhouse effect, and compile a poster to be presented to the class. Responsibility for learning was hereby transferred to learners through creative assessment activities

4.5.2 Research question 3.2: Why do science teachers choose to use these strategies?

The factors that cause teacher participants to choose certain innovative strategies as part of the lessons is of vital importance. Equally important is the choice of participant nine and ten not to incorporate any innovative teaching strategies in the lessons they taught.

The rationale behind the choice of innovative or non-innovative teaching and assessment strategies by participants is vital in the understanding of how science teachers can engage in curriculum innovating in environment and sustainability education.

4.5.2.1. Theme 1: Teachers' enablement through the Honours professional development programme.

All participants indicated that the module that included innovation, Curriculum Development in Science and Mathematics, was a well-structured, highly effective module that was a necessity in their professional growth. All participants revealed that this specific module was beneficial to their teaching of environment and sustainability education. Responses from all participants provided evidence that this module ignited a flame inside them to be innovative teachers of environment and sustainability education.

The following responses emerged from the individual interviews:

> *It has positively impacted on my teaching… I feel renewed… I feel rejuvenated. I was caught in the rut of just teaching without concern for learners, but now I changed and motivated to encourage learning…* (P4 – II)

> *This module has made me more confident and I now have a new outlook to teaching… I believe I have come a long way; this professional development has really transformed and empowered me.* (P2 – II)

> *This module enabled me to think and practice different ways to teach Natural Sciences…* (P3 – II)

> *Actually I would not have been the teacher I am now if I had not done this Honours module. It has changed me.* (P1 – II)

The subsequent journal entries affirmed the above response:

> *I was bored using the textbook and notebook, to teach now I feel transformed in the classroom…* (P8 – RJ – Oct 2015)

> *Prior to this professional development, I felt bored teaching… now I feel changed and awake in my teaching.* (P6 – RJ – Sept 2015)

> *I find that you naturally have it in you to be innovative, but all you need is the support or the push to do it. This Honours module was actually a catalyst for my change.* (P1 – RJ – Aug 2015)

It is apparent from the preceding responses that participants had been renewed as innovative teachers. Participants were actively involved in the professional development and were not passive recipients. This resonates with Gulamhussein's (2013) assertion that many programmes on professional development involving curriculum reform place the teacher as a passive listener and not as someone who is actively involved in the programme. Some of the participants indicated that all they needed was some sort of support or direction to be innovative and they would have been inspired to do so. This concurs with Vygotsky's (1978) ZPD that asserts a more capable individual (professional development facilitator) could provide scaffolding through effective long term support for a teacher to develop a new understanding. In this case it would be innovative, creative strategies of teaching and

assessment. This is supported by Owston's (2006) assertion that there are several contributing factors that are needed for innovation to be sustained, one of which is support from internal and external school management. This indicated that the HOD (internal school manager) and the subject advisor (external manager) have a vital role to play in the innovation process, and that their involvement can propel or stifle any intentions of curriculum innovating when teachers teach environment and sustainability education. From his study, Owston (2006, p.1) discovered that "essential conditions for the sustainability of classroom innovation were teacher and learner support of the innovation, teachers perceived value of the innovation, teacher professional development and principal approval". The latter part of the quote is of relevance to this study because the approval of the principal is valued in the process of innovating.

Participants exhibited ownership of their ability to be innovative and indirect responsibility for the innovation itself. This correlates with Tytler's (2007) assertion regarding research conducted in Australia. He states that teachers must have a vision of their innovation. They need to be able to acquire new skills and knowledge that will re-invent them as new innovative science teachers in science education (*ibid*). By having a vision of their innovation teachers became confident and dynamic in their teaching. It is interesting to analyse the remarkable transformation that all of these participants had experienced. They had undergone a major change in their attitudes, beliefs and practices due to them having engage with the Curriculum Development is Science and Mathematics education module, and having received the necessary school based support.

There was added allusion to factors that enabled them to be innovative in their lessons. These factors could have come directly from the professional development or as a consequence of the professional development.

The following responses arose from the individual interviews:

> *This professional development module has given be the ability to be innovative in my teaching.* (P1 – II)
>
> *I now have the knowledge to develop innovations.* (P3 – II)
>
> *This module has given me the skills and knowledge to be an innovative teacher in the science classroom.* (P5 – II)

Participants indicated that by studying the Curriculum Development in Science and Mathematics education module their sensitivity to opportunities for innovative teaching in environment and sustainability education was enhanced.

The following response emerged from the individual interviews:

> *Prior to this professional development module I felt less confident. Through this professional development module I developed and gained confidence. The notes gave me knowledge, the activities made me think, and the innovative lesson that I had to plan and teach made me a passionate and innovative teacher.* (P2 – II)

> *I feel more empowered. The tasks did enhance my knowledge; however the major task was the portfolio, where I had to plan and implement an innovative lesson, really changed my view of teaching. I was able to look into different techniques in teaching. This module increased my knowledge and ability to teach.* (P2 – II)

> *I would say this module positively impacted me and my teaching. You see I always wanted to be innovative but I never saw the reason to be. This Honours module exposed me to the benefits of being an innovative teacher.* (P3 – II)

> *After this Honours module I found that I was a lot more confident. This module has increased my knowledge, skills and teaching ability. I can now see areas where I can be innovative in my teaching.* (P1 – II)

> *This module has given me a lot. Before it I would have never been able to see areas in certain topics where I can be innovative. Now I can see opportunities for innovation. I have the knowledge of how to be innovative in my teaching. This module has increased my knowledge and my teaching ability.* (P8 – II)

The following journal entries affirmed the above responses:

> *I find ways to be innovative in class…* (P2 – RJ – Oct 2015)

> *I believe that innovation is both a matter of choice and capacity from a teacher and with that said I am encouraged to be innovative because of this professional development* (P3 – RJ – Nov 2015)

> *Now I do feel as though I have the capacity to be innovative in my teaching.* (P4 – RJ – Oct 2015)

> *I strongly feel that having engaged in the professional development, and my experiences gained has greatly influenced and developed my capacity to be innovative as I teach environment and sustainability education.* (P5 – RJ – Nov 2015)

> *The planning and teaching of an innovative lesson gave me the chance to be innovative. I was not very innovative before that. But now I am motivated to be an innovative teacher.* (P6 – RJ – Sept 2015)

The preceding responses revealed that participants felt that the module which incorporated innovation had benefited them and had made them aware of the potential benefits of curriculum innovating. Their views highlighted the effectiveness of the Curriculum Development in Science and Mathematics education module in specifically addressing their individual needs as teachers of science education. This resonates with Singh's (2011) assertion that effective professional development engages the teacher in a process but the teacher is also aware of the reasons for their engagement in that process.

Participants were given the freedom to choose to engage with the professional development. The module allowed for visible space or opportunities for curriculum innovating to occur. Participants' responses indicated that they were also able to identify topics from content where innovative strategies of teaching could be implemented. They were also enabled to construct the knowledge and skills that permitted them to realise why they needed or required that professional development. These teachers had more confidence because of their increased pedagogical content knowledge. This echoes the assertion of Desimone (2011) that teachers use the knowledge, skills, attitudes and beliefs gained from effective professional development, to improve their own teaching or their direct view of teaching itself. In the Curriculum Development in Science and Mathematics Education participants had to engage with a lesson incorporating innovation. This required them to get more involved in researching ways to enhance their ability to be innovative in their specific school context. Participants had to take ownership of their teaching and learning in order to be more effective in the classroom. In this way teachers took responsibility for enriching their knowledge repository of subject matter content, and pedagogical content knowledge. Through this teachers were emboldened and had more courage and confidence to engage in new practices in their teaching.

4.5.2.2. Theme 2: Enhanced teacher motivation based on improved learner responses and performance

The participants responses indicated that their motivation to engage in curriculum innovating was enhanced due to their engagement in the professional development.

The following responses emerged from individual interviews:

> *This professional development module has increased my knowledge and I can now plan lessons more creatively… it has enhanced my assessment methods. I find learners are doing better now.* (P2 – II)

> *I can now teach innovative lessons. The learners love it and are performing better in their assessment tasks. (P8 – II)*

The subsequent journal entries affirmed the above responses:

> *I never was very innovative but now because I've seen how well learners performed in the task I gave them during my lesson, I now want to teach all my classes in the same way.* (P3 – RJ – Nov 2015)

> *I learnt the importance of making teaching and learning fun. If learners find the lesson or activity interesting then they work better.* (P4 – RJ – Oct 2015)

> *Learners are just tired of traditional methods of assessment and are open to exciting new ways of learning and developing their understanding. I am not suggesting that traditional methods should be abandoned completely, there is still a niche for traditional assessment methods, but teachers need all the help they can get to motivate and encourage learners to think critically, and I believe that innovative methods of assessment is the way to achieve this.* (P5 – RJ – Nov 2015)

> *I am more confident. I find that I am better at planning and implementing my class activities and assessments in a way that can facilitate better learner understanding.* (P7 – RJ – Nov 2015)

Effective professional development had altered the teaching practices of participants which had a positive effect on the performance of learners in their classroom, and teachers subsequently possessed an increased sense of self-efficacy. This concurs with the view of Supovitz and Turner (2000) that there exists a direct link between effective professional

development, improved teaching practices of science teachers, and resultant improved performance of learners in science. Participants were of the view that curriculum innovating in environment and sustainability education can and had improved the performance of learners in science education. This improvement in learner performance and enthusiasm provided teachers with motivation to continue being creative and innovative. This correlated with the Vygotsky's (1978) ZPD that states that there exists a critical space of potential development where the individual can be given the opportunity to develop new knowledge through support. In this case the teacher can be motivated to engage in curriculum innovating through collaboration with peers.

The following responses which link teacher capacity and teacher motivation arose from individual interviews:

> *What has kept me so motivated are my learners because they are now alive in my class.* (P2 – II)
>
> *My learners were very positive and excited. They enjoyed my lesson. They improved in terms of results. They were all actively engaged and motivated me in my lesson.* (P3 – II)
>
> *I noticed the change in them and that enabled and motivated me to continuously be innovative.* (P3 – II)
>
> *…you will feel so motivated with the learners' positive responses…* (P7 – II)

The following journal entries affirmed the above responses:

> *The learners responded so well to my lesson and I was very motivated by that.* (P3 – RJ – Nov 2015)
>
> *I am motivated to be innovative especially after gaining positive feedback from my learners.* (P4 – RJ – Oct 2015)
>
> *The learners responded so well to the lesson I taught. I was very motivated by this.* (P7 – RJ – Nov 2015)

The preceding responses all have a common factor that was the source of participants motivated viz. the positive responses of learners to their innovative teaching and assessment strategies. This concurs with findings from a study conducted in Singapore by Tin et al.

(1996) who found that most teachers are motivated by the increase in participation and performance of their learners. Participants were motivated to innovate because of the affirming responses from their learners. This provides a solution for a common teacher complaint as proposed by de Jesus and Lens (2005) that teachers find it difficult to motivate their learners to work and that difficulty becomes a de-motivating factor for the teacher themselves. These participants made a conscious decision to be innovative in their teaching of environment and sustainability education. This resonates with the assertion of de Jesus and Lens (2006) that it is only the motivated teacher that guarantees implementation of a reform (innovation in this case).

The following views emerged from the reflective journals:

> *I am now able to be innovative in my teaching and the learners are excited about the lessons. They are learning and I have now tried to be innovative in other subjects that I teach.* (P5 – RJ – Nov 2015)

> *Because the one class responded so well to my innovative lesson, I tried it in other classes…* (P7 – RJ – Nov 2015)

> *I never was very innovative but now because I've seen how well learners performed in the task I gave them during my lesson, I now want to teach all my classes in the same way.* (P3 – RJ – Nov 2015)

The preceding reflections indicated that participants had experienced success in their new-found method of teaching. Their success inspired them to extend their innovative teaching methods to other classes that they taught. This finding reminds one of with Mayer's and Torracca's (2010) assertion that innovation is flexible in nature and has the ability to be adapted to different contexts. These authors add that it is important for teachers to find a place for innovation in their teaching. These participants had seen the positive effects of innovation in their teaching from the reactions of their learners. Participants were able to find space for innovating in their teaching as they had to teach different classes. These responses indicated that the classroom practices of participants had been transformed as they were able to innovate as they taught environment and sustainability education. This concurs with Guskey's (2000) view that by changing the classroom practices of the teacher, the performance of the learners in the classroom can improve, and this can lead to the beliefs and attitudes of the teacher changing. This finding also resonates with Steyn's (2008) suggestion

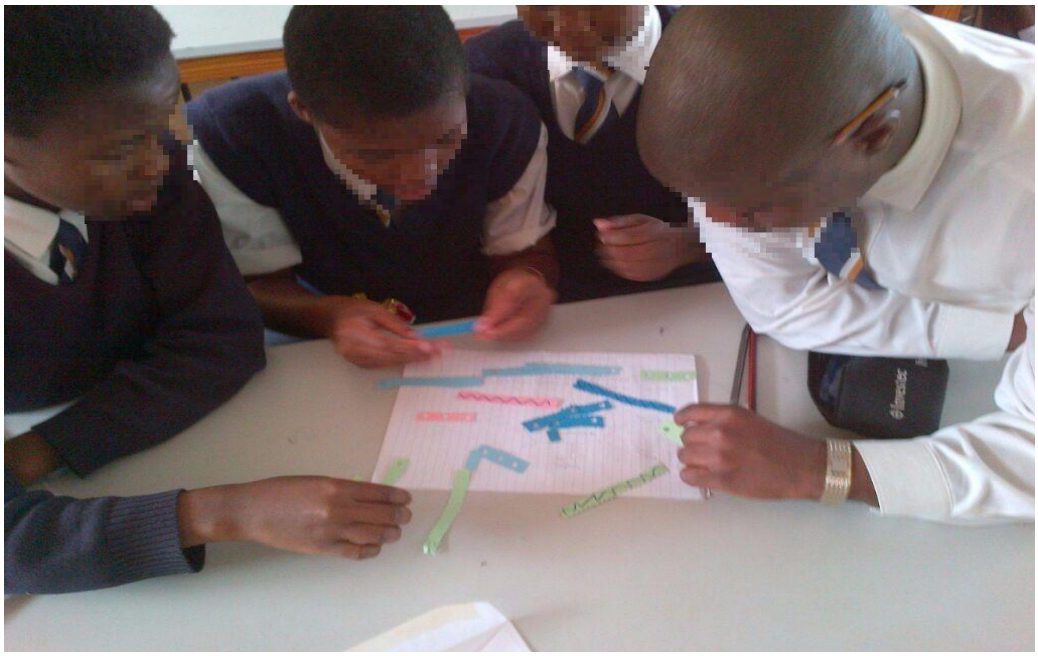
that the purpose of professional development should not be to train teachers on how to implement new curriculum policies, but it should rather be to improve the classroom practices of teachers.

The subsequent views emerged from the individual interviews:

> *I have noticed that my quiet learners are more vibrant and they understand when I teach…* (P1 – II)
>
> *You see my learners results are improving so it makes me want to be innovative.* (P1 – II)
>
> *Also from my lesson I found that using different techniques creates maximum learner participation and also understanding of concepts in science, specifically environmental education…* (P2 – II)
>
> *I noticed learners are happier to learn, they understand and are doing better in science…* (P6 – II)

The following photo narratives affirmed the above responses:

Photograph 3



Learners were excited about the lesson I planned for them. I arranged learners in groups and they were enthusiastically engaged with the activity I gave them. Learners understood what I was explaining to them by physically classifying the organisms I had given them.

Photograph 4

Learners were given a picture and asked to identify the rare organism. They then had to answer questions based on their analysis of the picture. This activity gave learners an opportunity to see organisms that were not familiar with.

Photograph 5

The leaf samples that I had given to learners really helped them understand the concepts I had explained to them. Learners were excited to physically see the characteristics of each leaf. This helped them to develop the dichotomous key.

Photograph 6

This activity actively engaged all learners in the class. Learners had fun debating with each other and learning from this interaction. Using a debate provided learners with a platform to share their views and also inform their own personal knowledge of environmental issues in society.

Photograph 7

Learners were placed in groups and given three questions in this activity. This activity was used to determine learners' prior knowledge about the atmosphere. This kind of activity gives that teacher an understanding of the prior knowledge that learners possess before beginning the lesson.

The preceding photo-narratives demonstrated that innovative methods of teaching had created a happier and learner-friendly atmosphere in the classroom. The learners appeared to be gainfully involved in the tasks and the responses of teacher participants indicated that learners also performed better as a result of these innovative methods of teaching. This can be viewed as a direct consequence of effective professional development that has empowered participants to teach an innovative lesson on environment and sustainability education, and thus learners' understanding had been enhanced and they produced better results. This is crucial in any effective teaching setting and concurs with Supovitz and Turner's (2000) argument that embedded in the call for effective professional development is the consequence that once teachers have been empowered and motivated by effective development, they will practice it in the classroom. They add that this will enhance learner understanding which will translate into better learner performance.

Their transformed classroom practices, and improved performance of learners in response to the new practices resulted in participants' increased valuing of innovating. The revelation of the advantages of curriculum innovating within the science classroom can have massive implications for the overall performance of learners in science education in South Africa. Effective professional development for science teachers can lead to stronger, more innovative teachers who enhance learning within the classroom, with the end result being improved performances of learners in science education. This concurs with views of Kriek and Grayson (2009), Sherron and Fletcher (2008) and Mestry, Hendricks and Bisschoff (2009) that more effective professional development enhances the teaching abilities of teachers which equips learners to perform better in science education.

4.5.2.3. Theme 3: Deeper teacher understanding of the benefits of technology to enhance curriculum implementation

A majority of the participants who included innovation in their lesson plans chose to use technology in their lessons. Six out of eight participants used a power-point presentation, video clip, music video or a combination of all three in their lessons. This indicated a link between the use of technology and curriculum innovating in environment and sustainability education.

The following views emerged from the individual interviews:

> *I feel using media in the class will really assist learners in understanding. I showed a video clip when I was teaching my lesson. I paused at points to show different organisms to learners… sometimes learners don't know certain organisms so they cannot make out in their heads, but if you show them a video clip they will understand.* (P3 – II)

> *Showing them the music video really captivated my learners, automatically they were settled and ready to work. By showing learners visual aids on a power-point, learners immediately make connections.* (P5 – II)

> *After the professional development I am always searching the internet for videos to show learners…* (P6 – II)

> *When I started the lesson and learners saw my laptop and the data projector they were immediately attentive. They responded to my teaching. Previously, it was hard to*

explain to them certain concepts, but with the video learners could actually see, like a live example of what I was talking about. (P8 – II)

The following journal entries affirmed the above responses:

But now, I have learnt how to teach by incorporating technology into my classes and I believe that I have grown in that regard. (P3 – RJ – Nov 2015)

I believe that I am an innovative teacher. Reasons for that are I have found alternative ways of teaching rather than the traditional approaches of teaching, which is incorporating computer technology into the classroom and making its availability conducive towards teaching and learning. (P3 – RJ – Nov 2015)

I strongly believe that more emphasis must be placed on the use of technology in environment and sustainability teaching. It must not be the only way it can be taught, but technology must be part of the lesson because learners are surrounded by technology in their daily live… (P8 – RJ – Oct 2015)

I do see a place for technology in teaching environment and sustainability education because technology goes with innovation I feel. Like using computers and a data projector, that is how many schools function today. It must be seen as an option for teachers…. (P9 –RJ – Oct 2015)

Rogan (2007) ZFI postulates that as the teacher receives effective support and has adequate resources, they are able to move through the zone of feasible innovation and move from traditional methods of teaching to more ideal methods. In the present study, these ideal methods of teaching are informed by the increased pedagogic content knowledge participants gained from their engagement with the professional development module. The support and resources that these teachers received was enhanced by the use of technology. Stahl (n.d., p. iii) expands on Vygotsky's Engagement Theory by stating that technology provides "open-ended opportunities for promoting and supporting engaged learning". The use of technology gave teachers the opportunity to engage their learners and this provided a platform for teaching and learning.

The following photo narratives affirmed the preceding individual interview responses and the subsequent journal entries:

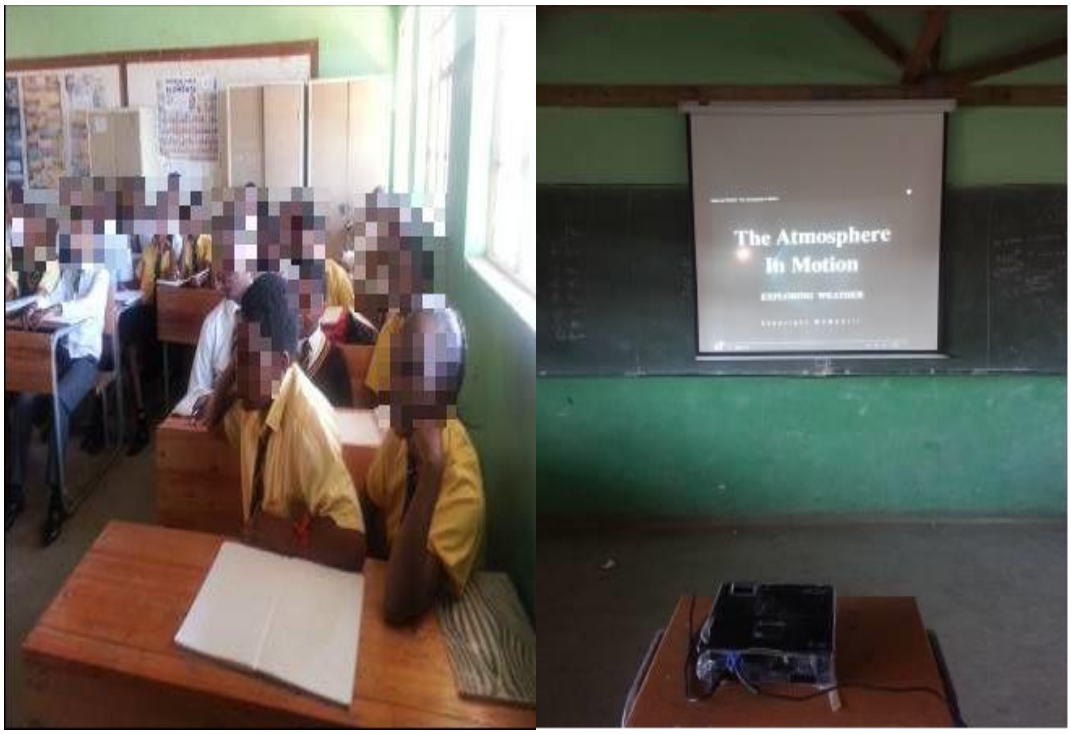
Photograph 8

The use of technology is demonstrated in this lesson through the use of a computer and data projector to show learners biodiversity. This is inspiring as learners can see 3-dimensional images rather than flat 2-deimensional images in the textbooks.

Photograph 9

Learners are given an attractive, colourful visual impression of what I am discussing in the lesson. This is reflected from the data projector onto the whiteboard. This use of technology supersedes what a textbook or a chalkboard diagram may offer a learner.

Photograph 10



The attention of learners is grasped by using new media to teach. These learners are quiet and attentively watching the presentation done by the teacher. This illustrates the effectiveness of technology in enhancing learner interest and understanding of environment and sustainability education.

Photograph 11

Technology captures the attention of learners. Learners here are captivated by the presentation and are also consulting their textbooks as they watch. This strategy reflects collaboration between the use of technology and the use of a textbook to teach an innovative lesson.

The preceding responses reveal that participants had identified a space for the use of technology to aid innovating in the science classroom. The use of technology was something new to the teachers and their learners and learners were captivated by what they were seeing. But through their engagement with the Curriculum Development in Science and Mathematics Education module, these teachers were motivated to use different resources because of what they had learnt in this module. They realised the potential benefits of using technology in their teaching. This correlates with Archer's (2013) assertion that innovative teaching is a necessity in the South African classroom. She adds that one such initiative is the use of Information Computer Technology (ICT) in the classroom. She advocates for the use of digital literacy as an alternative and innovative strategy to educate learners. This kind of innovative strategy cannot be ignored as a potentially highly effective method of teaching, especially because it relates to contemporary modern society. The use of technology appealed to learners whose understanding deepened when audio-visual material was used. It is

apparent from participants responses that they now have an awareness that the leveraging of multiple resources was needed to appeal to the diverse learning styles in their classroom. Participants had seen the benefits of technology in their lessons and demonstrated the capacity to support such an innovative teaching strategy. These teachers were able to use novel ways of presenting lessons that captured and sustained learners' interest. By capturing learners' attention and keeping learners interested, participants experienced fewer classroom management challenges. This correlates with Rogan's (2007) ZFI that highlights the learner as a contributory factor to a teacher's motivation and capacity building for innovating. If learners are meaningfully occupied in the classroom it provides teachers with the motivation to persevere and continue to build their capacity to innovate, and to initiate future innovations (Rogan & Aldous, 2005).

These participants were able to enact the curriculum through innovating. The opportunities for innovating had been rendered visible through the module "Curriculum Development in Science and Mathematics Education". These teachers felt more confident and motivated to experiment with and enact innovative strategies in the classroom. The positive responses from learners to innovative teaching strategies, the increased learner motivation to learn, enhanced learner performance and the increased interest among learners all contributed to these teachers being able to sustain curriculum innovating.

4.5.2.4. Theme 4: School-based factors that enabled curriculum innovating in environment and sustainability education

There were school-based factors that allowed the participants to engage in curriculum innovating as they taught environment and sustainability education. The following responses arose from the individual interviews:

> *My HOD encourages teachers to teach in new ways… I have support to be innovative in my classroom.* (P1 – II)

> *The school management never intrude or ask why I teach in a particular way… so for me to be innovative wasn't difficult.* (P8 – II)

> *Resources are available… that helped me to be innovative in my teaching.* (P8 – II)

> *We have enough resources in my school we can make use of the media centre for learners to do research.* (P4 – II)

Learners responded well to my innovative lessons…that showed me that the lesson was working. (P8 – II)

Learners understood better when I showed them the power-point. (P3 – II)

The following journal entries affirmed the preceding responses:

The physical resources I engaged with during this development did allow me to be innovative in my teaching. (P1 – RJ – Aug 2015)

I was able to use resources such as the use of my phone to do a quick internet search and get further clarity with what I was unclear about at that time. (P3 – RJ – Nov 2015)

The following photo narratives affirmed the individual interview responses and the subsequent journal entries:

Photograph 12

Learners are provided with sufficient resources that allow a teacher to be innovative. Learners are involved in the lesson due to the availability of resources in the classroom.

Photograph 13

Learners are engaged in discussions using resources made available to them. This promotes enhanced thinking and learning for learners as they are engaged in vibrant communication with their peers.

Photograph 14

The school yard can be a unique and creative resource that learners can access. Here learners make use of the trees and organisms in their school to discuss content on biodiversity.

The preceding responses of participants revealed that they had developed and become science teachers who were able to support curriculum innovating. They had taken responsibility for enhancing their own knowledge of teaching. Participants possessed the capacity to support innovations. Responses from participants revealed that support from their school management, adequate resources available to them, and the positive responses of learners to the innovative teaching and assessment strategies provided an environment that was conducive to curriculum innovating. This concurs with Altinyelken's (2010) assertion that positive school leadership will affect teacher motivation, influence teachers' capacity to be innovative, and affect teachers' attitude and willingness to implement change. This concurs with Rogan and Aldous's (2005) assertion about the ZFI, that a school that is well resourced, has teachers who are engaged in effective professional development and a school management that is supportive, is more likely to succeed in curriculum innovating. The fact that these participants possessed knowledge of how to innovate, had ample resources at their disposal, and had a school management team that promoted a positive and supportive school

ethos, collectively played a catalytic role in teachers being able to successfully engage in curriculum innovating in environment and sustainability education.

Participant three was able to identify an opportunity to take learning beyond the classroom and initiate outdoor learning. This participant demonstrated increased levels of creativity and innovation. Learners were encouraged to get involved in nature and the environment around them at school. This correlates with the argument by Bloom *et al.* (2010) that learners need to develop a concern for the natural world around them and one way to do this is through authentic experiences in the environment. They add that outdoor learning encourages learners to develop an appreciation for the environment. The choice by participant three to use the school grounds as part of the lesson is vital. It emphasised the importance of the physical resources of a school, which were used to assist this teacher in creating an enhanced learning environment for the learners. This concurs with Rogan and Aldous's (2005) observation that the physical resources (the school grounds in this instance) of a school can be used to aid curriculum innovating.

4.6. Research question 4: Which factors are obstructive to curriculum innovating in environment and sustainability education? How do science teachers respond to these factors?

Participants identified factors that were obstructive to their efforts of curriculum innovating in environment and sustainability education.

4.6.1. Theme 1: School-based factors that restricted curriculum innovating in environment and sustainability education

(This section is different from section 4.4.2 because it addresses the inability to engage in curriculum innovating after participants studied the Honours module)

From the individual interviews conducted with all participants, responses reveal that only two out of the ten participants were unsuccessful in curriculum innovating in environment and sustainability education. These two participants expressed debilitating contextual factors that restricted them from innovating. This resonates with Altinyelken's (2010) assertion that it is crucial to recognise that every school will differ in its capacity to implement innovations. The factors that obstructed these participants from being innovative in the science classroom are interrogated.

Data generated from the lesson plans of participants revealed that two participants did not include innovation in their teaching or in their assessment strategies. An interpretation of the individual interviews and reflective journals of these two participants is presented.

The following view arose from the individual interviews:

> *I was not able to teach an innovative lesson because there are a number of factors at my school that restrict me.* (P10 – II)

The following journal entries affirmed the above response:

> *…but now this professional development has inspired me to be an innovative teacher. Unfortunately I don't have the chance to do that.* (P9 – RJ – Oct 2015)

> *I have learnt how to be innovative and I have also identified the need for innovation, but in the school that I am currently teaching there is no room for innovation due to the contextual factors such as learner apathy, teacher conflicts and the lack of resources.* (P9 –RJ – Oct 2015)

It was apparent from these responses that the both participants who said they could not innovate were aware of the "need for innovation" in their teaching. These responses are probably as a consequence of the professional development module they had engaged with, because they did not show this awareness prior to having studied the module. This resonates with the views of O' Sullivan *et al.* (n.d.) who state that if teachers are wilfully engaged in professional development, they will exude passion and enthusiasm in their professional learning. Participants nine and ten were wilfully engaged in the professional development and that provided a platform for them to learn and be able to identify a need for innovating in science teaching. There was, however a disconnection between the knowledge and skills for innovating which they had acquired during the professional development training, and their capacity to implement what they had learnt.

Although participants nine and ten believed that they possessed the capacity to identify opportunities to be innovative, a deeper, more detailed look at their individual interviews and reflective journals exposed contextual factors that restricted them from being innovative.

The following responses emerged from the individual interviews:

> *This professional development has developed me, but my school is severely under-resourced. We only teach using the chalkboard and a limited number of textbooks. Even running out worksheets is difficult due to a lack of paper. We don't have data projectors for teachers or computers for learners to use.* (P9 – II)

> *At my school we are very under-resourced. Teaching is done mainly by using the chalkboard and a prescribed textbook. Due to a lack of funds we are restricted and rarely use worksheets or anything like that. I would like to be innovative but I cannot. I have no support to be innovative.* (P10 – II)

> *Learners are not interested in working and this creates a bad working environment. I will not go the extra mile for nothing and we have very large class sizes. If I did plan an innovative lesson and purchased my own resources, it would be wasted on the learners. Even purchasing resources creates tension between teachers at my school and the school management are not very supportive in any case.* (P10 – II)

> *In my school there is a general feeling of apathy amongst the staff and the learners. If you do try to make a difference and try something new, staff see you as rocking the boat or creating waves. Even if I have new ideas the school management is not interested. I think the management is this way because learners demotivate the teachers and vice versa. (P9 – II)*

Rogan's (2007) ZFI states that for teachers to move from routine practices to ideal practices they require outside support. Without this outside support teachers will be unable to acquire the necessary pedagogic knowledge and skills to engage in curriculum innovating, and will not be able into the ZFI towards ideal practices. Rogan (2007) asserts that outside support also helps enhance the teacher's capacity to support innovation.

The influence of context in terms of school management factors, teacher factors and learner factors was profound for these two participants. Minimal funding in their schools was associated with scarce teaching resources. This led to the use of uninspiring teaching strategies and consequently, learner disinterest. Apathy among staff, professional jealousy, and unenthusiastic managers, colluded to form an insurmountable challenge to curriculum innovating. These teachers were unable to engage in curriculum innovating despite having studied the professional development module. Effective professional development, in the

absence of school-based support, cannot enable curriculum innovating. This is the reason I excluded "professional development" from the title of this thesis.

The preceding views demonstrate the deleterious effects of contextual factors that prohibited participants nine and ten from being innovative in their teaching. These responses reveal that these participants possessed a desire to engage in curriculum innovating when they taught environment and sustainability education, but were restricted.

The first contextual factor indicated by participants nine and ten was learner apathy and a poor work ethic. This reminds one of Schou's (2015) assertion that learner apathy is a serious issue of concern and it has the ability to leave long lasting problems. Schou (2015) and Benders (2011) concur that learner apathy is a rampant problem especially when learners reach high school level. Responses from participants nine and ten indicated they were in schools that were not functioning to their full capacity and this had contributed to the general apathetic atmosphere in their respective schools.

The second contextual factor that restricted participants nine and ten from engaging in curriculum innovating was a lack of resources at their schools. Resources are a vital part of effective and innovative teaching and learning. This is echoed by Manqele's (2012) assertion that a lack of resources can impede the progression of effective teaching and learning. He adds that because science is a challenging subject in schools in South Africa, and due to the critical nature of science, maximum resources are needed to enhance both teaching and learning.

The third factor that hindered participants nine and ten from being innovative when they taught environment and sustainability education was the lack of support from their school management teams. This also created an atmosphere of disinterest within the school with regards to promotion of high quality teaching and learning. The importance of support from the school management team is highlighted by Schleicher (2015) who emphasised that members of the school management team should provide opportunities and support to their teachers. This resonates with Ndimande's (2005) assertion that it is the critical responsibility of the school management team to motivate teachers to improve their professional and teaching qualifications and in turn improve the performance of their learners in the classroom. Ndimande (2005) adds that his study conducted with teachers in South Africa revealed that many of the respondents indicated they had received insufficient support from the school management team to help them enhance learner performance. This is a notable

finding because it denotes the lack of support from the school management team as something that has existed for a period of time and is therefore not unique to this study. This highlights the need for school management teams to be active and effective especially in schools that encounter increased social and contextual challenges. The prohibitive contextual factors alluded to by these participants had collectively doused their desire to innovate when they taught environment and sustainability education. These contextual factors had permeated the atmosphere in the classrooms of these two teachers and this articulates with the view of Scholtz et al. (2004) who assert that what teachers take away from professional development programmes and use in their classrooms is based on a number of social and physical influences. They add that this could include the number of learners in a class, the size of the classroom, the resources available and the scientific equipment at their disposal. It was evident that these participants were in a situation that was not unique. Many schools in South Africa have serious teaching and learning challenges due to insufficient resources, lack of funding, lack of visionary management and learners who are not willing to work.

Participant nine and ten also stated the following in individual interviews:

> *I can teach using innovation, but because I need to complete the syllabus, and the school gives no support, I just teach in a traditional manner.* (P9 – II)

> *I feel like I just have to teach to finish the syllabus there is like a feeling in the school that we must just complete the syllabus… learners hardly respond in lessons. Teaching innovative lessons would be a waste.* (P10 – II)

The subsequent journal entries affirmed the above views:

> *I just teach to complete the syllabus and make sure all the content is covered.* (P9 – RJ – Oct 2015)

> *I am just teaching content and I don't bother if learners are learning. All I worry about is completing the syllabus.* (P10 – RJ – Oct 2015)

It is evident from the preceding responses that participants nine and ten clearly felt pressurised in their schools to complete the prescribed syllabus and to do it without any questions. This highlights the concept of curriculum innovating versus curriculum implementation. Frost (2012) provides deep insight into the realm of curriculum innovating versus curriculum implementation. He states that there is an assumption that professional

development is a method or a strategy for the implementation of curriculum. He argues that this should not be the case because professional development is viewed in different ways under curriculum innovating and curriculum implementation. With regards to curriculum innovating, professional development should be viewed as an engine that drives the innovation (*ibid*). In curriculum implementation however, professional development is a more passive process and could tantamount merely to a vehicle for delivery (*ibid*). Frost (2012) underscores the distinct difference between professional development in curriculum innovating and professional development in curriculum implementation. The impact of this difference manifested in the compulsion to comply, which was experienced by participants nine and ten who merely implemented curriculum and had no time for curriculum innovating.

All participants agreed on the importance of curriculum innovating in the teaching and learning of science. However, two participants had insurmountable obstacles that restricted them from being innovative when they taught environment and sustainability education, and more evidence of this is provided in the subsequent excerpts.

> *Innovation is possible but with no support, a lack of resources and school management that doesn't support it, I could not teach using innovation.* (P9 – II)

> *No resources, learners don't want to learn, management that doesn't want to effect any change… there is no point of me even trying to be innovative in my teaching. Even if I wanted to for example purchase my own resources other teachers will question why is that being done for one or two classes only?* (P10 – II)

> *The school stops me from being innovative.* (P9 – II)

> *My school is situated in a community that is not well educated. Education is not seen as a priority to the parents of the learners. There is a severe lack of parental involvement in the lives of learners. Many of the parents do not respond to notices regarding poor performance and behaviour of their children and this adds to the already pathetic work ethic in the school.* (P10 – II)

The following journal entries supported the above responses:

> *I do feel that I have the capacity to be innovative but because of the contextual factors at my school I do not have the opportunity or freedom to be innovative.* (P9 – RJ – Oct 2015)

This professional development increased my confidence to be innovative although I don't have the opportunity to do it at my current school. (P10 – RJ – Oct 2015)

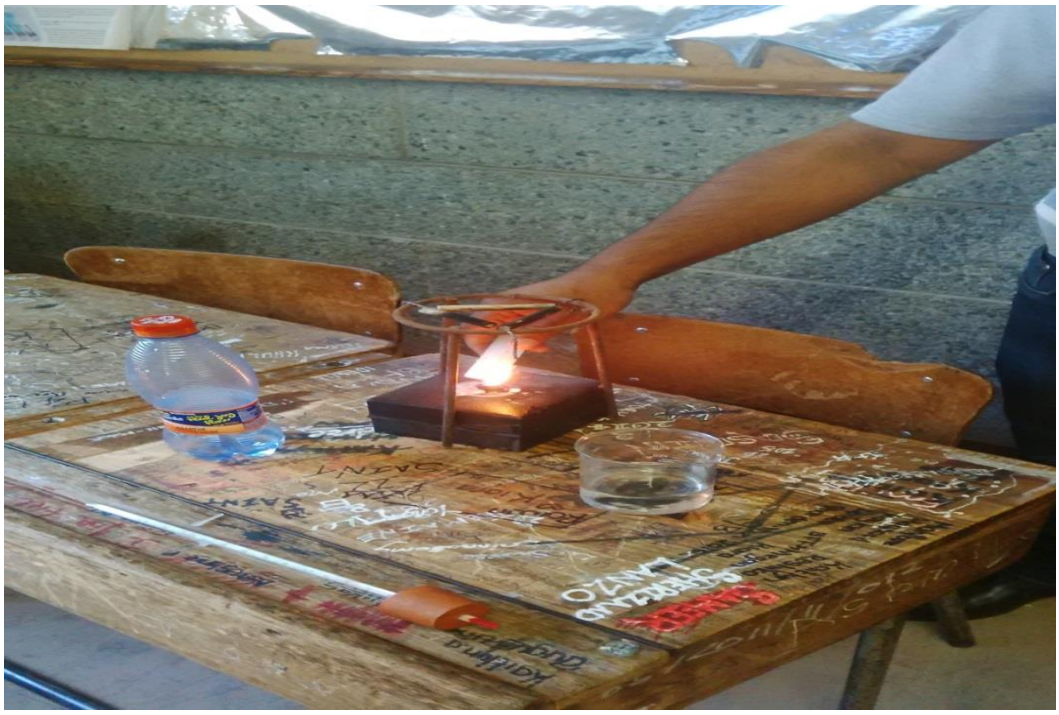
I do feel that I would be able to teach environment and sustainability in an exciting and innovation manner if I had the opportunity. I know my capacity to innovate has increased but I am still not able to do so at the school I am in because I have no support from the HOD or any resources. If I moved to a different school I would be happy to teach innovative, interesting lessons that really captures the attention of learners. I now have the skills and the knowledge. (P10 – RJ – Oct 2015)

The following photo narratives supported the preceding individual interview responses and subsequent journal entries:

Photograph 15

This is the current state of the science laboratory. Heavy rains caused the roof to collapse, and with no funding to repair it the laboratory cannot be used and had to be abandoned.

Photograph 16



With no funding and a very unsupportive school management this is the only way to demonstrate experiments for learners 300 science learners. This is the only science equipment that is available for experiments.

Participants nine and ten were unique in this study because they were at a disadvantage due to a lack of opportunities for curriculum innovating. They appeared to be restricted by the contextual factors of their schools and were unable to pursue in their quest to be innovative science teachers. These participants had become disillusioned by the lack of resources, unsupportive staff and learner apathy. The lack of maintenance to the infrastructure of the school also affected the morale and confidence of these teachers. Their situation is not unique because researchers such as Altinyelken (2010) assert that poor conditions and limited resources limit the performance of both teachers and learners in the school. A lack of specialized resources to teach science caused dependence on teacher-led demonstrations and this restricted learner's ability to develop laboratory skills. This concurs with Rogan and Aldous's (2005) assertion that not all schools possess the capacity to implement an innovation at the same level and intensity. What is evident is that if a teacher who possesses the capacity to be innovative and can recognise the opportunity for innovation, he/she still needs support and resources from the school for the innovation to be implemented. This

indicated that professional development can only effect change to a limited extent and that without other support, curriculum innovating is limited.

The following responses emanated from the individual interviews:

> *…because of this I just taught in the traditional manner.* (P10 – II)

> *I could not do anything. I had to teach in a normal way…* (P9 – II)

The subsequent journal entries affirm the preceding views:

> *I had no resources so I chose to teach a lesson that had no innovation…* (P9 – RJ – Oct 2015)

> *I was unable to teach an innovative lesson so I just taught a normal lesson without any resources; I used only the chalkboard and the one textbook.* (P10 – RJ – Oct 2015)

Due to the absence of the components necessary for curriculum innovating participants nine and ten chose not to teach using innovation. It is evident that they "gave up" and reverted to the traditional methods of teaching and assessment. This resonates with the assertion of Nsengimana *et al.* (2014) who state that because certain schools lack the capacity to support innovation, teachers withdraw to the security of a more traditional method of teaching. This correlates with Altinyelken's (2010) affirmation that poor management within the school creates an environment where innovation can no longer be sustained. A desire for innovative teaching can easily be eradicated by the contextual factors of the school.

4.6.2. Theme 2: Overcoming challenges: Creating spaces for innovating

Some participants who had successfully engaged in curriculum innovating indicated they had encountered restrictions or barriers which could have deterred them from being innovative. These barriers were different and unique to each participant. The following responses arose from their individual interviews:

> *I did have some issues with resources because they were limited… but this professional development module gave me motivation to want to be innovative. So I had to find ways to get my own resources and work around the crowded classroom…* (P2 – II)

The resources were a bit limited but I felt a need to overcome this and ensure I could make my lesson innovative and exciting for learner by creating my own worksheets and models of diagrams from the textbooks. (P2 – II)

With regards to resources it was an issue, especially desks and chairs and few textbooks for learners. But I was motivated by the professional development and I had the capacity to work through these challenge. I learnt that you can be resourceful and develop your own resources and worksheets and use technology that can attract learners' attention. (P5 – II)

The subsequent journal entries affirmed the responses from the individual interviews:

I was able to make use of resources at school, however resources are limited. Being innovative actually gave me the confidence to continue with the lesson in this capacity. (P2 – RJ – Oct 2015)

…teachers do have freedom to be innovative in class. This is difficult though due to the lack of physical resources at school. At times, there are not enough desks and chairs for the learners. Teachers within the school have their own methods of teaching and no contact takes place between teachers about how sections should be taught. At the beginning of my teaching year last year, this was difficult as I was not offered much guidance. After the professional development I found new ways to teach a class and became more confident in my teaching. (P2 – RJ – Oct 2015)

To a certain degree I did experience a lack of resources; however I felt that I needed to find ways to work around such constraints e.g. alternate certain activities. (P4 – RJ – Oct 2015)

…lack of resources caused a problem but I was motivated to work around those problems and still be innovative in my teaching. Even if it meant creating my own resources such as worksheets or models of diagrams that learners see in the textbook. (P4 – RJ – Oct 2015)

Although I had full access to the physical resources at the school, these resources were limited. Due to the large class sizes, furniture was limited and learners had to use the side benches and bring in furniture in order to complete the classroom tasks… Many of the learners had to share textbooks, but the use of the data projector assisted

in curbing those challenges as it outlined all the crucial information on an easy to view presentation that was accessible by all the learners, this ensured that they all received the same information and no one was left out or left behind. I was motivated to work and overcome these challenges. (P5 – RJ – Nov 2015)

Teachers overcame barriers by creating models and other resources and alternating activities in order to teach science successfully. They supplemented the use of textbooks, which were in short supply, by using an additional resource, such as a data projector. They brought in furniture to ensure that the classroom environment was conducive to teaching. In this way, teachers transcended barriers associated with limited resource provision. This correlates with Rogan's (2007) ZFI which states that once the teacher has the capacity to support innovation they will be able to move from routine practices to more ideal practices. These teachers were able to navigate their way through the ZFI and into more ideal practices regardless of the hurdles facing them. The use of technology emphasised that these teachers now possessed knowledge of the benefits of the use of technology to engage their learners in teaching and learning which forms part of Vygotsky's Engagement Theory (Stahl, n.d.).

The following photo narratives supported the preceding individual interview responses and subsequent journal entries:

Photograph 17

Learners work in close proximity to each other and this can be a distraction as they work through activities. But these learners are not discouraged by the lack of space and are enjoying their discussion.

Photograph 18

There are not enough chairs and space for learners to engage with the activities given to them. But it is apparent that these learners are meaningfully engaged with their activity regardless of the restrictions.

Photograph 19

This picture illustrates the lack of space. However, these learners are unperturbed by their confinements and are happily engaged in their work.

Participants' responses indicated a degree of difficulty with regard to physical resources available at their school. This resonates with Adler's (n.d.) assertion that physical resources can be used to support and promote learning within the classroom. Physical resources have the power to either promote or restrict learners' access to knowledge. Adler (n.d.) adds that a resource has the ability to make learning visible to learners and grasp their attention. The preceding photo-narratives demonstrated that some participants had been restricted in their attempt to innovate when they taught environment and sustainability education, due to the lack of physical resources at their schools. To some teachers a lack of resources may be overwhelming and curriculum innovating may be difficult to envisage. But the responses of participants clearly highlighted their desire and dedication to teach innovative lessons on environment and sustainability education. These participants were able to tap into the knowledge they had gained from the professional development module to innovate, despite being in under-resourced schools. Although these participants faced challenges and barriers, they chose not to abandon the quest to be creative and innovative.

The perseverance displayed by these participants is symbolic of the qualities of a leader. Participants demonstrated greater confidence and a realisation that they possessed the freedom to innovate and were not restricted by the factors that surrounded them. These participants were able to navigate from their current practice, through the ZFI and towards ideal practices that were more suited to their context of teaching. Participants did not only bring in science equipment but considered other physical resources such as furniture which was brought from other classrooms, and the use of data projectors compensated for a lack of textbooks for learners. This concurs with the Rogan's and Aldous's (2005) contention that teacher factors, learner factors and physical resources all contribute to a teacher being able to engage in curriculum innovating.

These participants initiated and drove the process of curriculum innovating in environment and sustainability education. They were motivated to overcome the barriers and find to their own resources. The professional development module stimulated these teachers to work beyond the boundaries of their usual classroom practice and make decisions that a leader would take. This correlates with views by O'Sullivan *et al.* (n.d.) that school leadership is second only to effective professional development. This is supported by Frost's (2012) assertion that transformation and innovation in education is associated with leadership. These participants demonstrated increased levels of leadership by managing and alternating their available resources in a manner that maximised learner participation. This professional development module gave these participants the opportunity to be responsible for the level of effective teaching and learning occurring within their own classrooms. These science teachers were given ownership of their classrooms rather than being mere tenants of their classrooms. This concurs with Frost's (2012) contention that the act of giving teachers ownership (responsibility) of their classrooms arouses a potent driving force within them that releases an intense enthusiasm, and they attribute a sense of moral purpose to their teaching.

Change empowerment and transformation

Teachers articulate the following in analysis of individual interviews and reflective journals:

> *"feel renewed, rejuvenated"*
>
> *"passionate and innovative teacher" "I am motivated to be an innovative teacher"*
>
> *"change towards teaching, I think and practice in different ways"*

"I developed and gained confidence, I feel more empowered and I have the capacity to be innovative"

This signalled a change in teachers' professional identity. This change was marked by transformation and empowerment in teachers as they moved through the ZFI through creative teaching and assessment strategies. This was facilitated by action on the part of teachers, school management, learners and providers of the professional development module, and is the justification for embedding this study in the critical paradigm.

Discussion

Curriculum innovating is a necessity if there is to be an improvement in learner performance in environmental education and science as a whole. The ZFI is a point in the process of teaching where this improvement can be initiated. A teacher can move through the ZFI and initiate innovative, exciting lessons that stimulate learners' attention. One way in which this can be accomplished is if the teacher is actively involved in effective professional development.

According to Rogan and Aldous (2005) the degree to which a teacher will innovate is dependent on the following constructs:

- Capacity to innovate

Rogan and Aldous (2005, p.317) state that this construct "is an attempt to understand and elaborate on the school-based factors that are able to support, or hinder, the implementation of new ideas and practices". They add that it must be noted that not all schools possess the capacity to implement an innovation at the same level and with the same intensity. Findings from this study revealed that the following school based factors increased teachers' capacity to innovate: the teaching resources, the teacher factors, the learner factors and the school ethos and management. Each of these factors played a significant role in participants being able to engage in curriculum innovating. Participants who had positive experiences of these school based support factors were able to innovate as they taught environment and sustainability education. Participants nine and ten however had a negative experience of a combination of all three factors that restricted their attempts to innovate.

- Outside influences

This construct "is intended to describe the kinds of actions undertaken by organisations outside of a school that nevertheless attempt to influence its practice" (Rogan & Aldous, 2005, p.318). This construct reflects the various levels of support/resistance offered by organisations to the school to affect change (Rogan & Aldous, 2005). In my study the outside influence was the professional development module, Curriculum Development in Science and Mathematics Education. All ten participants revealed that, after they had engaged with the Curriculum Development in Science and Mathematics education module as part of the professional development, they possessed the capacity to innovate. Eight out of ten participants revealed that the outside support, the school context and the knowledge gained through the professional development module, propelled them to be innovative. Eight out of ten participants also agreed that they have gained strategies and methods of teaching and assessment, from the Curriculum Development in Science and Mathematics Education module that allowed them to be innovative in their teaching. These participants revealed that due to their engagement with this module, they acquired the necessary tools required to be innovative and also achieved the requirements of the curriculum, that is timeous completion of the stipulated curriculum.

- Profile of implementation

"This construct is used to comprehend and articulate the degree to which the principles of a set of curriculum proposals are being put into practice" (Beni, 2014, p.72). Rogan and Grayson (2003, p.1181) assert that "the profile of implementation is intended to suggest a plan of the learning area and to propose a number of potential paths that could be taken to a number of destinations". In my study the profile of implementation for participants included the following: classroom interaction, practical work and teaching and assessment strategies. Around 80 percent of participants were able to plan and execute their lessons incorporating curriculum innovating. The participants' capacity to innovate as well as support from the major stakeholders of the school, allowed them to successfully engage in curriculum innovating in environment and sustainability education.

More simply, capacity to innovate refers to the personal factors than enhance or constrain a teacher from being innovative. The outside influences refer to the factors outside of the control of the teacher that enhance or constrain a teacher from being innovative. And, the

profile of implementation refers to the different methods or strategies that could be used by the teacher to be innovative.

It is evident from the responses that participants had gained knowledge and skills of innovative methods and strategies from this module and they were enabled to teach innovative lessons in environment and sustainability education. Participants had indicated that, after engaging with the module on Curriculum Development in Science and Mathematics Education they had the capacity to be innovative.

Responses of participants also revealed that before engaging with this Curriculum development in Science and Mathematics education module they did not possess that ability to be innovative. It would appear that out of the three constructs of the ZFI postulated by Rogan and Aldous (2005) that the most crucial in the process of being innovative in science teaching is the capacity to innovate. This indicates that the teacher is the focal point of the process to be innovative. This resonates with Lamie's (2004) assertion that the teacher plays a vital role in the process of innovating.

Fishman and Krajcik (2003) allude to an important facet of the process of innovating which is that teachers fail to implement an innovation when their personal capacity is lower than the capacity required for them to innovate when they teach. The participants in this study indicated that before studying this Honours module their capacity to innovate was below the level required to be innovative in their teaching of environment and sustainability education. This resonates with Rogan's (2007) assertion that there exists a continuum of practice: a zone called the ZFI where innovation can be made possible. As soon as a teacher has increased the capacity to be innovative, the ZFI is widened and the teacher is able to move from old or routine methods of teaching and assessment to new or innovative methods of teaching and assessments, and finally towards ideal practice. The preceding responses of participants (p. 160) revealed that their capacity to innovate had increased, their ZFI had widened and they were able to teach and assess using new, innovative methods. The Curriculum Development in Science and Mathematics education module that participants had engaged with had increased their capacity to innovate in environment and sustainability education.

Table 8: A summary of the responses from participants regarding their personal capacity building to support innovation after having engaged in the Honours programme.

Tick indicates participant answered yes to the question

Cross indicates participant answered no to the question

THEME	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Can you now engage in curriculum innovating in environment and sustainability education?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Do you possess the capacity to support curriculum innovating?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Do learners respond better to the "new" (innovative) method you have adopted?	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Will you use your ability to innovate curriculum in your teaching of other subjects?	✓	✓	✓	✓	✓	✓	✓	✓	X	X

4.7. Conclusion

In this chapter, I analysed the findings that emerged inductively from the data. The findings were presented in the form of themes in response to four research questions that framed this study. The findings included practicing science teachers' views and experiences of curriculum innovating in environment and sustainability education as they studied towards a Bachelor of Education (Honours) qualification. The first view was the lack of innovation in environment and sustainability education in the Science and Mathematics Honours programme. The second view was that participants expressed a call or a need for more innovation to form part of the Science and Mathematics Honours degree. The experiences of participants in curriculum innovating in environment and sustainability education revealed both challenges and benefits. Participants revealed a lack of effective professional development, a lack of knowledge on environment and sustainability education, a lack of

resources, a lack of support from school management and poor work ethic of learners, as challenges when attempting curriculum innovating in environment and sustainability education. In spite of these challenges some participants revealed that when they engaged in curriculum innovating in environment and sustainability education it enhanced participation, learning and understanding of their learners in the science classroom. Data from participants revealed that the increased levels of participation, learning and understanding of learners serves as a motivating factor for sciences teachers themselves. Findings from participants further revealed that by possessing amplified levels of motivation and having knowledge of how to innovate, they were able to find more opportunities for curriculum innovating in environment and sustainability education as well as in other topics in science education. Literature was presented in substantiation of the themes that emerged. The next chapter will focus on a summary of the main findings together with recommendations and conclusions.

CHAPTER 5

Summary, Recommendations and Conclusions

CONTENTS **PAGE**

5.1. Introduction 166

5.2. Summary of significant research findings 166

5.3. Recommendations: Insights derived from the findings 174

5.3.1. Insight one 174

5.3.2. Insight two 175

5.3.3. Insight three 176

5.3.4. Insight four 177

5.4. Implications for further research 181

5.5. Limitations 181

5.6. Conclusion 181

5.1. Introduction

This qualitative study sought to explore how science teachers who are studying towards an Honours qualification engage in curriculum innovating in environment and sustainability education. This chapter serves to recapitulate the key findings that emerged inductively from the data. These findings contribute towards answering four critical questions which guided the study. First, a summary of significant research findings addressing each research question is presented. Second, a discussion of the recommendations directed to teacher education institutions, school management teams, subject advisors, professional development programme developers and practicing sciences teachers brings this chapter to a conclusion.

5.2. Summary of significant research findings

This chapter captures the responses of participants to the following four research questions that framed this study:

1. What professional development related to innovating in environment and sustainability education is being offered to science teachers studying towards an Honours degree at a higher education institution?

2. What challenges did teachers encounter when working with environment and sustainability education before they engaged with the professional development module at the higher education institution and did teachers display a transformation in their teaching after engaging with professional development?

3. How do science teachers who have engaged in professional development activities enact the curriculum by innovating in environment and sustainability education?

    3.1. What types of strategies do science teachers use when innovating in environment and sustainability education?

    3.2. Why do science teachers use these strategies?

4. What factors are obstructive to curriculum innovating in environment and sustainability education? How do science teachers respond to these factors?

The responses to the research questions will be presented as themes that have emerged out of this study.

Research question one sought to induce data regarding participants' views about Honours modules related to curriculum innovating in environment and sustainability education. The findings revealed that participants were of the view that there was a lack of information about innovation in environment and sustainability education in the science and mathematics education Honours degree. Participants all shared the view that there was only one module, Curriculum Development in Science and Mathematics Education that included content and/or practical work regarding curriculum innovating in environment and sustainability education. It was found that participants expressed confusion surrounding the reason for the lack of innovation in environment and sustainability education in the Honours degree and placed responsibility for this situation on the module coordinators at the university.

This study further revealed that participants believed that there was a need for inclusion of more information related to innovation in environment and sustainability education in the science and mathematics education Honours degree. Participants revealed a desire to engage with more pedagogical content knowledge of environment and sustainability education. Findings from this study revealed that participants were able to identify topics in other modules of the Honours degree that could have been an initiation point for curriculum innovating in environment and sustainability education. Participants in this study argued for the use of more practical work to better assist them in curriculum innovating in environment and sustainability education.

Figure fourteen illustrates the views expressed by participants who were studying towards an Honours qualification and engaged in curriculum innovating in environment and sustainability education.

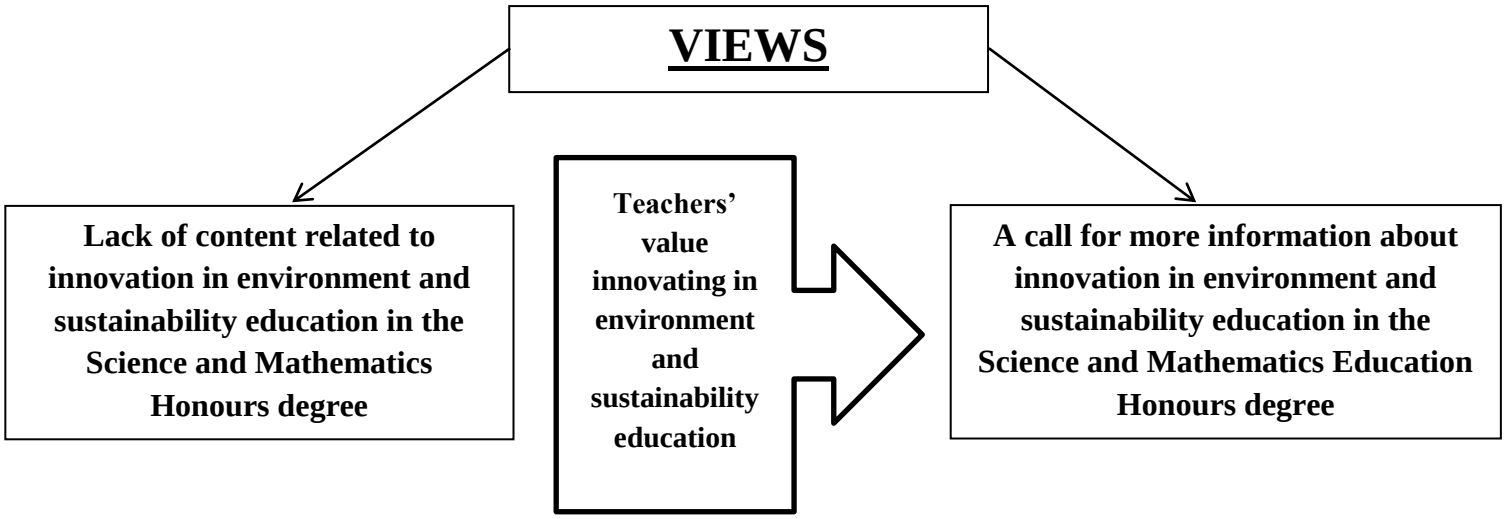


Figure 14 – Views expressed by teachers as they engaged in curriculum innovating.

The next set of themes emerged from the second research question in which the participants were asked about the challenges they encountered when working with environment and sustainability education topics, before engaging with the professional development programme, and whether they had experienced a transformation in their teaching due to the professional development.

Professional and contextual challenges were evident in the data. The first included ideas around the lack of knowledge and skills related to teaching strategies/methods to innovate when teaching environment and sustainability education and ineffective professional development (initiated by Department of Basic Education) related to innovating in science teaching. The second included ideas around a lack of support from school management and other stakeholders and a lack of resources in school which were cited as part of the challenges.

The findings of this study revealed that participants had experienced challenges, both professional and contextual in nature. The challenges experienced by participants affected the way they enacted the curriculum. Participants experienced professional challenges that made them doubt the deep understanding of their subject matter and pedagogic content knowledge of environment and sustainability education. Participants expressed their lack of confidence in teaching this specific topic in Natural/Life Sciences. This inherent lack of confidence that participants experienced was exemplified by their severe lack of knowledge about teaching and assessment methods. In addition to the professional challenges, which included a lack of knowledge regarding innovative strategies for teaching environment and sustainability

education and ineffective professional development (offered by the Department of Basic Education) (DoE), participants also experienced contextual challenges.

Contextual factors were unique in some instances and restricted some participants from innovating as they taught environment and sustainability education. This is significant given that all participants had experienced challenges of a contextual nature. Participants reported ineffective professional development offered by the Department of Basic Education, a lack of support from the school management and other stakeholders, and a lack of resources in the school as part of the contextual challenges.

In research questions 3.1 which explored teaching and assessment strategies used when innovating in environment and sustainability education, two themes emerged.

All of the participants chose to teach a topic from either Natural Sciences or Life Sciences and each lesson was an attempt to enact the curriculum by innovating in environment and sustainability education. Findings revealed that the teaching strategies selected by participants varied as they chose different topics to teach. Eight out of ten participants adopted strategies for curriculum innovating, while the other two participants were unable to innovate in their lessons. What was evident was that certain teaching strategies were preferred by a majority of the participants. All eight of the participants who engaged in curriculum innovating made use of group work as a pedagogical strategy. Five out of the eight participants that did innovate in their lessons chose audio-visual aids to enhance their teaching. Participants saw the value of technology in their lessons and the benefits for learning that it afforded. Participants who made use of technology in their lessons reported increased levels of participation from their learners and an unparalleled excitement amongst learners about learning. Participants' responses revealed that technology (in the form of a power-point presentation, for example) is a tool that must be utilised in the classroom because it captivates the attention of the learner and gives the learner a point of focus in the classroom.

When asked about assessment strategies used by participants when innovating in environment and sustainability education, it was found that participants' understanding of what curriculum innovating is influenced the methods of assessment that they chose to implement. Eight out of the ten participants displayed innovative methods of assessment in their lessons. Participants nine and ten were again unable to innovate as they assessed their lesson on environment and sustainability education.

Of the eight participants that did innovate in their assessment methods, their choice of methods for assessment was diverse. This was an indication that these participants were able to identify which methods of assessment would be best suited for their specific context. Rogan's (2007) ZFI speaks of innovation working in a specific context and no one type of innovation can be effective in every context. These eight participants had grasped this concept and used their knowledge of their unique context and their specific learner factors when selecting the most appropriate assessment methods. The most common method of assessment selected by participants was the poster presentation (three out of eight participants chose this method). The most unique method of assessment was selected by participant two who assessed learners' understanding by asking them to classify leaves using a dichotomous key which they had to construct. This was a more intricate method than the poster presentation, but again this demonstrated this participant's understanding and evaluation of the school context. Another interesting finding that demonstrated the unique and knowledgeable approach to the selection of assessment methods was the fact that all eight participants reported that their learners were enthusiastic and excited about the assessment tasks. Participants stated that their learners were intrigued and very interested in the different and exciting activities set before them. They were excited to be part of the lesson and to respond to the assessment tasks. This was a crucial factor in sustaining teacher motivation for curriculum innovating.

When asked why participants chose specific strategies of teaching and assessment, in research question 3.2, three themes emerged.

This study revealed that all participants, after engaging with the module on curriculum development in science and mathematics education, were able to recognise a need to innovate when they taught environment and sustainability education. This need however, was blurred due to the various and diverse contextual factors affecting each participant at their specific schools. Findings revealed that only eight out of ten participants were able to innovate while the other two noted the extreme and restrictive contextual factors that prohibited them from being able to innovate as they taught environment and sustainability education. Of the eight participants that did innovate, a variety of innovative teaching and assessment methods were selected. Many of the eight participants chose to use technology in their lesson and that proved to be a useful tool during lessons as learners were able to make conceptual connections by engaging with it visually. Although contextual factors such as a lack of resources, uncooperative learners and uninspiring management existed in some cases, these

eight participants were able to move their teaching and assessment strategies from the routine towards the ideal. These participants were able to drive the innovation. This is correlates with Rogan's and Aldous' (2005) assertion that through the use of resources teachers' teaching and assessment strategies can be enhanced to the benefit of the learner in the classroom.

This study further revealed that participants became more aware of the requirements for curriculum innovating in environment and sustainability education. This awareness was brought about through their engagement with one module of the professional development programme. A key finding is that majority of participants who taught innovative lessons used technology to teach. These participants saw a link between the use of technology and innovating in the science classroom. Participants revealed that their learners were more attentive and responsive when they used technology, in the form of a computer and data projector, compared to using a worksheet. Another finding was that participants were able to find the exact space in their lessons for the use of technology. This resonates with the ZFI because participants were able to move from their traditional, routine methods of teaching to new, ideal methods that were better suited to their context.

Participants shared the view that before studying this module (Curriculum Development in Science and Mathematics Education) they had neither the knowledge nor the capacity to innovate when they taught environment and sustainability education. However findings from this study revealed that after these participants engaged with this module their content and pedagogical knowledge of curriculum innovating, and their capacity to innovate, had increased. This is congruent with Rogan's (2007) ZFI which postulates that as a teacher engages with outside support (effective professional development for example) they are able to build their capacity to innovate and they move from their old, traditional methods of teaching and assessment to more ideal and appropriate methods. This is a major revelation of this study. This study revealed how constructs in Rogan's ZFI can be enacted, thereby bringing to life the theory-practice transition. Teachers who were unable to innovate were now empowered and transformed into innovative practitioners. Findings revealed that visibility of opportunities for curriculum innovating increased, and enabled these teachers to innovate, not only in science but also in other subjects.

Findings from this study further revealed that there were factors that allowed participants to innovate when they taught environment and sustainability education. These factors gave

participants the opportunity to use the knowledge and skills they had gained from the professional development module to engage in curriculum innovating. Participants had the support of their school management as well as the resources in school to help them innovate as they taught environment and sustainability education. Interestingly data generated from participants revealed that these factors were in fact part of the curriculum development in science and mathematics education module that they had engaged with. Enabling factors included sufficient resources to plan and teach the lesson, adequate support from the school management team and most importantly, enthusiastic learners.

Resources and support from school management play a vital role for any teacher that has the vision of curriculum innovating. Rogan's (2007) ZFI states that teachers will be able to build their capacity to innovate if they have the required resources and invaluable support from the school's higher authority. The attitude of the learners was a major contributing factor to the success or failure of curriculum innovating for these participants. Findings that arose from this study indicate that the role of the learner in teaching and learning is of vital significance. If learners are enthusiastic about learning and show an interest in what is being taught, teachers are directly motivated to be more prepared and more efficient in the classroom.

In research question four which explored factors which restricted participants from engaging in curriculum innovating, three themes emerged.

This study revealed that two out of ten participants were unable to innovate as they taught environment and sustainability education. These two teachers were constrained by the contextual factors at their schools. These factors included a lack of resources, inadequate support from the school management team and a negative attitude to learning displayed by learners in their classrooms.

Additional findings from the study were that these two participants' attempts to innovate were thwarted by contextual factors. They therefore resolved to teach environment and sustainability education in the more traditional manner.

A key finding from this study is that the contextual factors these two participants encountered were partly similar to those that other participants experienced at their schools. What was different was that some participants created spaces and overcome the restrictions by being innovative and creative in their planning and teaching. Teachers, whose barriers included a lack of resources and an unsupportive school management, created opportunities to transcend

these metaphorical boundaries. They borrowed resources from other schools and revealed their potential for curriculum innovating, regardless of the scant support from the school management members. These teachers chose to navigate beyond the zone of routine practices, and into a zone which was feasible for experimentation and innovation; this latter zone refers to Rogan's ZFI (2007). These micro-movements by participants illustrated a renewed and different view of teaching that was necessary in order for them to improve their teaching of environment and sustainability education. Two teachers were unable to innovate. They circuitously allowed their context to prescribe the methods they should use to teach. This was because these two teachers lacked the capacity to innovate, they did not have the support from stakeholders of the school and they did not have the necessary knowledge of the methods of innovative teaching. The three constructs of Rogan's ZFI (2007), namely capacity to innovate, outside support and profile of implementation all need to exist for a teacher to engage in curriculum innovating. If all constructs do not exist in the context of the teacher, opportunity for curriculum innovating decreases.

All participants experienced challenges when they attempted to engage in curriculum innovating in environment and sustainability education. Key finding emerged regarding participants who created spaces for curriculum innovating. These participants were able to tap into their knowledge gained from the Curriculum Development in Science and Mathematics Education module and ignite a desire and willingness to persevere towards curriculum innovating. One participant networked with another school and was able to borrow resources that facilitated curriculum innovating. Lave and Wenger (1991) postulate that networking between teachers provides a unique and useful way of negotiating problems in teaching. When teachers form relationships with other teachers of similar subjects, resources can be shared, as well as ideas about teaching and assessment. This participant was able to engage in curriculum innovating by borrowing resources, thereby addressing the school-based challenge of a lack of teaching resources. Another school-based factor that was overcome was a lack of furniture for learners. One of the participants went to a neighbouring teacher's classroom and borrowed furniture so that each learner had a desk and chair. This correlates with Lave's and Wenger's (1991) assertion that building a community of practice allows teachers the opportunity to find solutions to certain contextual limitations and be able to successfully teach content to learners. Without building a community of practice these participants would have not been able to tap into the potential support of teachers and management in their schools. This indicates a connection between building a community of

practice, even within a specific school, and the potential benefit of outside support to create opportunities for teachers to engage in curriculum innovating. These participant were also able to use their pedagogic knowledge gained from the professional development module to successfully teach environment and sustainability education.

Participants who were able to engage in curriculum innovating demonstrated perseverance and highlighted the qualities of good classroom leaders. This in turn illuminated the increased confidence of these participants to strive to find the space where curriculum innovating can be enacted.

5.3. Recommendations: Insights derived from the findings

Different science teachers have different experiences of curriculum innovating in environment and sustainability education. These experiences are shaped by their engagement with professional development programmes which are stipulated as mandatory by the DoE, and which differ from personal professional development endeavours that a teacher can pursue in terms of a postgraduate degree.

In a country where science is seen as a critical, but cognitively challenging, there needs to be more emphasis on the value of a scientifically literate people, the perspectives that science teachers have about the value of science (both Natural Sciences and Life Sciences), and the attitude of learners in the classroom. I wish to propose a number of insights that have been derived from the findings that may assist in reclaiming the esteem that was once attached to science.

5.3.1. Insight one: Effective, relevant professional development

Professional development is intended to enhance teachers' disciplinary and pedagogic knowledge. Rogan and Aldous (2005), referring to Rogan's ZFI, categorise the factors that affect a teacher under the construct *capacity to innovate*. They postulate that the factors that affect a teacher negatively will not allow him/her to build the capacity to innovate. Teachers who attend workshops or professional development programmes need to be given tools and methodologies by competent facilitators that will assist them in the classroom. Vygotsky's (1978) ZPD can be used as the blueprint for facilitators in the construction of professional

development programmes. The ZPD can be viewed as scaffolding that bridges the gap between what is known as what is yet to be known. The aim of professional development programmes should be to provide teachers with new knowledge and understanding, taking teachers from their current methods of teaching and assessment to new, ideal methods.

In science education teachers require assistance in respect of resources, pedagogic content knowledge and addressing the needs of learners who have difficulty understanding concepts. Professional development programmes should be constructed around the core needs of a science teacher and that there can be no fixed criteria for professional development (Singh, 2011). There needs to be a restructuring of the manner in which professional development programmes are co-ordinated and delivered. Teachers should perceive a workshop as a gateway to receive valuable knowledge, and a platform to network on issues related to challenges and opportunities in their teaching. The idea of teachers from different schools, of similar subjects, working together correlates with Lave and Wenger's community of practice (1991). Teachers working together and sharing insights into teaching and assessment difficulties and success can greatly enhance the teaching in schools. Effective professional development allows the teacher to be actively involved rather than passively receiving whatever the co-ordinator deems useful (Gulamhussein, 2013). There needs to be a change in the rationale of professional development programme developers, a change that will start to address teaching and learning challenges facing teachers rather than misconceptions in the CAPS documents.

5.3.2. Insight two: Teacher support from more knowledgeable others e.g., subject advisors

Teachers are critical to the process of teaching and learning. The role of the subject advisor in this process cannot be over-emphasised. Subject advisors are crucial in the implementation phase of teaching any new method or innovation (Gulamhussein, 2013). Rogan and Aldous (2005) alluding to Rogan's ZFI, categorise school management under the construct "capacity to innovate". This part of the process of teachers building their capacity to innovate is dependent on the quality and level of support they receive from their school management. If support from the school management is inadequate it will hinder the teacher from being able to innovate when they teach (Rogan & Aldous, 2005).

Currently, most subject advisors visit schools only on account of what is deemed necessary by superintendents, namely, to assess and sign the teaching preparation files of a teacher. This does little towards the professional development of the teacher. Some of the challenges that have emerged from this study which could be discussed with subject advisors are: alternative methods of teaching content in a context with scant resources, support from HODs, the poor work ethic amongst learners and what could be done to remedy the situation, the ineffectiveness of many of the professional development programmes which teachers are compelled to attend and which do not enhance the content and pedagogic knowledge of the teacher, the language barrier facing learners in the classroom, and assistance to expand opportunities for assessment and learning. Subject advisors need to re-look at their portfolios and become more actively involved in their teachers' professional lives. An active, interested subject advisor can create an atmosphere of learning for the teachers and a space for them to have their difficulties heard and addressed. This correlates with Rogan's ZFI (2007). The teacher needs to have the support from the subject advisor who is situated outside the school. This support can be invaluable to the teachers as they attempt to overcome school-based factors that restrict them from engaging in curriculum innovating. It is important to note that every school context is different and the support of the subject advisor becomes instrumental in a teacher's progression through the ZFI. The subject advisor position could be interpreted as being that of "a more knowledgeable other" (according to Vygotsky ZPD) who could provide skills and knowledge to enable teachers to learn how to overcome challenges.

5.3.3. Insight three: Effective school management teams

A school is only as effective as the management team that runs it. Some schools are enjoying the rewards of effective and progressive school management teams, while other schools are declining due to the ineffective, stagnant approach of their school management teams. Principals, vice-principals and heads of department should consider the learners in every decision that they make. School management teams should have effective teaching and learning in mind and aim to grow the school in this fashion. School management teams should assist teachers and be visible in the process of teaching and learning (Singh, 2011). Rogan's ZFI places importance on the school and all facets of the school (Rogan & Aldous, 2005). The school and the management of the school need to be effective in the capacity building of the teacher and the development of the learner. One way to do this would be to

provide encouragement and long term opportunities to allow teachers to experiment with new teaching and learning strategies. A weak or poorly managed school will have teachers with less than the required capacity to innovate and learners that are apathetic towards school and their assessment tasks. Rogan and Aldous (2005) propose that school management team should be visible and should promote responsible and effective functionality within the school.

It is essential that every learner in the school is seen as valuable and that not one learner should be deprived of effective teaching and learning. The learner composition of any school should not be ignored in any decision taken by the school's management. According to Rogan's (2007) ZFI the teacher, the school management and ethos, and the physical resources of the school all affect the proficiency of the learners in the school. A school that has teachers who are able to innovate when they teach, has a committed, strong and visible school management and ethos, and has adequate teaching resources will produce learners who are responsible, fluent and willing to try new kinds of learning (Rogan & Aldous, 2005). As a consequence, teachers will draw inspiration from these positive factors and their motivation to innovate can be sustained. Strong school management, hard-working learners and relevant resources provide teachers with the impetus to initiate and enact curriculum innovating.

5.3.4. Insight four: Teachers as progressive, conscious practitioners

A teacher is central to curriculum delivery. Teachers should recognise themselves as vital in the process of education. Science teachers should realise that knowledge can become obsolete and that acquiring new knowledge is vital to them being effective in the classroom (McFarlane, 2013). Effectively growing one's knowledge as a teacher will allow one to navigate past misconceptions of policy and be able to meaningfully affect the lives of learners. Science teachers should be able to recognise when a method of teaching or assessment is failing and be able to adjust without disadvantaging the learner. This is where teachers should be able to engage with curriculum innovating in order to be effective. This is possible through effective, long-term professional development in the form of post-graduate degrees at university. These degrees offer teachers the opportunity to develop and become progressive teachers who are able to adapt to the environment and specific needs of learners they encounter. Having the ability to be aware of learners' needs is crucial to effective

teaching and learning (Davis *et al.*, 2006). Rogan's (2007) ZFI places the teacher at the forefront of curriculum innovating. The teachers should move from current practice to ideal practices, teachers should build their capacity to innovate and teachers should be able to identify opportunities for curriculum innovating as they teach environment and sustainability education (Rogan, 2007).

In light of the above mentioned recommendations, I propose a model (which borrows selectively from models in chapter 2) for curriculum innovating in figure 15.

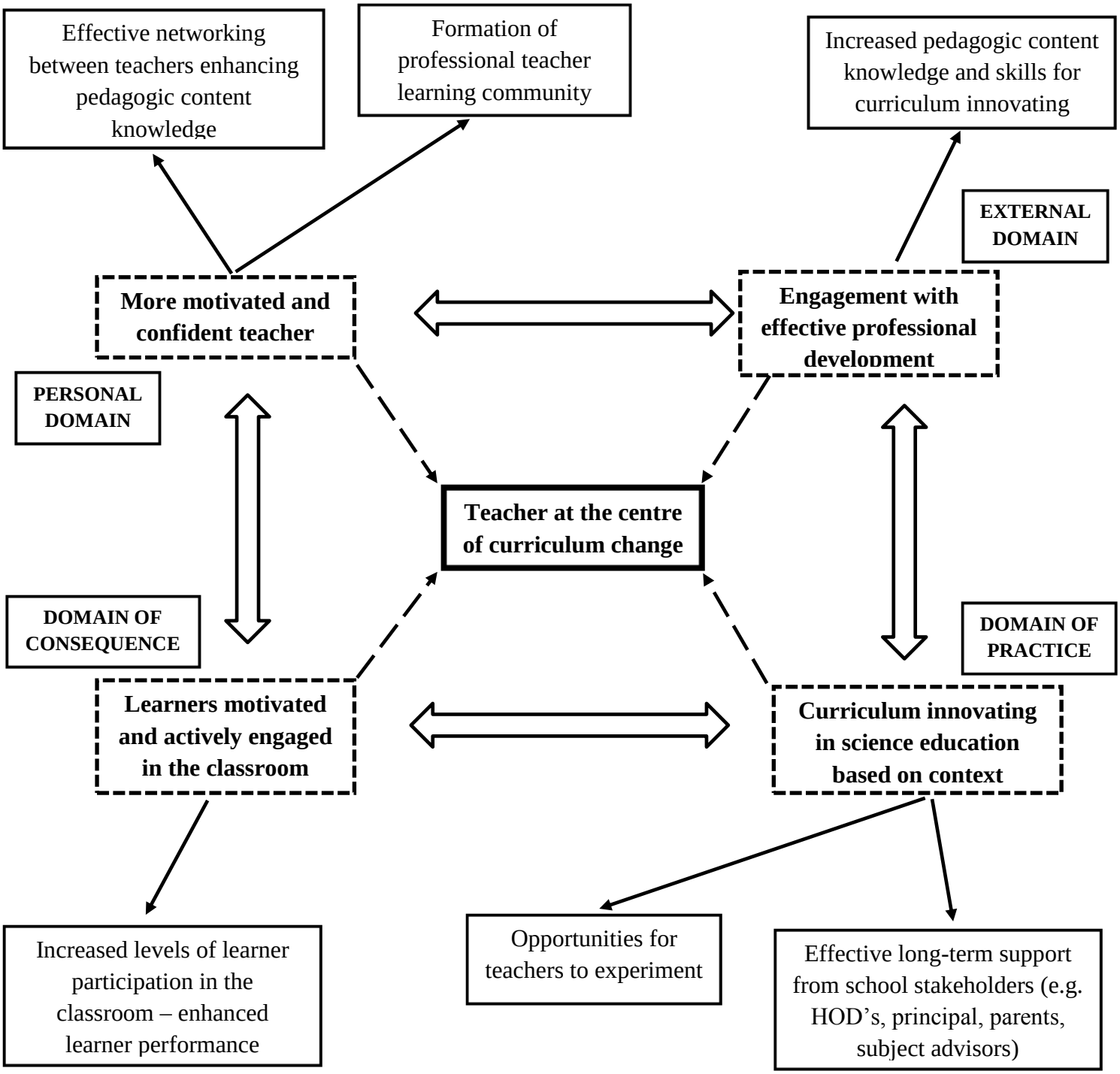


Figure 15 – Ismail's model on enabling teachers to engage in curriculum innovating

The role of the teacher cannot be discounted in curriculum innovating. The teacher should be at the centre of any curriculum change. Being at the centre of curriculum change gives the teacher the opportunity to embrace the change and develop with the change. The professional growth of a teacher occurs in four interconnected cyclic domains namely: external domain, domain of practice, domain of consequence and the personal domain (Clarke & Hollingsworth, 2002). The effectiveness of science teachers depends on their development within each of these domain. The external domain is where the teacher is exposed to effective professional development, for example, and increases pedagogic content knowledge and skills for curriculum innovating. The domain of practice charts teacher progression from routine teaching practices to more ideal teaching practices due to increased pedagogic content knowledge and positive responses from learners. The teacher is able to experiment and engage in curriculum innovating. This is made possible through long-term support from school stakeholders (e.g. HOD's, principal, parents and subject advisors). Positive learner responses to teacher innovation become visible to the teacher and encourages the teacher to sustain curriculum innovating. The personal domain is marked by transformation of teacher identity, from being a transmitter of knowledge to be a passionate, innovative agent of knowledge construction. This empowers the teacher who chooses to network with other teachers and further increase pedagogic content knowledge.

Curriculum innovating gives a science teacher the opportunity to make science content exciting and interesting to learners. For teachers to be able to innovate as they teach they will need to build their capacity to support an innovation. A science teacher can build capacity to innovate by engaging with effective professional development that is focused on innovation. A science teacher can then plan and teach innovative lessons that excite and actively involve learners in the classroom. From the active involvement of learners, teachers can draw motivation and confidence to continue to innovate as they teach and this can serve to further increase learner enthusiasm and performance. This model postulates that one innovation cannot be simply transferred from one context to another (Smith, 2006). However, for the professional development programme to be innovative and effective it must build the capacity of the teacher to a level that allows the teacher to innovate in any context or any subject. This idea concurs with the view of Ismail and Mudaly (2016) who assert that when teachers engage in effective professional development that increases their content knowledge of a subject, their teaching will be enhanced and renewed. These new teaching methods can motivate learners to improve their performance in science, for example. This in turn

motivates teachers to continue renewing and enhancing their teaching because they become encouraged by the positive response of the learners (*ibid*).

5.4. Implications for further research

There is a paucity of literature in the area of teachers engaging with curriculum innovating in environment and sustainability education. This study supplements the discourse of environment and sustainability education. Further studies in the field of curriculum innovating are of importance. There should be critical exploration into the teaching methods of teachers who have engaged in effective professional development to explore how long after the professional development these teachers continue to innovate as they teach environment and sustainability education. More research is required on how teachers can sustain practices related to innovating in environment and sustainability education. Research which focuses on the role of school managers and professional development educators in enabling teachers who engage in curriculum innovating is needed. Research which analyses strengths and weaknesses of different approaches with a view to supporting science teachers, is crucial.

5.5. Limitations

This study was conducted at only one teacher education institution and the findings cannot be generalised to other teacher education institutions. It is suggested that further research be conducted with other teacher education institutions. This study was reliant on the information articulated by participants, who worked within particular school contexts. The use of various methods enhanced the trustworthiness of the study.

5.6. Conclusion

The main aim of this chapter was to present a summary of the main research findings and recommendations of my study. My findings revealed that when teachers engage with effective professional development they are able to engage in curriculum innovating in

environment and sustainability education. Recommendations were made based on the findings and the discussion of the findings. The insights reveal that curriculum innovating in science education is contingent on a confluences of factors, which include effective relevant professional development; support from more knowledgeable others such as subject advisors; effective visionary school management members and teachers who position themselves as progressive conscious practitioners. In terms of professional development teachers in this study enacted curriculum innovating by drawing on skills to enhance their disciplinary content knowledge and pedagogical knowledge which were learnt through effective professional development. Teachers obtained long term guidance and support from school community members and managers. School managers who afforded teachers opportunities to take risks and experiment with the curriculum enabled teachers to enact curriculum innovating in environment and sustainability education effectively. This motivated teachers to enact curriculum innovating by researching disciplinary content knowledge and employing new strategies which were learner centered to facilitate knowledge construction. This process was enhanced through the use of technology to teach. Teachers' awareness of resources which could be leveraged or created enabled teachers to enact curriculum innovating effectively. Positive responses by learners to transformed teacher practices served to empower teachers to teach more creatively and enact the curriculum effectively. This freedom to develop oneself as a teacher resulted in a changed teacher identity; one which was characterized by an intrinsic motivation to become an innovative, passionate and conscious science teacher.

Several recommendations resonated with theoretical constructs from the ZFI. These recommendations emanated from the insights of this study and were directed to the department of education, professional development programme co-ordinators, subject advisors, school management teams and teachers themselves.

It is envisaged that the model I have presented will inform future professional development programmes and enlighten curriculum designers on the potential benefits of curriculum innovating in environment and sustainability education.

REFERENCES

Adler, J. (x). Conceptualising Resources as a Theme for Teacher Education (pp. 1-33). South Africa: University of the Witswatersrand.

Akram, S., Sufiana, & Malik, K. (2012). Use of Audio Visual Aids for Effective Teaching of Biology at Secondary Schools Level. *Leadership Management, 50,* 10597-10605.

Altinyelken, H. K. (2010). Curriculum Change in Uganda: Teacher Perspectives on the New Thematic Curriculum. *International Journal of Educational Development, 30,* 151-161.

Archer, D. (2013). Innovation Needed in Education. 1-3. Retrieved from http://mg.co.za./print/2013-04-26-00-innovation-needed-in-education

Ary, D., Jacobs, L. C., & Razavieh, A. (2002). *Introduction to Research in Education* (6th ed.). Australia: Wadsworth.

Babbie, E., & Mouton, J. (2001). *The Practice of Social Research*. Cape Town: Oxford University Press Southern Africa

Bailey, K. (1994). *Methods of Social Research* (4th ed.). New York: The Free Press.

Bantwini, B. D. (2010). How Teachers Percieve the New Curriculum Reform: Lessons from a School District in the Eastern Cape Province, South Africa. *International Journal of Educational Development, 30*, 83-90.

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study, Design and Implementation for Novice Researchers. *Qualitative Report, 13*(4), 554-559.

Benders, D. S. (2011). Student Apathy: The Downfall of Education. 2-21. Retrieved from http://ssm.com/abstract=19686

Beni, S. (2014). *Foundation Phase Teachers' Interpretation and Implementation of the Natural Science Curriculum in the Life Skills Learning Programme: A Case Study.* Doctor of Philosophy University of KwaZulu-Natal, Durban.

Bertram, C. (2012). What Does Research Say About Teacher Learning and Teacher Knowledge? Implications for Professional Developement in South Africa. *Journal of Education, 52,* 3-26.

Bertos, D. J. (2014). The Teachers Role in Environmental Education. Retrieved from https://prezi.com/xisth15uywph/the-teachers-role-in-environmental-education/

Bloom, M. A., Holden, M., Sawey, A. T., & Weinburgh, M. H. (2010). Promoting the use of Outdoor Learning Spaces by K-12 Inservice Science Teachers Through an Outdoor Professional Development Experience. In A. M. Bodzin, B. S. Klein & S. Weaver (Eds.), *The Inclusion of Environmental Education in Science Teacher Education* (pp. 97-110). London: Springer.

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal, 9*(2), 27-40.

Bryman, A. (2004). *Social Science Research Methods* (2nd ed.). New York: Oxford University Press.

Campbell, T., Medina-Jerez, W., Erdogan, I., & Zhang, D. (2010). Exploring Science Teachers Attitudes and Knowledge About Environmental Education in three International Teaching Communities. *International Journal of Environmental and Science Education, 5*(1), 3-29.

Carleton-Hug, A., & Hug, J. W. (2010). Challenges and Opportunities for Evaluating Environmental Education Programs. *Evaluation and Program Planning, 33*, 159-164.

Chee, Y. S., Mehrotra, S., & Ong, J. C. (2014). Professional Development for Scaling Pedagogical Innovation in the Context of Game-Based Learning: Teacher Identity as Cornerstone in "Shifting" Practice. 1-22. Retrieved from http://dx.doi.org/10.1080/1359866x.2014.962484

Christians, C. G. (2005). Ethics and Politics in Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage Handbook of Qualitative Research* (3rd ed., pp. 139-164). London: Sage Publications.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a Model of Teacher Professional Growth. *Teaching and Teacher Education, 18*, 947-967.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6th ed.). London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2009). *Research Methods in Education* (6th ed.). New York: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education* (7th ed.). New York: Routledge.

Conde, M. C., & Sanchez, J. S. (2010). The School Curriculum and Environmental Education: A School Environmental Audit Experience. *International Journal of Environmental and Science Education, 5*(4), 477-494.

Corbin, J., & Strauss, A. (2015). *Basics of Qualitative Research* (4th ed.). Los Angeles: Sage.

Cotton, D. R. E. (2006). Implementing Curriculum Guidance on Environmental Education: The Importance of Teachers' Beliefs. *Journal of Curriculum Studies, 38*(1), 67-83.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Method Approaches* (2nd ed.). Thousand Oaks: Sage.

Creswell, J. W. (2012). *Educational Research Planning, Conducting and Evaluating Quantitative and Qualitative Research* (4th ed.). London: Pearson.

Creswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry. *Theory into Practice, 39*(3), 124-130.

Damodharan, V. S., & Rengarajan, V. (1999). Innovative Methods of Teaching. *Educational Journal Publication.*

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges New Science Teachers Face. *Review of Educational Research, 76*(4), 607-651.

De Beer, J., Dreyer, J., & Loubser, C. (2014). Environmental Issues and Risks. In C. P. Loubser (Ed.), *Environmental Education and Education for Sustainability. Some South African Perspectives* (pp. 1-39). Pretoria: Van Schaik.

de Jesus, S. N., & Lens, W. (2005). An Integrated Model for the Study of Teacher Motivation. *Applied Psychology: An International Review, 54*(1), 119-134.

De Vos, A. S. (2002). Qualitative Data Analysis and Interpretation. In A. S. De Vos, H. Strydom, C. B. Fouche & C. S. L. Delport (Eds.), *Research at Grass Roots: For the Social Sciences and Human Service Professions* (2nd ed.). Pretoria: Van Schaik.

De Vos, A. S. (2004). Qualitative Data Analysis and Interpretation. In A. S. D. Vos, H. Strydom, C. B. Fouche & C. S. L. Delport (Eds.), *Research at Grass Roots for the Social Sciences and Human Service Professions* (2nd ed., pp. 339-355). Pretoria: Van Schaik.

Denzin, N. K., & Lincoln, Y. S. (2000). Introduction: The Discipline and Practice of Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (2nd ed., pp. 1-28). London: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The Discipline and Practice of Qualitative Research In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (3rd ed., pp. 1-32). London: Sage Publications.

Derrington, M. L., & Angelle, P. S. (2013). Teacher Leadership and Collective Efficacy: Connections and Links. *International Journal of Teacher Leadership, 4*(1), 1-14.

Desimone, L. M. (2011). A Primer on Effective Professional Development. *Kappan, 92*, 68-71.

Dimenas, J., & Alexandersson, M. (2012). Crossing Disciplinary Borders: Perspectives on Learning about Sustainable Development. *Journal of Teacher Education for Sustainability, 14*(1), 5-19.

Donald, D., Lazarus, S., & Lolwana, P. (2002). *Educational Psychology in Social Context* (2nd ed.). Cape Town: Oxford University Press.

Down, L. (2006). Addressing the Challenges of Mainstreaming Education for Sustainable Development in Higher Education. *International Journal of Sustainability in Higher Education, 7*(4), 390-399.

Dreyer, J., & Loubser, C. (2014). Curriculum Development, Teaching and Learning for the Environment. In C. P. Loubser (Ed.), *Environmental Education and Education for Sustainability. Some South African Perspectives* (pp. 145-177). Pretoria: Van Schaik.

Ellsworth, J. B. (2000). Surviving Change: A Survey of Educational Change Models. Retrieved from http://ericir.syr.edu/itheme

Emo, W. (2009). *Teachers who Initiate Curriculum Innovations: Motivations and Benefits.* Doctor of Philosophy, University of York.

Ezzy, D. (2002). *Qualitative Analysis: Practice and Innovation*. London: Routledge.

Farbotko, C., & Lazrus, H. (2012). The First Climate Refugees? Contesting Global Narratives of Climate Change in Tuvalu. *Global Environmental Change, 22*(2), 382-390.

Ferrari, A., Cachia, R., & Punie, Y. (2009). Innovation and Creativity in Education and Training in the EU Member States: Fostering Creative Learning and Supporting Innovative Teaching. Literature Review on Innovation and Creativity in E & T in the EU Member States (ICEAC) (pp. 1-54). Luxembourg: Institute for Prospective Technological Studies.

Fishman, B. J., & Krajcik, J. (2003). What Does It Mean to Create Sustainable Science Curriculum Innovations? A Commentary *Science Education, 87*, 564-573.

Frost, D. (2012). From Professional Development to System Change: Teacher Leadership and Innovation. *Professional Development in Education, 38*(2), 205-227.

Fundisa for Change Programme. (2013). *Introductory Core Text*. Grahamstown: Rhodes University.

Gasson, S. (2004). Rigor in Grounded Theory Research: An Interpretative Perspective on Generating Theory from Qualitative Field Studies. In M. E. Whitman & A. B. Woszczynski (Eds.), *The Handbook of Information Systems Research* (pp. 79-102). Hershey: Idea Group.

Gay, L. R., Mills, G. E., & Airasian, P. (2009). *Educational Research: Competencies for Analysis and Application* (9th ed.). New Jersey: Pearson.

Gobo, G. (2009). Re-conceptualising Generalisation: Old Issues in a New Frame. In P. Alasuutari, L. Bickman & J. Brannen (Eds.), *The Sage Handbook of Social Research Methods* (pp. 193-213). Los Angeles: Sage.

Greeff, M. (2002). Information Collection: Interviewing. In A. S. de Vos, H. Strydom, C. B. Fouche & C. S. L. Delport (Eds.), *Research at Grass Roots: For the Social Sciences and Human Service Professions* (pp. 291-320). Pretoria: Van Schaik.

Green, J. M. (1998). Curriculum Review and Reorientation Experience. *Journal of Family Ecology and Consumer Sciences, 26*(1), 27-33.

Gulamhussein, A. (2013). Teaching the Teachers: Effective Professional Development in an Era of High Stakes Accountability (pp. 1-44): Center for Public Education.

Guskey, T. R. (2000). *Evaluating Professional Development*. California: Sage Publications Company.

Guskey, T. R. (2002). Professional Development and Teacher Change. *Teachers and Teaching: Theory and Practice, 8*(3), 381-391.

Guskey, T. R., & Huberman, M. (1995). The Role of Personal Bases and Characteristics Part 1. In T. R. Guskey & M. Huberman (Eds.), *Professional Development in Education New Paradigms and Practices* (pp. 7-8). New York: Teachers College Press.

Hairon, S., & Dimmock, C. (2012). Singapore Schools and Professional Learning Communities: Teacher Professional Development and School Leadership in an Asian Hierarchical System. *Educational Review, 64*(4), 405-424.

Hameed, G. (2013). Teachers' Views About Curriculum Change at Primary Level: A Case Study of an Urban Girls Primary School. *International Journal of Academic Research and Reflection, 1*(2), 26-36.

Henning, E. (2004). *Finding Your Way in Qualitative Research*. Pretoria: Van Schaik.

Hewson, P. W. (2007). *Teacher Professional Development in Science: A Case Study of the Primary Science Programme's CTI Course*. Paper presented at the Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education, Maputo.

Irwin, P., & Lotz-Sisitka, H. (2014). History of Environmental Education in South Africa In C. P. Loubser (Ed.), *Environmental Education and Education for Sustainability. Some South African Perspectives* (pp. 41-63). Pretoria: Van Schaik.

Ismail, R., & Mudaly, R. (2016). Navigating Beyond the Boundaries of Routine Practices: Tracking Science Teachers' Movement into the Zone of Feasible Innovation Through Professional Development. *PONTE International Scientific Researches Journal, 72*(8), 115-129.

Jara, M., & Mellar, H. (2010). Quality Enhancement for E-learning Courses: The Role of Student Feedback. *Computers and Education, 54*(3), 709-714.

Jickling, B. (1997). If Environmental Education is to Make Sense for Teachers, We Had Better Rethink How We Define it. *Canadian Journal of Environmental Education, 2*, 86-103.

Jimenez-Aleixandre, M. P., & Santamaria, F. E. (2010). Adaption of Innovative Methods in Science Education (pp. 1-86). Austria: Austrian Institute of Ecology.

Johnson, C. C. (2007). Whole-School Collaborative Sustained Professional Development and Science Teacher Change: Signs of Progress. *Journal of Science Teacher Education, 18*, 629-661.

Johnson, S., Hodges, M., & Monk, M. (2000). Teacher Development and Change in South Africa: A Critique of the Appropriatness of Transfer of Northern/Western Practice. *Compare: A Journal of Comparative and International Education, 30*(2), 179-192.

Kahle, J. B., & Boone, W. (2000). Strategies to Improve Student Science Learning: Implications for Science Teacher Education. *Journal of Science Teacher Education, 11*(2), 93-107.

Kalimaposo, K., & Muleya, G. (2014). Mainstreaming Environmental Education in the School and Teacher Education Curriculum in Zambia. *Standard Global Journal of Educational Research, 1*(4), 76-88.

Karkkainen, K. (2012). Bringing About Curriculum Innovations: Implicit Approaches in the OECD Area (pp. 1-65).

Keke, B. (2008). *Science Foundation Students' Experiences at a Tertiary Institution.* Masters of Education, University of KwaZulu-Natal, Durban.

Kinginger, C. (2002). Defining the Zone of Proximal Development in US Foreign Language Education. *Applied Linguistics, 23*(2), 240-261.

Kirkgoz, Y. (2008). A Case Study of Teachers' Implementation of Curriculum Innovation in English Language Teaching in Turkish Primary Education. *Teaching and Teacher Education, 24*, 1859-1875.

Kriek, J., & Grayson, D. (2009). A Holistic Professional Development Model for South African Physical Science Teachers *South African Journal of Education, 29*, 185-203.

Lamie, J. M. (2004). Presenting a Model of Change *Language Teaching Research, 8*(2), 115-142.

Lateh, H., & Muniandy, P. (2010). Environmental Education (EE): Current Situational and the Challenges Among Trainee Teachers at Teachers Training Institute in Malaysia. *Procedia Social and Behavioral Sciences, 2*, 1896-1900.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. London: Cambridge University Press.

Le Grange, L. (2010). 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, 10*(1), 13-26.

Lee, E., & Luft, J. A. (2008). Experienced Secondary Science Teachers' Representation of Pedagogical Content Knowledge. *International Journal of Science Education, 30*(10), 1343-1363.

Lessing, A., & de Witt, M. (2007). The Value of Continuous Professional Development: Teachers' Perceptions. *South African Journal of Education, 27*(1), 53-67.

Leung, W. L. A. (2008). Teacher Concerns About Curriculum Reform: The Case of Project Learning. *The Asia-Pacific Education Researcher, 17*(1), 75-97.

Lichtman, M. (2011). *Understanding and Evaluating Qualitative Educational Research*. London: Sage Publications.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. London: Sage Publications.

Lotz-Sisitka, H. (2011). National Case Study. Teacher Professional Development Within 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.

Mackenzie, N., & Knipe, S. (2006). Research Dilemmas: Paradigms, Methods and Methodology. *Issues in Educational Research, 16*(2), 193-205.

Maloshonok, N. (2014). *Vygotsky's Theory: Lessons for Student Engagement Research*. Paper presented at the SERU International Research Conference, Moscow.

Manqele, C. M. (2012). *An Investigation of the Role of Learners and Teachers Resource Materials in Determining a School Performance and Quality Education: A Case Study of Isiphosemvelo Secondary School.* Master of Education, University of South Africa, Pretoria.

Maree, K. (2009). *First Steps in Research*. Pretoria: Van Schaik.

Marshall, C. J., & Rossman, B. G. (2006). *Designing Qualitative Research*. Thousand Oaks: Sage.

Mashile, E. O. (2002). Continuous Professional Development of Educators: The State, Professional Councils and Higher Education. *South African Journal of Higher Education, 16*(1), 174-182.

Mayer, M., & Torracca, E. (2010). Innovative Methods in Learning of Science and Technology: National Findings and International Comparison (pp. 1-242). Austria: Austrian Institute of Ecology.

McColskey, W., & O'Sullivan, R. (2000). How to Assess Student Performance in Science: Going Beyond Multiple-Choice Tests (pp. 1-55). Greensboro: University of North Carolina.

McDonald, J. T., & Dominguez, L. A. (2010). Professional Preparation for Science Teachers in Environmental Education. In A. M. Bodzin, B. S. Klein & S. Weaver (Eds.), *The Inclusion of Environmental Education in Science Teacher Education* (pp. 17-30). Bethlehem: Springer.

McFarlane, D. A. (2013). Understanding the Challenges of Science Education in the 21st Century: New Opportunities for Scientific Literacy. *International Letters of Social and Humanistic Sciences, 4*, 35-44.

McMillan, J. H., & Schumacher, S. (2010). *Research Education: Evidence-Based Inquiry* (7th ed.). New Jersey: Pearson.

Merriam, S. B. (1998). *Case Study Research in Education: A Qualitative Approach*. San Francisco: Jossey-Bass.

Mertens, D. M. (1998). *Research Methods in Education and Psychology: Integrating Diversity with Quantitative and Qualitative Approaches*. London: Sage.

Mertens, D. M. (2009). *Transformative Research and Evaluation*. New York: Guilford Press.

Mertens, D. M. (2010). *Research and Evaluation in Education and Psychology: Integrating Diversity with Quantitative, Qualitative and Mixed Methods* (3rd ed.). Los Angeles: Sage.

Mertler, C. A., & Charles, C. M. (2008). *Introduction to Educational Research* (6th ed.). New York: Pearson.

Mestry, R., Hendricks, I., & Bisschoff, T. (2009). Perceptions of Teachers on the Benefits of Teacher Development Programmes in one Province of South Africa. *South African Journal of Education, 29*, 475-490.

Miliszewska, I., & Horwood, J. (2004). *Engagement Theory: A Framework for Supporting Cultural Differences in Transnational Education.* Paper presented at the HERDSA Conference

Millar, R. (2009). Analysing Practical Activities to Assess and Improve Effectiveness: The Practical Activity Analysis Inventory (PAAI). 1-30. Retrieved from http://www.york.ac.uk/depts/educ/research/ResearchPaperSeries/index.htm

Misfud, M. (2012). Environmental Education Development in Malta: A Contextual Study of the Events that have Shaped the Developmment of Environmental Education in Malta. *Journal of Teacher Education for Sustainability, 14*(1), 52-66.

Mogalakwe, M. (2006). Research Report: The use of Documentary Research Methods in Social Research. *African Sociological Review, 10*(1), 221-230.

Moon, J. (2001). Learning Through Reflection. In F. Banks & A. S. Mayes (Eds.), *Early Professional Development for Teachers*. London: David Fulton Publishers.

Ndimande, B.S. (2005). The Role of School Management Teams in Enhancing Learner Academic Performance. Masters Degree in the Department of Educational Planning and Administration at the University of Zululand.

Nieuwenhuis, J. (2007a). Introducing Qualitative Research. In K. Maree (Ed.), *First Steps in Research* (pp. 46-68). Pretoria: Van Schaik

Nieuwenhuis, J. (2007b). Qualitative Research Designs and Data Gathering Techniques. In K. Maree (Ed.), *First Steps in Research* (pp. 70-92). Pretoria: Van Schaik.

Nkosi, B. (2012). Teachers Unprepared for Curriculum, *Mail and Guardian,* pp. 1-3.

Nsengimana, T., Ozawa, H., & Chikamori, K. (2014). The Implementation of the New Lower Secondary Science Curriculum in Three Schools in Rwanda. *African Journal of Research in Mathematics, Science and Technology Education, 18*(1), 75-86.

O' Donoghue, R. (2013). *Framing Active Teaching and Learning in CAPS. Fundisa for Change Programme*. Grahamstown: GIZ Expert Net.

O' Sullivan, H., McConnell, B., & McMillan, D. (x). Continuous Professional Development and its Impact on Practice: A North-South Comparative Study of Irish Teachers' Perceptions, Experiences and Motivations (pp. 1-63): Standing Committee of Teacher Education North and South.

Odora Hoppers, C. A. (2001). Indigenous Knowledge Systems and Academic Institutions in South Africa. *Perspectives in Education, 19*(1), 73-85.

Onwu, G. O. M. (2000). How Should We Educate Science Teachers for a Changing Society? *South African Journal of Higher Education, 14*(3), 43-50.

Oosthoek, J., & Gills, B. K. (2008). *The Globalisation of Environmental Crisis*. London: Routledge.

Opfer, V. D., & Pedder, D. (2011). Conceptualizing Teacher Professional Learning. *Review of Educational Research, 81*(3), 376-407.

Opie, C. (2004). *Doing Educational Research: A Guide for First Time Researchers*. London: Sage.

Oversby, J. (2014, 21-27 September 2014). *Innovative Pedagogy Using Examples from Climate Change Education.* Paper presented at the 16th International Organisation of Science and Technology Conference, Kuching, Malaysia.

Owston, R. (2006). Contextual Factors that Sustain Innovative Pedagogical Practice Using Technology: An International Study *Journal of Educational Change,* 1-17.

Park, J., Conca, K., & Finger, M. (2008). *The Crisis of Global Environmental Governance Towards a New Political Economy of Sustainability*. London: Routledge.

Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods* (3rd ed.). London: Sage Publications.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What Makes Professional Development Effective? Strategies that Foster Curriculum Implementation. *American Educational Research Journal, 44*(4), 921-958.

Phelps, R. (2005). The Potential of Reflective Journals in Studying Complexity in Action. *International Journal of Complexity and Education, 2*(1), 37-54.

Pienaar, H. C., Nieman, M. M., & Kamper, G. D. (2011). Implementing a Teaching Approach Based on the Multiple Intelligence Theory in a South African School: A Case Study. *African Education Review, 8*(2), 267-285.

Pinto, R. (2005). Introducing Curriculum Innovations in Science: Identifying Teachers' Transformations and the Design of Related Teacher Education. *Science Education, 89*, 1-12.

Powell, J. C., & Anderson, R. D. (2002). Changing Teachers' Practice: Curriculum Materials and Science Education Reform in the USA. *Studies in Science Education, 37*(1), 107-135.

Reddy, C. (2011). Inaugral Address Environmental Education and Teacher Development: Engaging a Dual Curriculum Challenge. *Southern African Journal of Environmental Education, 28*, 9-28.

Reddy, V., Prinsloo, C. H., Netshitangani, T., Moletsane, R., Juan, A., & Janse van Rensburg, D. (2010). An Investigation into Educator Leave in the South African Ordinary Public Schooling System. South Africa: Department of Education

Resnik, D. B. (2015). What is Ethics in Research and why it is Important? *National Institute for Environmental Health Sciences*. Retrieved from http://www.niehs.nih.gov/research/resources/bioethics/whatis

Rickinson, M., & Lundholm, C. (2008). Exploring Students' Learning Challenges in Environmental Education. *Cambridge Journal of Education, 38*(3), 341-353.

Ritchie, J. (2003). The Applications of Qualitative Research Methods In J. Ritchie & J. Lewis (Eds.), *Qualitative Research Practice: A Guide for Social Science Students and Researchers* (pp. 24-46). London: Sage.

Robson, C. (2002). *Real World Research* (2nd ed.). Oxford: Blackwell Publishers.

Robson, C. (2011). *Real World Research* (3rd ed.). Oxford: Wiley Publishers.

Roehrig, G. H., Kruse, R. A., & Kern, A. (2007). Teacher and School Characteristics and Their Influence on Curriculum Implementation. *Journal of Research in Science Teaching, 44*(7), 883-907.

Rogan, J. M. (2007). How Much Curriculum Change is Appropriate? Defining a Zone of Feasible Innovation. *Science Education, 91,* 439-460.

Rogan, J. M., & Aldous, C. M. (2005). Relationships Between the Constructs of a Theory of Curriculum Implementation. *Journal of Research in Science Teaching, 42*(3), 313-336.

Rogan, J. M., & Grayson, D. J. (2003). Towards a Theory of Curriculum Implementation with Particuluar Reference to Science Education in Developing Countries. *International Journal of Science Education, 25*(10), 1171-1204.

Sahlberg, P. (x). Curriculum Change as Learning: In Search of Better Implementation (pp. 1-8).

Sauve, L. (2002). Environmental Education: Possibilities and Constraints. *Connect, 5*(27), 1-4.

Schleicher, A. (2015). Schools for 21st-century Learners: Strong Leaders, Confident Teachers, Innovative Approaches *International Summit on the Teaching Profession*.

Scholtz, Z., Watson, R., & Amosun, O. (2004). Investigating Science Teachers' Response to Curriculum Innovation. *African Journal of Research in Mathematics, Science and Technology Education, 8*(1), 41-52.

Schou, R. A. (2015). *Countering Student Apathy to Increase Student Engagement* Doctor of Education, Walden University, Washington.

Seale, C. (1999). Quality in Qualitative Research. *Qualitative Inquiry, 54*(4), 465-478.

Seidel, J. V. (1998). Qualitative Data Analysis. The Ethnographic V5 Manual, Appendix E. Retrieved from http://www.qualisreach.com

Shenton, A. K. (2004). Strategies for Ensuring Trustworthiness in Qualitative Research Projects. *Education for Information, 22,* 63-75.

Sherron, T., & Fletcher, C. (2008). *Exploring the Effects of Professional Development on Science Teaching Practices*. Paper presented at the Association for Science Teacher Education.

Sikes, P. (2004). Methodology, Procedures and Ethical Concerns. In C. Opie (Ed.), *Doing Educational Research: A Guide to First Time Researchers* (pp. 16-32). London: Sage.

Singh, S. K. (2011). The Role of Staff Development in the Professional Development of Teachers: Implications for In-Service Training. *South African Journal of Higher Education, 25*(8), 1626-1638.

Smith, C. (2006). *The Future of a Concept: The Case for Sustaining Innovation in Education* Paper presented at the Australian Association of Research in Education, Adelaide.

Smith, M. K. (2003). Communities of Practice. *The Encyclopedia of Informal Education*.

Songqwaru, N. Z. (2012). *Supporting Environment and Sustainability Knowledge in the Grade 10 Life Science Curriculum and Assessment Policy Context: A Case Study of the Fundisa for Change Teacher Education and Development Programme Pilot Project.* Masters of Education, Rhodes University, Grahamstown.

Stahl, G. (n.d). Engagment Theory. http://GerryStahl.net/elibrary/philosophy

Steyn, G. M. (2008). Continuing Professional Development for Teachers in South Africa and Social Learning Systems: Conflicting Conceptual Frameworks of Learning. *Koers, 73*(1), 15-31.

Steyn, G. M. (2011). Continuing Professional Development in South African Schools: Staff Perceptions and the Role of Principals. *Journal of Social Sciences, 28*(1), 43-53.

Supovitz, J. A., & Turner, H. M. (2000). The Effects of Professional Development on Science Teaching Practices and Classroom Culture. *Journal of Research in Science Teaching, 37*(9), 963-980.

Tan, A., & Leong, W. F. (2014). Mapping Curriculum Innovation in STEM Schools to Assessment Requirements: Tensions and Dilemmas. *Theory into Practice, 53*(1), 11-17.

Teddlie, C., & Tashakkori, A. (2009). *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*. Los Angeles: Sage.

Tin, L. G., Hean, L. L., & Leng, Y. L. (1996). What Motivates Teachers? *New Horizons in Education, 37*, 1-9.

Tobin, G. A., & Begley, C. M. (2004). Methodological Rigour Within a Qualitative Framework. *Journal of Advanced Nursing, 48*(4), 388-396.

Tytler, R. (2007). *Re-imagining Science Education: Enagaging Students in Science For Australia's Future*. Australia: ACER Project Publishing.

Tytler, R. (2009). School Innovation in Science: Improving Science Teaching and Learning in Australian Schools. *International Journal of Science Education, 31*(13), 1777-1809.

Tytler, R., Symington, D., & Smith, C. (2011). A Curriculum Innovation Framework for Science, Technology and Mathematics Education. *Research in Science Education, 41*, 19-38.

van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching, 38*(2), 137-158.

van Driel, J. H., Bulte, A. M. W., & Verloop, N. (2005). The Conceptions of Chemistry Teachers About Teaching and Learning in the Context of a Curriculum Innovation. *International Journal of Science Education, 27*(3), 303-322.

van Driel, J. H., Verloop, N., Inge van Werven, H., & Dekkers, H. (1997). Teachers' Craft Knowledge and Curriculum Innovation in Higher Engineering Education. *Higher Education, 34*, 105-122.

van Laren, L., Mudaly, R., Singh, S., Mitchell, C., & Pithouse-Morgan, K. (2012). Exploring University Educators' Lived Experiences of Curriculum Innovating Through Integrating HIV and AIDS. *Alternation, 19*(2), 138-161.

van Teijlingen, E., & Hundley, V. (2002). The Importance of Pilot Studies. *Nurs Stand, 16*(40), 33-60.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Process*. Cambridge: Harvard University Press.

Wang, C. C., Yi, W. K., Tao, Z. W., & Carovano, K. (1998). Photovoice as a Participatory Health Promotion Strategy. *Health Promotion International, 13*(1), 75-86.

Welman, Kruger, & Mitchell. (2005). *Research Methodology* (3rd ed.). Cape Town: Oxford University Press Southern Africa.

Wertsch, J. V. (1985). *Vygotsky and the Social Formation of Mind*. London: Harvard University Press.

Wiersma, W., & Jurs, S. (2009). *Research Methods in Education: An Introduction* (9th ed.). London: Pearson.

Wilkinson, D., & Birmingham, P. (2003). *Using Research Instruments: A Guide for Researchers*. London: Routledge.

Williamson, B., & Payton, S. (2009). Curriculum and Teaching Innovation: Transforming Classroom Practice and Personalisation (pp. 1-63). United Kingdom.

Willis, J. W. (2007). *Foundations of Qualitative Research: Interpretive and Critical Approaches*. London: Sage.

Wood, W. B. (2009). Innovations in Teaching Undergraduate Biology and Why We Need Them. *The Annual Review of Cell and Developmental Biology, 25*(5), 1-20.

Yildrim, A., Akar, H., Haller, H., Freitag, L., List-Ivankovic, J., Brodigan, B., & Dincelek-Letinga, J. (2007). Collection of Methods and Materials for the Evaluation of Active Citizenship: Socrates Action

Yin, R. K. (2003). *Case Study Research Design and Methods* (3rd ed.). London: Sage.

Yin, R. K. (2009). *Case Study Research: Design and Methods* (4th ed.). Los Angeles: Sage.

Young, R., & Lee, S. (1984). *EFL Curriculum Innovation and Teachers' Attitudes*. Paper presented at the Annual Convention of the Teachers of English to Speakers of Other Languages, Houston.

Zevenbergen, R, (1999). Student Constructed Posters: A Tool for Learning and Assessment in Preservice Mathematics Education. *Mathematics Teacher Education and Development*, 1, 72-83.

APPENDICES

1. Ethical clearance from University of KwaZulu- Natal
2. Letter to the Head of School
3. Letter to the Head of Science and Technology Cluster
4. Letter to Life Sciences/Natural Sciences teachers (informed consent)
5. Letter to school principals
6. Document analysis schedule
7. Photo narrative schedule
8. Individual interview schedule
9. Reflective journal schedule
10. Individual interview transcripts
11. Reflective journals of participants
12. Critical reading approval letter
13. Published articles approval letter
14. Turnitin Report

APPENDIX 1

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

28 April 2015

Ms Reeesa Ismail [205605755]
School of Education
Edgewood Campus

Dear Ms Ismail ,

Protocol reference number: HSS/1561/014D
Project title: Exploring how science teachers engage in curriculum innovating in environment and sustainability education

Full Approval – Expedited Application

With regards to your application received on 19 November 2014, the documents submitted have been accepted by the Humanities & Social Sciences Research Ethics Committee and **FULL APPROVAL** for the protocol has been granted.

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 Ronicka Mudaly
Cc Academic Leader Research: Professor P Mondjele
Cc School Administrator: Ms Tyzer Khumalo / Ms Rong Bhengu

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

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

APPENDIX 2

Dear: The Dean of the School of Education

I am a Doctor of Philosophy (PhD) student at the University of KwaZulu-Natal Edgewood campus and currently engaging in a research project which is entitled "Exploring how science teachers engage in curriculum innovating in environment and sustainability education". I seek permission to conduct this research within the school. The purpose of this project is to explore what professional development related to innovating in environment and sustainability education is being offered at a higher education institution and how science teachers' environment and sustainability knowledge can be enhanced through professional development. In addition the study will focus on how science teachers who have engaged in professional development learning activities enact the curriculum through innovating in environment and sustainability education. I will collect data from 15 practicing Life Sciences/Natural Sciences teachers who are registered in the B.Ed Honours programme. Data will be collected using multiple methods. These include two interviews, each of 45 minutes duration which will be audio recorded, analysis of participants portfolios which would be developed as a requirement for an Honours module (this includes photo narratives and lesson plans), and development of reflective diaries on teacher participants experiences of curriculum innovating. This study is purely for academic purposes and there will be no financial gain involved. The significance of this study is that it is expected that through this study Life Sciences/Natural Sciences teachers obtain insight into curriculum innovation. The findings of the research will not be used for any other purpose other than the Doctoral dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants and the identity of the school. All information disclosed will be kept in confidence. The participation in this research is voluntary and should participants desire to withdraw or terminate their participation in the research, this may be done without any negative consequences.

Thank you

Yours faithfully

Raeesa Ismail (student no. 205505755) Cell no: 0844814290

Email: 20505755@stu.ukzn.ac.za

Supervisor: Dr R Mudaly Email: mudalyr@ukzn.ac.za

Mr P. Mohun from the Research Office may also be contacted. His details are:

University of KwaZulu-Natal

Humanities and Social Sciences Research Ethics

Govan Mbeki Centre

Tel +27312604557

Fax +27312604609

Email: mohunp@ukzn.ac.za

Acknowledgement - Head of School

I,……. (Name of Head of School) hereby grant/ do not grant (delete that which is not applicable) permission for the research project entitled "Exploring how science teachers engage in curriculum innovating in environment and sustainability education" to take place during the first and second semester of 2015 in the School of Education.

_____

Signature

_____

Date

APPENDIX 3

Dear: Dr N. Govender

I am a Doctor of Philosophy (PhD) student at the University of KwaZulu-Natal Edgewood campus and currently engaging in a research project which is entitled "Exploring how science teachers engage in curriculum innovating in environment and sustainability education". I seek permission to conduct this research within the school. The purpose of this project is to explore what professional development related to innovating in environment and sustainability education is being offered at a higher education institution and how science teachers' environment and sustainability knowledge can be enhanced through professional development. In addition the study will focus on how science teachers who have engaged in professional development learning activities enact the curriculum through innovating in environment and sustainability education. I will collect data from 15 practicing Life Sciences/Natural Sciences teachers who are registered in the B.Ed Honours programme. Data will be collected using multiple methods. These include two interviews, each of 45 minutes duration which will be audio recorded, analysis of participants portfolios which would be developed as a requirement for an Honours module (this includes photo narratives and lesson plans), and development of reflective diaries on teacher participants experiences of curriculum innovating. This study is purely for academic purposes and there will be no financial gain involved. The significance of this study is that it is expected that through this study Life Sciences/Natural Sciences teachers obtain insight into curriculum innovation. The findings of the research will not be used for any other purpose other than the Doctoral dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants and the identity of the school. All information disclosed will be kept in confidence. The participation in this research is voluntary and should participants desire to withdraw or terminate their participation in the research, this may be done without any negative consequences.

Thank you

Yours faithfully

Raeesa Ismail (student no. 205505755) Cell no: 0844814290

Email: 20505755@stu.ukzn.ac.za

Supervisor: Dr R Mudaly Email: mudalyr@ukzn.ac.za

Mr P. Mohun from the Research Office may also be contacted. His details are:

University of KwaZulu-Natal

Humanities and Social Sciences Research Ethics

Govan Mbeki Centre

Tel +27312604557

Fax +27312604609

Email: mohunp@ukzn.ac.za

Acknowledgement - Head of Science and Technology Cluster

I, ……. (Name of Head of Science and Technology Cluster) hereby grant/ do not grant (delete that which is not applicable) permission for the research project entitled "Exploring how science teachers engage in curriculum innovating in environment and sustainability education" to take place during the first and second semester of 2015 in the School of Education.

_____

Signature

_____

Date

APPENDIX 4

Dear: Life Sciences/Natural Sciences teacher

I am a Doctor of Philosophy (PhD) student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, "Exploring how science teachers engage in curriculum innovating in environment and sustainability education". The purpose of this project is to explore what professional development related to innovating in environment and sustainability education is being offered at a higher education institution and how science teachers' environment and sustainability knowledge can be enhanced through professional development. In addition the study will focus on how science teachers who have engaged in professional development learning activities enact the curriculum through innovating in environment and sustainability education. I would like to collect data from you by multiple methods. These include two interviews, each of 45 minutes duration which will be audio recorded, analysis of your portfolios which you would have developed as a requirement for an Honours module (this includes photo narratives and lesson plans), and development of reflective diaries on your experiences of curriculum innovating. This study is purely for academic purposes and there will be no financial gain involved. The significance of this study is that it is expected that through this study Life Sciences/Natural Sciences teachers obtain insight into curriculum innovation. The findings of the research will not be used for any other purpose other than the doctoral dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect your identity and the identity of your school. All information disclosed will be kept in confidence. The participation in this research is voluntary and should you find that you wish to withdraw or terminate your permission for the research, you may do so without any negative consequences.

Thank you.

Yours faithfully

Raeesa Ismail (student no. 205505755) Cell no: 0844814290

Email: 20505755@stu.ukzn.ac.za

Should you have any queries you can contact my supervisor Dr. Ronicka Mudaly.

Telephone no: 031- 260 3643

Email: mudalyr@ukzn.ac.za

Mr P. Mohun from the Research Office may also be contacted. His details are:

University of KwaZulu-Natal

Humanities and Social Sciences Research Ethics

Govan Mbeki Centre

Tel +27312604557

Fax +27312604609

Email: mohunp@ukzn.ac.za

Acknowledgement – Life Sciences/ Natural Sciences teacher

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

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

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

_____ _____

Signature of teacher Date

_____ _____

Phone number Email address

APPENDIX 5

Dear: The Principal

RE: Request for permission to conduct research at your school.

My name is Raeesa Ismail, I am a Doctor of Philosophy (PhD) student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, "Exploring how science teachers engage in curriculum innovating in environment and sustainability education". The purpose of this project is to explore what professional development related to innovating in environment and sustainability education is being offered at a higher education institution and how science teachers' environment and sustainability knowledge can be enhanced through professional development. In addition the study will focus on how science teachers who have engaged in professional development learning activities enact the curriculum through innovating in environment and sustainability education.

I hereby request to conduct my research with Life Sciences/Natural Sciences educator/s at your school. I would like to collect data from Life Sciences/Natural Sciences educator/s at your school using multiple methods. These include two interviews, each of 45 minutes duration which will be audio recorded, analysis of portfolios which the educator/s would have developed as a requirement for a B.Ed Honours module (this includes photo narratives and lesson plans), and development of reflective diaries on their experiences of curriculum innovating. This study is purely for academic purposes and there will be no financial gain involved. The significance of this study is that it is expected that through this study Life Sciences/Natural Sciences teachers obtain insight into curriculum innovation. You are assured that the findings of the research will not be used for any other purpose other than the doctoral dissertation. In this regard, no harm will be caused to your school and the educator/s participating in this study. Furthermore, the anonymity of both the school and the educator/s are assured. Pseudonyms will be used to protect the identity of your school and educator/s. All information disclosed will be kept in confidence. The participation in this research is voluntary and should you find that you wish to withdraw or terminate your permission for the research, you may do so without any negative consequences.

Thank you.

Yours faithfully

Raeesa Ismail (student no. 205505755) Cell no: 0844814290

Email: 20505755@stu.ukzn.ac.za

Should you have any queries you can contact my supervisor Dr. Ronicka Mudaly.

Telephone no: 031- 260 3643

Email: mudalyr@ukzn.ac.za

Mr P. Mohun from the Research Office may also be contacted. His details are:

University of KwaZulu-Natal

Humanities and Social Sciences Research Ethics

Govan Mbeki Centre

Tel +27312604557

Fax +27312604609

Email: mohunp@ukzn.ac.za

Acknowledgement by the principal

I _____, the principal of_____ grant permission to Raeesa Ismail to conduct her research in the above mentioned school.

_____ _____

Signature of principal Date

APPENDIX 6

Document Analysis Schedule

Modules outlines

The documents to be analysed are the modules outlines for the Bachelor of Education Honours Programme in Mathematics and Science Education.

- Do the module outlines incorporate curriculum innovating in environment and sustainability education? What features relate to curriculum innovating in environment and sustainability education? Do these relate to content/teaching methodology/both?

Participants' Life Sciences and Natural Sciences lesson plans

- Questions guiding the analysis of Life Sciences and Natural Sciences teachers' lesson plans

- Does the lesson plan incorporate curriculum innovating in environment and sustainability education? What innovative teaching and assessment methods are incorporated in the lesson plan?

- How is innovation planned and enacted in terms of the capacity to innovate, outside support and profile of implementation? (Rogan & Aldous, 2005).

APPENDIX 7

Photo Narrative Schedule

Life Sciences and Natural Sciences teachers are required to photograph moments of curriculum innovation during their lessons on environment and sustainability education.

- Capture ± ten moments of curriculum innovating during your lesson presentation
- Accompanying each photograph should be a narrative description of the curriculum innovation
- Your narrative description should incorporate the factors that enabled you to be innovative. These could include the following:

➢ Support from peers

➢ Professional development

➢ Monitoring/assistance from HOD's/subject advisors

➢ Physical resources

➢ Your capacity as a teacher

➢ Learners capacity

➢ The ethos and management of the school

➢ Assessment strategies that were used

➢ Other

APPENDIX 8

Interview Schedule

1. Did you feel the professional development related to environment and sustainability education has impacted on your teaching of science education? Explain.
2. Were you able to identify the need for innovation in environment and sustainability education? Is curriculum innovating a requirement for teaching and assessment? Do you have to be innovative when teaching this content or can you teach it in a traditional manner?
3. What is your understanding of innovation?
4. Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?
5. What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?
6. In your opinion, would more professional development of this nature be beneficial to your science teaching?
7. What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?
8. What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?
9. In your teaching, what factors enable or enhance innovating when teaching environment and sustainability education? Specifically at your school.
10. In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.
11. Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.
12. Did your current teaching practice of environment and sustainability education change after you engaged with the professional development (Honours module)? Explain.
13. Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

APPENDIX 9

Reflective Journal

- Please structure your reflections using paragraphs, as you answer the questions below.

1). **What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development? Which events come to mind in this regard?**

In your answer to the question above, structure your response according to the following sub-headings. Use the bullets under each sub-heading to write your response.

a). Capacity to innovate

- How did your personal capacity as a teacher become enhanced as you went through the professional development?
- How did the environment (lecture venue) affect your professional growth as a teacher? Were you able to make use of resources (books, notes, etc.) to enhance your capacity to be innovative? Were you affected by your peers that were part of the professional development?
- How did the management of the professional development affect you? Did the structure of the professional development aid/discourage you to increase your capacity to innovate?

b). Outside influences

- Did the facilitator/lecturer provide you with support/assistance during the professional development? Did the assistance/support, or lack of it, affect your ability to increase your capacity to innovate?
- Did the facilitator/lecturer monitor your progress through the professional development? Did the monitoring, or lack of it, impact your capacity to be innovative?
- Were they actively engaged with your peers in the professional development? How did this affect you?

c). Profile of implementation

- Taking into consideration your response in a) and b), do you feel that having engaged in the professional development that you now have the capacity to innovative as you teach environment and sustainability education?
- Do you feel confident to teach this topic, or would you rush through this section due to a lack of confidence in how to be innovative when teaching it?

2). **What innovative strategies of assessment in environment and sustainability education did you gain from being part of this professional development? Describe events related to this**.

In your answer to the question above, structure your response according to the following sub-headings. Use the bullets under each sub-heading to write your response.

a). Capacity to innovate

- What innovative strategies did you gain? Explain in detail.
- Do you feel confident in administering innovative assessment strategies to learners?
- Was the environment (lecture venue) conducive for your capacity to innovate to be increased?
- Do you now possess the capacity to be innovative in assessment of environment and sustainability education?

b). Outside influences

- Did you engage with your peers during the professional development? Did this enhance your ability to be innovative in assessment?
- Did you engage with the facilitator/lecturer during the professional development? Did you receive assistance/monitoring to enhance your ability to be innovative in assessment?
- Were you able to utilise any physical resources to enhance your ability to be innovative in assessment?

c). Profile of implementation

- Taking into consideration your response in a) and b), do you feel that having gone through the professional development that you now have the capacity to be innovative when you assess learners on content from environment and sustainability education?
- When assessing learner would you look for innovative methods to assess them? Or would you make use of traditional methods of assessment?

3). **In your teaching, what factors enable or enhance innovating when teaching environment and sustainability education? Describe events related to this.**

In your answer to the question above, structure your response according to the following sub-headings. Use the bullets under each sub-heading to write your response.

a). Capacity to innovate

- Were you able to make use of physical resources at the school?
- Did you feel as though you had the capacity to be innovative as you were teaching? Were you confident enough to be innovative as you taught?
- Did the different learning abilities of the learners in your class affect the magnitude (amount) of the innovation used of your lesson?
- Does your school allow or give teachers the freedom to be innovative in their teaching? Did this affect your capacity to be innovative?

b). Outside influences

- Did you receive support/assistance from your HOD or subject advisor as you planned, taught and reflected your lesson?
- Did your engage with any of your peers as you planned, taught and reflected on your lesson?

c). Profile of implementation

- Taking into consideration your response in a) and b), do you feel that having engaged in the professional development that you now have the capacity to be innovative as you teach environment and sustainability education?
- Can you say that you now possess the capacity to be innovative, after engaging with the professional development?

4). **In your teaching, what factors constrained innovating when teaching environment and sustainability education? Describe the related events.**

In your answer to the question above, structure your response according to the following sub-headings. Use the bullets under each sub-heading to write your response.

a). Capacity to innovate

- Did a lack of physical resources (chairs, tables, classroom size etc.) constrain you from being innovative?
- Did you at any point during your teaching feel as though you lacked the capacity (ability) to be innovative? Elaborate if possible.
- Was your teaching affected by the different learning abilities of learners in your classroom? Elaborate if possible.

b). Outside influences

- Does your school promote an atmosphere that allows teachers to be innovative? Is your school highly strict with regards to curriculum completion and does not allow time for teachers to be innovative? Was this a factor in your teaching?
- Did the HOD or subject advisor constrain you from being innovative?
- Did a lack of contact between you and your peers hinder you from being innovative?
- Did a lack of physical resources at your school discourage you from being innovative?

c). Profile of implementation

- Taking into consideration your response in a) and b), discuss how you were able to overcome these constraints and be innovative in your teaching of environment and sustainability education.
- If these factors mentioned above were too overwhelming, please state what support or assistance you could have received to ensure innovative teaching in your lesson. (e.g. support from HOD, monitoring from subject advisor, resources to teach with, peer-work etc.)

5). **Did the professional development bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.**

In your answer to the question above, structure your response according to the following sub-headings. Use the bullets under each sub-heading to write your response.

a). Capacity to innovate

- Did the physical resources engaged with during the professional development allow for you to be innovative in your teaching?
- Are you more comfortable teaching the content of this topic?
- Do you feel that your thinking has undergone a transformation? Are you more confident teaching environment and sustainability education?
- Did the structure (time, management, method of delivery) of the professional development allow you to increase your capacity to be innovative in your teaching?
- Do you feel that the structure of the professional development had a direct impact on your capacity to be innovative?
- Specifically, with elements of the professional development transformed your teaching?

b). Outside influences

- Did the lecturer/facilitator support and assist you to become an innovative, transformed teacher? Was the support and assistance a catalyst in your transformation to an innovative teacher?
- Did the physical resources used during the professional development prove to be influential in your transformation as a teacher? (time spent, venue, resources).

c). Profile of implementation

- Taking into consideration your response in a) and b), discuss how your teaching has holistically been transformed.
- Discuss whether or not you are now a more innovative teacher due to the professional development you engaged in.
- Are you now more confident in teaching environment and sustainability education?
- In your future teaching, will you be discouraged when faced with a new curriculum to be taught? Or will you be innovative and able to teach it, taking into consideration the professional development you engaged in?

- Discuss your personal feelings/opinion on how professional development for teachers should be conducted. Be clear on your position regarding it and how it should be presented to teachers.

APPENDIX 10

Individual Interview Transcripts

Participant 1 –II 1 – 15: 00 – 01/07/2015

Raeesa – Good afternoon, I am sitting in with participant 1 and I am conducting an individual interview.

Participant 1 – Good afternoon.

Raeesa – Did you feel the professional development related to environment and sustainability education has impacted on your teaching of science education? Explain.

Participant 1 – Definitely it has, actually I did not have an education background. My first degree was biotechnology and I had to do a PGCE in order for me to be a teacher. The PGCE was just for one year, so I felt I did not have enough experience or modules that equipped me to be a good teacher. So I had to go further and register for the Honours programme. The curriculum development module was the only module that prepared me to be an innovating teacher. After this Honours module, I found that I was a lot more confident. This module has increased my knowledge, skills and teaching ability. New techniques were taught to me. Actually I would not have been the teacher I am if I had not done this Honours module.

Raeesa – So would you say it has impacted you positively?

Participant 1 – Yes, definitely.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education? Is innovating requirement? Do you have to be innovative when you teach content or can you teach in a traditional manner?

Participant 1 – Yes. Innovation is needed because environment and sustainability education is difficult to teach. The innovative way is the best way to teach. We are in the jet age, kids no longer can sit and listen, and they get bored. So as an educator teaching EE you definitely have to be creative and innovative.

Chalk and talk is gone. So yes, I identified the need for innovation. Although there are some sections in the Natural Sciences and Life Sciences content, where you just have to explain using chalk and talk, but I try my best to be innovative all the time. I feel when I start a section I have to be innovative. It gets the learners attention. But especially in EE you can't be using the textbook and just reading.

Raeesa – What is your understanding of innovation?

Participant 1 – Teaching in a more attractive manner. My own understanding is bringing in new ideas and upgrading my teaching. Removing an old technique and teaching in a different way.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 1 – Yes – there was this particular assignment where we had to take pictures of the moments of innovation in our lesson. This forced me to be innovative. The course packs and notes enhanced my knowledge. When I taught the lesson using innovation I found my lesson more productive. Learners answered so many questions. But you know this innovating should have been in all Honours modules. If curriculum innovating was included in all Honours modules it would be more beneficial. Like we did teaching and learning 2, where we did practical work, maybe innovation should have been included. Also we did a module issues in science education where we planned lesson on IKS. Maybe innovation could have been incorporated. Right now I am innovating in every aspect of my teaching. You see, curriculum innovating could have been present in all Honours specialist modules.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 1 – There were no negatives. I would definitely say it was all positive. The lecturer really explained well and provided assistance. The course packs were well designed. I gained a lot of knowledge and I became a better teacher. The module helped me to overcome all my challenges I faced as an educator. I also learnt from working in groups, peer learning, so I can say we all developed together. This module increased my knowledge, provided me with more techniques to get learners involved in my lessons. Innovation is needed to grasp the attention of learners. I have noticed that my quiet learners are more vibrant and they understand when I teach.

Raeesa – In your opinion, would more professional development of this nature be beneficial to your science teaching?

Participant 1 – Certainly, it will be beneficial – professional development including curriculum innovation will be very beneficial. I am done with the Honours module, but there is space for curriculum innovating in all modules.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did u gain from being part of this professional development?

Participant 1 – In the module we did a presentation. I tried it out in my classroom. This was a new way of teaching. Learners loved it. I grew as a teacher. The portfolio activity was very useful for me. A big part of this module was that innovation allowed me to get to learners that don't want to participate. It promotes understanding.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 1 – I learnt to assess learners using different methods. Alternative methods of assessment like role plays, presentations, group work, debates are much better than the

traditional methods. It is amazing but learners actually perform better with the innovative assessment methods.

Raeesa – In your teaching, what factors enable or enhance innovating when teaching environment and sustainability education? Specifically at your school.

Participant 1 – Ok, firstly the school was a resourced school. We had resources e.g. data projectors, labs etc. the principal and HOD did not mind that I brought in my own pattern of teaching. My HOD was open to change and subscribes to renewing things. My HOD embraced change. I feel the school, management, resources and learners fuelled innovating.

Also this professional development module provided me with more knowledge and I gained confidence to be innovative. I can now say that I have the capacity to be innovative in my science teaching. You know I am innovative in all aspects of my science teaching not only in EE.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 1 – I don't think I was constrained in any way. But I must say I was afraid to actually implement innovative teaching methods. I was afraid with how the principal and HOD will react, but the management and staff embraced my new ideas.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 1 – Yes I have been transformed. Remember I said I did not have a teaching background and the PGCE was not enough. I have gained more knowledge, I am more confident and I now have the capacity to be an innovative teacher. I was equipped more and also my learners understand better. I am a transformed teacher, whenever I teach I try to be innovative. This module has propelled me to continuously be innovative.

You see my learners results are improving so it makes me want to be more innovative.

Raeesa – If you were put in a situation where your school was not well resourced would you still be an innovative teacher?

Participant 1 – I am innovative regardless of the situation I find myself in. However, it will be difficult and it will be hard work.

Raeesa – Does the school have an influential role in the teacher being innovative?

Participant 1 – Yes – to be an innovative teacher you have to go the extra mile.

Raeesa – What about the HOD support?

Participant 1 – That plays a role. My HOD supported me. You see even this module supported me; we saw how the lecturers used innovative methods when lecturing to us.

Raeesa – Did you engage with any peers as you went through this module?

Participant 1 – Yes I learnt from my peers. Peers supported me, we discussed what we did in our schools, we shared ideas of teaching innovatively. We shared and compared teaching strategies, we also discussed how the kids reacted.

Raeesa – So you say peer learning helps you to be innovative?

Participant 1 – Yes.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging with this professional development? Are you now an innovating teacher?

Participant 1 – Yes, I know have a new outlook to teaching. I am a transformed teacher. Also I can't wait to get to my country and give them what I got. It has improved me. You find naturally you have it in you to be innovative but all you need is the support to push you to do it. This module was actually a catalyst for my change. The support this module provided me with changed me as an educator. This Honours module provided me with techniques and ways to be innovative. This Honours module exposed me to innovation, it gave me the knowledge and I had to actually implement in the classroom. And you know it works. I saw a difference with my learners. I am able to be innovative and also complete the curriculum so my HOD is not upset.

Participant 2 –II 2 – 10: 00 – 02/07/2015

Raeesa – Good morning, I am sitting in with participant 2 and I am conducting an individual interview.

Participant 2 – Good morning

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 2 – Yes is do feel that is has impacted very positively. I learnt how to be innovative and make my teaching more creative and practical.

Raeesa – Can you explain further how it has impacted you?

Participant 2 – It has increased my knowledge and it has allowed me to plan my lessons more creatively. I also teach more creatively now. I learnt more skills and techniques on how to teach environmental education and it has also enhanced my assessment methods, coz I find learners doing better now. I developed more creative ways of assessing learners. This professional development module has positively impacted on my teaching.

Raeesa – Did you need or require this professional development?

Participant 2 – Yes I did. Prior to this professional development module I felt less confident. Through this professional development module I developed and gained confidence. The notes gave me knowledge, the activities made me think, and the innovative lesson that I had to plan and teach made me a passionate and innovative teacher. This professional development module enabled me to teach in a more effective way.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 2 – Yes it did. I feel more empowered. The tasks did enhance my knowledge; however the major task was the portfolio, where I had to plan and implement an innovative lesson, really changed my view of teaching. I was able to look into different techniques in teaching. This module increased my knowledge and ability to teach.

Also we had peer learning, so we encouraged each other in selecting topics. This was new to me so just discussing with peers assisted and motivated me. The lecturer was very thorough and explained clearly. The course packs and Fundisa for change handbook was also useful.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 2 – Ok, there were no negatives. I really enjoyed the module; it has given me a new outlook to teaching science not only environmental education. But I feel that innovation should have been included in all the Honours modules. We only did innovation in one

module which was curriculum development. Curriculum is ever changing so innovating should have been done in all modules. Lectures were carried out in a way where we could actually learn new things. Lecturers explained well and monitored our progress. This module was not a repetition of what I already knew. The lecture discussions were very helpful. And the portfolio assignment impacted on my knowledge. It actually pushed me to be innovative.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 2 – Yes.

Raeesa – Can you elaborate?

Participant 2 – Erm… I think curriculum is ever changing; teachers need to be innovative in their teaching so that they can remain abreast with the curriculum. When I was in school chalk and talk was used but now it really won't work effectively. The types of learners are also different. Our methods of teaching need to definitely change in order to accommodate learners. All teachers need to be involved in this type of professional development because it allows teachers to develop and teach using new and trendy methods of teaching to enhance learning for learners. Teachers need to evolve with curriculum changes. They need the support in the form of professional development.

Raeesa – What is your understanding of innovation?

Participant 2–To be creative, to think out of the box. To teach in a more attractive manner, look for new ways to capture the interest of the learner. It involves teaching in a different way. And teaching in this creative manner will result in learning and understanding and better results.

My innovative lesson that I did in class was extremely successful. Learners were very excited and they wanted to learn. They responded positively. I don't normally get such positive responses but using innovative methods like games, videos and presentations spark their interest and willingness to learn. Even the quieter ones even took part in the lesson.

I found that learners understand the topic better, their results improved. Prior to this professional development module I found that learners were unable to make connections with the topics in EE, but after using new innovative techniques they really understand and performed better.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 2 – Yes I do. I think that it is important so that you have maximum involvement of learners and understanding. Also from my lesson I found that using different techniques creates maximum learner participation and also understanding of concepts in science specifically EE.

Raeesa – Can you tell me how they might be able to do this?

Participant 2 – Different teaching styles – not something that is content driven, practicals, outdoor learning, group work, presentations, using more resources. Allowing learners to find and bring in their own information to class. Fieldwork. If learners can see it in an ecosystem or in a video then they will be able to understand it. Ok you see EE is a hard topic to understand, sometimes in a class learners don't know what we are talking about when we mention algae, fungi – so if we take them out into the school ecosystem it will help learners connect with the content being taught an thus results in understanding.

Raeesa – Can you please give me an example from environment and sustainability education of a way in which Life Sciences/Natural Sciences teachers can be innovative?

Participant 2 – I used a dichotomous key and I had a whole lot of different leaves. First I showed them how to design a dichotomous key and then they had to use the leaves to design or make up their own key. So I would not normally teach this lesson in this way, I would just use the chalkboard and textbook. But now I used group work and leaves from the environment.

For Natural Sciences I did not get to environmental education section yet but I am innovative when teaching any section. So for grade 9 NS acids and bases I did a practical and I got learners to make their own red cabbage indicator. I found that learners were very interested and curious to see results. You see now there is a change in the way I teach any topic. What I learnt at university during undergraduate, it did not prepare me to teach effectively. After this professional development module I found that I am more confident and I am able to find various ways to teach. I see a shift, a change in the way I teach. I feel that this professional development module has built my capacity to innovate and it has provided me with the skill and knowledge to teach in a different way. You know I see that my practice has been transformed. I notice learners are more happy to learn, they understand and are doing better in science.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 2 – Yes. You can't just teach environmental education through a book. Also environment and sustainability education is difficult to teach and understand so innovation is needed. I was able to be innovative in my teaching and complete content which was a bonus.

Raeesa – Is innovating a requirement in terms of a policy, as far as you know?

Participant 2 – Yes, it is stipulated but the CAPS it also content driven.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 2 – I think that environmental education can be taught in a traditional manner but it won't have the same effect on the learner. I don't think learners will be able to make connections with science concepts. Teaching in an innovative way will allow learners to understand content and perform well.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 2 – I grew as an educator. I learnt how to be resourceful even though there were limited resources at my school. The resources were a bit limited but I felt a need to overcome this and ensure I could make my lesson innovative and exciting for learner by creating my own worksheets and models of diagrams from the textbooks

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 2 – Well I don't stick to traditional methods of assessing learners. I found that learners respond better to the innovative methods of assessment. For example, I would use group work, posters, presentations, projects or even a debate. Actually the Fundisa for change handbook has some fun ways of assessing learners. I also use models in my teaching. You know with using innovative methods learners are actively engaged in the lesson and also there is an improvement with their marks.

Raeesa – In your teaching, what factors enable or enhance innovating when teaching environment and sustainability education? Specifically at your school.

Participant 2 –For me my learners enhanced innovating. Learners' interest and enthusiasm. I have learners that want to learn. They cooperate with me. They get excited when I do new things in my lesson. The professional development module really enhanced me to be innovative. I gained confidence and I now have the knowledge and ability to be innovative in my science teaching. I have seen a change in my practice I am now a transformed/innovative teacher. Even though we are not a well-resourced school, I go out and get my own resources, I borrow; make my own, sometimes even purchase my own resources.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 2 – My HOD is a bit strict but I still cover all my content so I can be innovative.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 2 – Yes it did. I am now more confident in the way I teach and lessons that I plan than I was before. Before this professional development I was not very confident and I don't think I had the capacity to be innovative. I do see a change even my learners see it and are now enjoying my lessons. The innovative skills enabled me to adapt to any change in school. Irrespective of some of my conditions e.g. lack of resources I am still able to be an innovative teacher.

Raeesa – Did your current teaching practice of environment and sustainability education change after you engaged with the professional development (Honours module)? Explain.

Participant 2 – Yes it has changed. I now teach using innovation. I always look for better ways to teach my learners. I try to bring life into my class. I don't just stick to a textbook; I expose my learners to much more. Prior to this professional development I just used the textbook and chalkboard. So I definitely see a change. Whatever I teach I try my best to make it as innovative as possible. So I can say that my teaching methods and techniques have changed.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 2 – Yes. I don't get bored easily. So yes I am now an innovating teacher. I have a new outlook to teaching. What keeps me so motivated is my learners because they are now alive in my class. They understand and perform better. You know I also receive my projects and assignments on time now. I believe I have come a long way; this professional development has really transformed and empowered me as a teacher.

You know I have been for once off professional development workshops and really they were not useful. But this professional development really developed me. With once off workshops you don't come out with any skills or techniques to actually implement in the classroom.

Participant 3 – II 3 – 12: 00 – 02/07/2015

Raeesa – Good morning, I am sitting in with participant 3 and I am conducting an individual interview.

Participant 3 – Good day

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 3 – I would say yes, it has enabled me to think of different ways in which I can teach Natural Sciences. I have always wanted to teach using various methods but I think I did not have the skill. I am also a computer specialist so I have always wanted to use ICT in my teaching of Natural Sciences. This professional development has impacted me positively and also in our groups there were many other experienced teachers so I also learnt from them. So we did peer learning and also shared resources. Sometimes we discussed what my peers did in their class and I then tried to incorporate it in my classroom.

I am a kind of teacher that does not like to rely on textbooks in teaching. The internet has relevant examples that learners could relate to. I would say that this professional development positively impacted me and my teaching. You see I always wanted to be innovative but I never saw the reason to be. This Honours module exposed me to the benefits of being an innovative teacher.

Two things encouraged me:

1. Teaching my learners

2. Finding new and different ways of teaching and assessing.

The professional development enhanced my teaching and assessment methods. This professional development also gave me the opportunity to discuss and talk to different and more experienced professionals (teachers). We shared and discussed ideas of how to teach and assess.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 3 – I would say yes, but I did have the content knowledge. What it enhanced was my teaching strategies and techniques used. I was lacking on how to actually go about teaching it to my learners.

In my undergraduate modules I learnt the content but what this professional development enhanced was teaching skills and strategies on how to go about teaching EE in a fun and exciting way.

So you can say that u had the content knowledge to teach environmental education, but what I gained was the techniques, skills and ways to teach and assess. And this professional development exposed me to engage with other teachers, so we discussed what we did in our classes, we spoke about what worked in class. Then we were all motivated to try new things in our class. I think that environmental education is a relatively new section so many teachers don't really know how to teach it.

Any you see learners won't even understand concepts if we just teach straight from a textbook. We have to make our teaching relevant to learners. I can't just teach a food chain or web from the textbook. I rather take them out in the school garden and teach them what they are familiar with.

You see whatever I teach learners I always try to relate it to their lives and their own social context. Because what you see in textbooks is the content of environment and sustainability education globally e.g. North and South Pole, learners don't know all of this we need to teach what they experienced first.

I feel using media in the class will really assist learners understanding. Like I showed them a National Geographic video when teaching my lessons, and I showed learners different feeding relationships. I paused at points to show different organisms e.g. producer, herbivore, scavenger. I feel when you use visual and audio it enhances learning and understanding. Visual aids enhance learners understanding.

You see sometimes learners don't know certain organisms, so they cannot make out in their heads but if you show them a video clip they will understand.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 3 – Well I don't think there were any negatives. Positive in my view is credit should be given to the lecturers of the module. They motivated me to be innovative in my teaching. They assisted me with examples of different ways in which I could teach this content of environmental education. Notes were very engaging. The portfolio assignment was also very beneficial and it also showed me who I was from within.

Like I said I always wanted to be innovative but I did not know how to actually do it. Ok let me see how I can put it. It was this professional development that gave me the kick start to be innovative. It forced me to be innovative. Also I discussed and shared with peers in the module; we exchanged ideas and spoke about our challenges and how to overcome them.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 3 – Yes it would help. But for me what lacked was that I did not see my lecturers bringing in any resources to lectures. But they do give examples on how we could teach innovatively.

You see my learners feel it when I am innovative. I see the difference in them. So maybe if my lecturers are a bit more innovative I could also feel what my learners feel.

My learners were very positive and excited. They enjoyed my lesson. They improved in terms of results. They were all actively engaged and motivated me in my lesson.

Raeesa – What is your understanding of innovation?

Participant 3 – My understanding of innovation in terms of education is coming up with new ideas of teaching that attracts and catches the interest of learners.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 3 – Times are changing; curriculum is changing all the time so we as educators need to be innovative to adapt to change.

You see learners will have a problem making sense of certain aspects of environmental education. Therefore, we as educators we need to be innovative. It's in my head but I don't know how to put it.

It is difficult for learners to make links and connection if you just teaching from the textbook, but if you show them video clips and pictures then yes it will link up.

Like I said before visuals will definitely enhance understanding and do well (perform well) improve results.

Raeesa – Can you please give me an example from environment and sustainability education of a way in which Life Sciences/Natural Sciences teachers can be innovative?

Participant 3 – I would take them on a field trip or take them to a park, discussing ways on how they can protect the environment, or also showing how humans have an influence in negatively impacting the environment. I could also call in a guest speaker from parks and recreation department to have a talk with learners on how to protect the environment. I would create a sense of responsibility/attachment in my learners for the environment. I would also use outdoor learning and fieldwork.

You know YouTube is very useful. Sometimes I get most of my videos from YouTube. Before this professional development I never thought in this way. This professional development has inspired me and built my ability to innovate in my class. It has transformed me as an educator.

Trust me previously I would have taught in a very traditional manner but after this professional development module I now have the ability to be innovative.

I would have never used outdoor learning or ICT in my lessons. I think if I did not go through this professional development module I would have just taught EE using the textbook and blackboard.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 3 – Yes. There is a need.

Raeesa – But is innovating a requirement in terms of policy?

Participant 3 – I don't think so, but in the CAPS for all learning areas you are given suggestions that tend to guide you as to how you could teach a topic.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 3 – Well you can teach it in a traditional manner, but if you want to see understanding and improved results in my opinion you have to teach in an innovative way.

The content can be delivered but I feel for learners to understand and be engaged then innovation is required.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 3 – I learnt how to group learners. I learnt new ways of how to teach. I also learnt how to deliver content in an innovative way. I am currently practicing it in my class. Well I did grow as an educator, very much in terms of skills and techniques on how to teach content not only in EE but in all learning areas.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 3 – Yes, projects, presentations. It did. I now have a few ideas e.g. role play.

Raeesa – In your teaching, what factors enabled or enhanced innovating when teaching environment and sustainability education? Specifically at your school.

Participant 3 – There are two things that really enhanced or enabled me to be innovative. One is that I have resources and I have computers at my school. You see learners like to use technology. Also my learners enhanced innovating. Oh and also my principal and HOD are open to new ways of teaching so that also enabled me to be innovative. My principal always says he is from the old school and he wants new and trendy ideas in his school. In my school we have so much of resources, the library and computers but nobody uses it and sometimes the other teachers don't know how to use it.

At my school we have big boxes of computers with programmes installed but no one really uses it. I think I am the only one using it because I am also a computer teacher.

You see I noticed a change with my learners before they did not want to learn they were not motivated at all. But by using the computer and outdoor learning I noticed the change in them and that enabled and motivated me to continuously be innovative. This professional

development enabled me to gain confidence as a teacher and it built my capacity to be innovative. One more thing, you see to be an innovative teacher it is very time consuming so it really taken up time but I can say learners really enjoy the lesson.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 3 – I don't see any factors that hindered innovating. Like I said my principal and HOD is very flexible and open to new ideas.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 3 – Yes, it did transform me and also it enhanced my skills and made me aware of different ways on how I could teach a section. In terms of content knowledge I knew it but I did not know how to put it across to learners. I grew and learnt different teaching methods and skills.

Wait let me put it like this before this professional development I was trying to be innovative but I did not have the skills or capacity to do so but having registered for this module it forced me to be innovative. It gave me the boost or kick start.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 3 – Yes as a teacher I have changed and improved. I do see a change. My learners responded very positively. They enjoyed the creative way of teaching. You know those once off workshops, they just take long. This professional development really enhanced me. Those workshops did nothing for me, it gives me what I already have.

Participant 4 – II 4 – 15:00 – 02/07/15

Raeesa – Good afternoon, I am sitting in with participant 4 and I am conducting an individual interview.

Participant 4 – Good afternoon.

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 4 – Yes this professional development has enabled me to expand my knowledge, improve my teaching and assessment methods as well as enlighten me on the importance of innovation. This professional development positively impacted on my teaching. It has positively impacted me because there were excellent learning packs; the portfolio assignment also had a positive impact on my teaching.

Before engaging in this professional development module I felt like I was in a slump. I became accustomed to the traditional methods of teaching and I began to get frustrated with myself. I was de-motivated. So I needed to do something to change so I would say that I needed and required this professional development. I definitely needed some intervention from my part.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 4 – Yes I did.

Raeesa – Which particular events enhanced your knowledge?

Participant 4 – For me it was planning the innovative lessons and developing the portfolio. I really enjoyed planning the lesson; it forced me to be innovative. My learners also enjoyed it. I did group work and presentations. Also we had lectures that provided us with assistance and motivated us to be innovative. The resources and readings were also very useful and enhanced my knowledge. This module was fantastic; it enlightened me and broadened my knowledge.

You know what was also good; throughout the module we reflected and discussed with peers. We shared ideas with each other. So there was lots of peer learning. We discussed what we implemented in our class and what worked and what did not. So we learnt new ideas from our peers.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 4 – Well I can't seem to think of any negatives. But yes this professional development really impacted positively on my knowledge. The lecturer was well organised and explained quite well. The resources were fantastic and this really assisted me to plan

innovative lessons. The designing of the lessons which were compiled in a portfolio really impacted positively on my teaching.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 4 – Yes definitely. I think that all teachers need this kind of professional development. I feel that part of being a teacher is that you have to be an ongoing learner. The curriculum is ever changing so yes teachers need to be involved in this kind of professional development so that they can be current with their teaching. We as teachers need to keep abreast of such changes.

This professional development forced me to explore different teaching and assessment strategies. So I would say that designing that portfolio triggered that change in me. I have found that by using these new methods of teaching learners are now very enthusiastic and are happy to learn.

I have now realised that the traditional methods of teaching is not working. By using innovative methods it makes learning fun and exciting and as a result learners are motivated and willing to learn.

Prior to this professional development I was a traditional teacher and I became stuck in my ways. But now I see a change. My learners now enjoy coming to class and their feedback to me was very positive. I can say that I have seen a slight improvement in my learners' results. I guess because they are happy and motivated.

Raeesa – What is your understanding of innovation?

Participant 4 – It is when a teacher moves away from conventional techniques of teaching and assessing. It is when a teacher uses new and creative methods of teaching.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 4 – Yes definitely they need to be innovative.

Raeesa – Can you tell me why?

Participant 4 – We have different learners in our classrooms; and every learner learns in different ways. They have different learning styles. What we teach in environmental education is not easy; it is difficult for learners to absorb and grasp certain concepts. So innovation is needed to help learners connect and make links with the content being taught.

Raeesa – Can you please tell me how science teachers can be innovative in the classroom?

Participant 4 – Two of my favourite things are the use of a wide range of resources, e.g. visuals and models and doing group work. Well I can also say that I started teaching environmental education using outdoor learning so I make use of the school garden. I would

also like to plan field trips. I feel that learning in the environment about the environment makes a difference to learning and understanding. I did a lesson about the lichen so I took them out of the class and showed learners. I feel if learners see it physically it makes a huge difference to understanding science concepts.

Raeesa – What innovative method of teaching did you use in your portfolio assessment?

Participant 4 – I use computer technology. I am fortunate at my school because we have a newly designed computer room and media centre. It is an advantage for me because it is right next to my science lab. I grouped learners and took them to the media resource centre.

I did a group activity also where I gave each group different weird pictures, not something they have come across. They had to classify this organism. With these activities learners responded very well and you could see the enthusiasm.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 4 – Yes, environmental education needs innovation, it is difficult for learners to relate to. I find that innovation is required so that learners can connect to concepts in environmental education.

Raeesa – Is innovating a requirement in terms of policy?

Participant 4 – I think the policy gives us that space to be innovative. But I don't think it is stipulated to us to be innovative.

I think what is important is that as long as we stick to the curriculum, how it is taught and what methods the educator chooses to use is left to the educator.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 4 – OK, it can be taught in a traditional manner but I don't think it would be that effective. I don't think learners will enjoy it. I feel using innovative methods of teaching results in understanding and learning.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 4 – I learnt the importance of using resources and new ways to teach environment education, but I can say that this professional development module has taught me to be innovative not only in environmental education but in all aspects of science education.

I personally believe that a resource is not something expensive or you need to purchase. A resource can be the newspaper or every day materials or the school yard.

This professional development enabled me to try out new ways of teaching and assessing and I can say that I grew as an educator.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 4 – Yes I did. I learnt to move away from class tests and practicals in the form of a test.

I learnt and implemented presentations, peer assessment, projects, debates, posters, making models of an ecosystem. I now implement debate Friday. I have a discussion Friday, we discuss current news relating to science.

Raeesa – In your teaching, what factors enabled or enhanced innovating when teaching environment and sustainability education? Specifically at your school.

Participant 4 – I think the school itself allows the teachers to be innovative. The school gives us the freedom to try new things. My HOD encourages me to be innovative. He will sit in on my lesson, be part of the class discussions and complement me. This is what motivates me to be innovative. We have resources available but if I don't have then I make do; but this does not stop me from being innovative.

My learners also enable me to be innovative. I see the change in their attitude to learning. They are now more active and excited to be in the Life Sciences class.

I think that this professional development was a major contribution that enabled me to be innovative, because before this module or course I felt very de-motivated and I was in that rut. But now I am really enjoying my work and I feel much more confident. I can say that I have gained the capacity to be innovative. I see this as a start because there is a change, shift or transformation of my practice.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 4 – No, my HOD and learners supported me.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 4 – Yes it did. I have noticed a positive change. I was the traditional teacher and was getting very depressed with my job. But now I feel renewed. I see myself growing as an innovative educator. I am loving what i am now doing in my class.

Raeesa – Did your current teaching practice of environment and sustainability education change you engaged with the professional development (Honours module)? Explain?

Participant 4 – Yes I did see a change. I am more confident. I am not afraid to try new methods of teaching and assessing.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 4 – Yes I am planning and implementing innovative lessons with all my grades and classes. I am not only innovative in environmental education but I am in all aspects of science education. I see this change continuing because my learners are benefiting.

Participant 5 – II 5 – 10:00 – 03/07/15

Raeesa – Good morning, I am sitting in with participant 3 and I am conducting an individual interview.

Participant 5 – Good morning.

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 5 – Yes I do believe so. This professional development module gave me more direction in my teaching. You see prior to this professional development module I had ideas but I did not know how to actually implement it in my classroom. So this professional development module gave me the direction of how to be innovative. This professional development module was so good that I feel all teachers even undergraduates should be exposed to it. When I registered for this professional development I did not realise that I needed it; but after going through it I found that I really needed it.

This professional development module was extremely beneficial to me. One skill that I learnt was how to bring my subject across to learners. I did not have the skill of putting my subject across to learners. But now I have the "know how", the skills on how to breakdown concepts and put it across to learners. So you can say that this professional development provided me with the skills on how to bring my lesson across to learners to ensure maximum engagement and understanding.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 5 – Yes

Raeesa – OK, which parts of the professional development enhanced your knowledge?

Participant 5 – Well we had a lot of peer discussion, so we shared ideas and I learnt from my peers in the group. The portfolio assessment really enhanced my knowledge. My knowledge was also enhanced because I also was given the opportunity to interact with other professionals in the field.

The interaction with peers, lectures and notes really enhanced my knowledge of environment and sustainability education. the course packs were extremely useful and the structure of the module really enhanced my knowledge.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 5 – This course brought forth all my shortfalls as an educator that I had to address. The positive was that I was enabled to develop myself as an educator. The planning

of an innovative lesson really impacted on me positively. This module helped me to increase confidence in myself as a professional.

I just want to be honest the portfolio assignment was really frustrating at first because it took me out of my comfort zone. But after compiling the lessons and implementing it and looking at my learners responses, I saw the importance and need for innovation in the teaching of science.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 5 – Absolutely yes. I actually believe that this should have been a module in undergraduate studies because not all teachers register for an Honours module. All teachers need to be involved in this type of professional development. This kind of professional development allows teachers to develop and teach using new and interesting methods that enhances learning for learners. I have realised that learners enjoy innovative methods of teaching. I have learnt to step out of the box and even if other educators at my school complain, I just ignore it because I see the difference in my classroom.

I definitely grew as an educator and the learners enjoyed my new approaches to teaching. This professional development has also enabled me to adapt to change in curriculum.

You see science is an absolutely amazing subject but teachers kill the subject. We as teachers need to re-think how we teach science so that learners enjoy it.

Raeesa – Do you think science teachers need to be innovative in the classroom?

Participant 5 – Yes they do. Science is a challenging subject I believe if you are an innovating teacher you can make a difference in learners understanding. You see learners see science as something that is happening in a different universe altogether. We as educators need to bring science close to them; make it real using innovation.

Many learners have a fear for science. As an educator using innovative methods we can remove that fear and let learners enjoy science. See if you are more innovative when teaching science then learners will engage more readily with the subject and eliminate fear for science.

Raeesa – Can you please tell me how you could be innovative in the science classroom?

Participant 5 – Firstly I would say science is practical and so often we as science teachers just run on with theory. Maybe start of your lesson doing a practical, this automatically engages the learners and sparks their interest. Then from there you can ask questions and cover up the theoretical aspect. Also with environmental education I would structure my lessons out of the class, doing field work instead of just sticking to the textbook. I have used videos, games, debates and outdoor learning.

An example is classification of organisms; we always do it on paper. But now I have changed; I have made my lessons more exciting for learners. I ask them to imagine that they

are scientists and I give them make believe organisms to classify. I think hands on learning is very important.

Raeesa – Can you please give me an example from environment and sustainability education of a way in which Life Sciences/Natural Sciences teachers can be innovative?

Participant 5 –Well I used a video clip which so beautifully captured biodiversity. It had a song "what a wonderful world". This allowed learners to see what this world is made up of. This video clip allowed them to see the differences and how diverse we are.

Raeesa – What is your understanding of innovation?

Participant 5 – Perhaps creativity or making a topic exciting. I would say teaching a topic or concept in a new way. Innovation is finding alternative ways to teach something that learners may not have grasped using the traditional approach to teaching.

Innovation is about being creative in your own teaching context. From my experience of using innovative methods of teaching I found that it results in better understanding. Learners responded positively it was different and exciting.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 5 – Yes; innovation is needed. I am not only innovative in environmental education, but also when teaching the kidney and other aspects of science. We have studied it in the professional development specifically to environmental education but it took the skills and techniques I learnt to other aspects of science education.

Raeesa – Is innovating a requirement in terms of policy?

Participant 5 – I don't think so, I don't think it is stipulated.

Raeesa – In your view do you have to be innovative when teaching this content on environment and sustainability education or can you teach it in a traditional manner?

Participant 5 – No, it cannot be taught in a traditional manner effectively. If you want to make a change we have to be innovative.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 5 – I learnt how to be innovative or I can say I got the kick start to be innovative because part of our assessment was to plan and implement innovative lessons. So yes this module forced me to be innovative, at the same time I saw the importance of innovation. I also learnt that environmental education cannot be taught effectively in a traditional way. You have to be innovative; you have to plan outdoor activities. From this professional development I learnt new ways on how to teach and I developed a great amount of confidence. I also learnt how to be resourceful even when there are limited resources.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 5 – I feel that I have moved away from the fearful forms of assessment. I used projects, poster making of models, and I found that learners responded more positively to these forms of assessment. I also noticed that learners now started handing in their assessments.

I also used a quiz as a form of assessment. I learnt this from the professional development because the lecturer gave us a quiz on environmental education to fill in during one of our lectures.

I learnt new ways of assessing from this professional development. I am now implementing new ways of assessing like I did a debate on the human impact on the environment. I made learners do a model on a marine ecosystem.

Raeesa – In your teaching, what factors enabled or enhanced innovating when teaching environment and sustainability education? Specifically at your school.

Participant 5 – Well I can say definitely the teachers at my school. My school allowed me to be innovative, they supported me and allowed me to plan and implement my lessons differently. My HOD is quite flexible in the way I teach my content, but as long as my content is taught. Also I feel that the most important factor that enhanced my innovation was my learners. They were willing to learn. They loved my new teaching techniques and they were excited. You know learners told me many times we only look at the textbook and read and this is boring. I never knew what I was doing to them; but now my learners are very eager to learn.

This professional development module really opened my eyes and enhanced my knowledge about innovation. I always wanted to be innovative but I did not have the direction. This professional development laid the foundation to build my confidence to be innovative. I am not fearful anymore I can say that I now have the knowledge and ability to be innovative.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 5 – I think the only factor was the large numbers at my school, like my one class has 51 learners, but I try to be innovative. With regards to resources it was an issue, especially desks and chairs and few textbooks for learners. But I was motivated by the professional development and I had the capacity to work through these challenge. I learnt that you can be resourceful and develop your own resources and worksheets and use technology that can attract learners' attention.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 5 – Yes, I have been transformed, changed. Prior to this professional development module I was not innovative; I just used the traditional approaches. I now see a change in me as an educator. I am more confident. I am no longer confined in my teaching.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 5 – Yes overall my practice has changed. I am innovative in every aspect of science not only in environmental education. I now have a new outlook to teaching. I always try to incorporate innovation whenever I teach. I have moved away from teaching in a traditional manner. I have also noticed a change in my learners; they now ask questions, they don't normally do. I really found my learners more engaged and interactive.

Participant 7 – II 7 – 10: 00 – 06/07/15

Raeesa – Good morning, I am sitting in with participant 7 and I am conducting an individual interview.

Participant 7 – Good morning.

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 7 – Yes it has positively impacted on my teaching of science. This professional development module has increased my knowledge on environmental education. I learnt new skills and ways on how to teach environmental education. So yes I would say that this professional development had a positive impact on my teaching.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 7 – Yes as I said before it has greatly enhanced my knowledge. The course packs and readings really helped and motivated me to be innovative teacher. The lecturers were well structured and designed. What really caused the change or enhanced my knowledge was designing the innovative lessons and compiling it in a portfolio.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 7 – The portfolio assessment impacted very positively on me this actually pushed me or forced me to become an innovative teacher.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 7 – Yes it would definitely be beneficial. I personally feel that all teachers should be involved in this kind of professional development. Also the curriculum is always changing or being revised so teachers need to be innovative in order to remain current.

Raeesa – What is your understanding of innovation?

Participant 7 – I would say it is teaching in a more exciting, attractive, catchy and creative manner. I would also say that it is moving away from traditional teaching methods and doing new things in a lesson.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 7 – Yes they do. Especially because science is a difficult subject to understand. If teachers are not innovative then I feel that environmental education will not be taught

effectively. Science is difficult and learners need to be given every opportunity to understand the content. I feel that I must be innovative.

Raeesa – Can you please tell me why science teachers need to be innovative?

Participant 7 – Science is quite difficult as I have mentioned. Learners find the content challenging and cannot relate to it. So if we as teachers are innovative then we can try to link content to help learners make connections. Environmental education must be linked to the daily lives of the learners.

Raeesa – Can you please give me an example from environment and sustainability education of a way in which Life Sciences/Natural Sciences teachers can be innovative?

Participant7 – I think by using different teaching styles such as group-work, group presentations and by using the computer. All these resources can make science more exciting for learners. They can feel as though they are seeing science rather than just looking at it through a textbook.

I have noticed a change in my teaching after this professional development. I also saw a change in my learners and that is the reason why I will continue to be innovative when planning, teaching and assessing.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 7 – Yes I did; innovation is needed because environmental education is difficult to teach and also learners find it difficult to understand, as I have already mentioned. Innovation helps to remove some of the misunderstanding; learners can see for themselves how environmental education fits into their own lives.

Raeesa – Is innovating a requirement in terms of policy, as far as you know?

Participant 7 – In terms of policy I would say it is a requirement because the CAPS document gives suggestions to use group work, presentations, debates etc. It is just that to be an innovative teacher it requires a lot of time and planning; so that's why many teachers prefer using chalk and talk. But once you implement or present an innovative lesson using various visuals and resources; you will feel so motivated with the learners' positive responses; that you would realise that the planning and time it took was worthwhile.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 7 – Well yes; you can teach it in a traditional manner, that's what I was doing all along. But I can say that it is difficult; it is not enjoyable and learners get bored quickly. There were times when learners did not even understand what I was teaching.

But by using innovative methods it automatically gets the learners attention; learners ask questions and understand concepts. I have noticed an improvement in learners' results and participation in class.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 7 – I learnt new ways on how to teach and assess learners when I am teaching environment and sustainability education. This professional development has enhanced my knowledge. I can say that I have grown as an educator and I am a different science educator now after the professional development module.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 7 – I learnt to move away from the traditional methods of assessing learners. I used to implement the same old fashioned types of tests and projects. But now I feel that by using different methods of assessment learners respond better and perform better. I feel that the performance of learners is crucial and assessment must give all learners the opportunity to achieve good results in science.

Raeesa – In your teaching, what factors enabled or enhanced innovating when teaching environment and sustainability education? Specifically at your school.

Participant 7 – Firstly I can say that my learners enhanced my ability to innovate. Their positive responses and good results motivated me to continuously be innovative. I teach as a well-resourced school so to be innovative was quite easy. I was not challenged by limited resources. My principal and HOD were also the fuel that allowed me to be innovative in my teaching of environmental education. They encouraged me to pursue new ideas and motivated me when I was teaching.

The professional development also provided me with a kick start to be innovative; now I have the confidence, knowledge, ability and capacity to be innovative in my teaching of environmental education as well as other science content.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 7 – I don't see any factors that constrained me to be innovative. I just ask myself why I was not innovative before this Honours module. I can say that this module really gave me that boost to be innovative.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 7 – Yes a big change. I see myself as a transformed educator. My teaching and assessment has now changed. I have noticed a huge difference in my learners. They are much more enthusiastic and motivated to learn.

I have to say that I now have the capacity to be an innovative teacher. Before this professional development I used to teach in a very traditional manner but now I have been transformed and changed to a better more effective science teacher.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 7 – Yes I am now an innovating science teacher. I am also innovative in my teaching of physical sciences, not only natural sciences. I have a new outlook to teaching. I am always looking to teach and make my lessons more exciting for learners.

Participant 8 – II 8 – 12:00 – 06/07/15

Raeesa – Good day, I am sitting in with participant 8 and I am conducting an individual interview.

Participant 8 – Good day.

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 8 – Yes it has definitely impacted on my teaching of science. This professional development has increased my knowledge, teaching skills and assessment techniques. I really needed this professional development.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 8 – Yes is did greatly enhance my knowledge. I now feel more empowered than I felt before this professional development. The tasks done in the module enhanced my knowledge, but planning and implementing the innovative lessons had a great impact on me. That I feel was the real turning point for me.

Collaborating with peers and discussing our challenges faced at school with regards to innovating also motivated me and enhanced my ability to be innovative.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 8 – Well I can say that there were really no negative aspects. This professional development enabled me to grow as a teacher. I now have a new outlook to teaching science. I feel as though I have the capacity to be innovative. The portfolio assignment really had an impact on me. It sought of forced me to be innovative.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 8 – Yes I feel that all teachers should be involved in this kind of professional development. This professional development allows teachers to develop and teach using new and interesting methods that can enhance learning for learners.

Also our curriculum is always revised so teachers need to be innovative in their teaching so that they can remain current.

Raeesa – What is your understanding of innovation?

Participant 8 – I would say it is doing something in a different way. In a way that is more exciting and more attractive. Teaching using innovation would be like teaching in a different way that results in learners' interest being sparked and their understanding being enhanced.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 8 – Yes I personally think that science teachers need to be innovative because the content of environmental education is quite hard to understand if learners don't have an understanding of concepts. Sometimes learners don't have a visual understanding of an organism that we as teachers are referring to. So it is helpful to be innovative and move away from the textbook and bring in visual aids or videos that might enhance learner understanding.

I found that by using a power-point presentation, videos and fieldwork in my teaching, I obtained maximum learner participation in my lessons. I also found that learners are understanding concepts of environment and sustainability education when I used innovative methods.

Raeesa – Can you please tell me why science teachers need to be innovative?

Participant 8 – By teachers using different styles of teaching, e.g. outdoor learning or presentations in groups etc. I feel that a teacher must identify the best innovative methods that would work in their school and implement it. Sometimes schools may not have many resources, but I feel that innovation is still possible.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 8 – Yes innovation is definitely needed. It can be taught by using the chalkboard and textbook. We need to make it real for learners so that they can create a link to their own context and understand it.

Raeesa – Is innovating a requirement in terms of policy, as far as you know?

Participant 8 – In terms of policy I don't think it is stipulated. But I feel it is needed.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 8 – It can be taught in a traditional manned. I taught it before but learners felt bored and did not understand it. They just switched off during the lesson and did not want to participate.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 8 – This professional development module has made me aware of different methods and ways of teaching. Content like environment and sustainability education, which is not very exciting, I used to just rush though before.

I can really say that this professional development really empowered me and made me grow as a teacher. I see a change in my teaching and my learners now enjoy my lessons.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 8 – I can say that I no longer stick to the conventional methods of assessment. I have also found that learners respond better to the innovative methods of assessment. I now make use of posters, group work and debates when I assess learners.

Raeesa – In your teaching, what factors enabled or enhanced innovating when teaching environment and sustainability education? Specifically at your school.

Participant 8 – Ok for me there were many factors that enhanced innovating. Firstly my HOD is extremely supportive to me when I plan and implement innovative lessons. My HOD complemented me and motivated me when I did try to be innovative in my teaching and assessment. My HOD also allows me to be flexible when it comes to assessments; he allows me to go on field trips and then do my prescribed assessment. The school that I am at also allows me to be innovative. They allow me to take learners on field trips, environmental conferences and also to the beach.

I can also say that my learners enhanced innovating. I have learners that want to learn and support me when I want to implement an innovative method of teaching or assessment. When I ask my learners to prepare for a debate in groups they are ready and conduct their own research, they bring in their own videos to guide my teaching.

So I can say my school, HOD and learners really make it easy for me to be innovative, now that I possess the capacity to be innovative after this professional development. This professional development gave me the foundation and boost to be innovative.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 8 – I don't think there were any factors that constrained me. I have the capacity to innovate and I have support and resources so I am able to be an innovative science teacher.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 8 – Yes it did bring about a change and a transformation in my teaching. I feel that I am more confident in the way I teach. I am now open to new ideas. I also have the confidence to share ideas with others. I see a change in myself and this has also brought about a change in my learners.

Raeesa – Did your current teaching practice on environment and sustainability education change after you engaged with the professional development (Honours module)? Explain.

Participant 8 – Yes is has definitely changed. I am now empowered. I feel like a new teacher. I am always looking for better and new ways to teach my learners. Prior to this professional development I mainly used the textbook and the chalkboard. I now see a change in my teaching and I strive to relate the content to the lives of learners. This professional development has taught me to do this. I try to show them videos that are relevant to the environment around them.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 8 – Yes I am. I am an innovating teacher. Not only in science but in whatever I am asked to teach. I look for ways to be innovative now because of this professional development. I have come a long way, this module has developed me. It has transformed me as an educator. I feel like a new teacher, I have fresh ideas and I am motivated to ensure learners understand as I teach environmental education.

This module has given me a lot. Before it I would have never been able to see areas in certain topics where I can be innovative. Now I can see opportunities for innovation. I have the knowledge of how to be innovative in my teaching. This module has increased my knowledge and my teaching ability.

Participant 9 – II 9 – 09: 00 – 07/07/15

Raeesa – Good morning, I am sitting in with participant 9 and I am conducting an individual interview.

Participant 9 – Good morning, thank you.

Raeesa – Did you feel the professional development, like courses you do on the Honours programme, related to environment and sustainability education, has impacted on your teaching of science education? Explain.

Participant 9 – I can say that this professional development has had an effect on me, but not my teaching per se.

Raeesa – Can you explain further how it has impacted you?

Participant 9 – I have been teaching for many years and I have seen a lot. The school I am in, I have been there for over 15 years. It is difficult to teach an "old dog new tricks", but this professional development has given me a different perspective on teaching. But I am in a school where resources are very scarce and there is basically no room for innovation. There are so many other issues in the school day that there is no time to even think about to make the lesson more attractive or interesting for learners. I am to be ready to discipline the class and get them quiet and ready to work and complete the syllabus, which is the priority. So this professional development have given me new knowledge but it hasn't changed my teaching directly.

Raeesa – Did you need or require this professional development?

Participant 9 – I do feel I needed this professional development. Even a seasoned teacher has areas of the curriculum that they do not enjoy and I was not confident teaching environment and sustainability education to learners because I did not have any method to make it easy for them. So I needed some help in that regard, but it's unfortunate that I cannot implement what I have gained from this module.

Raeesa – Did the professional development enhance your knowledge of environment and sustainability education? Which events enhanced your knowledge?

Participant 9 – Yes very much so. I had a basic knowledge of environmental education and I never thought I needed to know much more. But this professional development module really surprised me and gave me something I didn't even know I could learn.

I feel the content on the one module really gave me something new. The activities and assignments that we had to complete really enhanced my knowledge. I gained a lot of knowledge that I can, in a different school use in the classroom to be an innovating teacher.

Raeesa – What aspects of the professional development impacted negatively or positively on your knowledge of environment and sustainability education?

Participant 9 – I don't think there was anything negative although we only had one module that included innovation. If I had to say, it would be that there should have been more modules that included innovation and how we could use innovation to teach.

Raeesa – In your opinion would more professional development of this nature be beneficial to your science teaching?

Participant 9 – Yes it would because it gives teachers alternatives. Having different options can make a world of difference to a teacher because they can change between one method to another that may be very helpful when a teacher gets stuck or is having difficulty.

Raeesa – What is your understanding of innovation?

Participant 9 – I think innovation means doing something in a different and more creative manner. Innovation is also about uniqueness and in teaching I think it would mean teaching in a unique way so that learners can understand.

Raeesa – Do you think science teachers need to be innovative in the classroom? Can you please tell me why?

Participant 9 – Yes they can if they are given the opportunity. Science is a difficult subject and sometimes learners are not confused by concepts and terminology. If a teacher can devise a way of teaching a difficult concept to learners using innovation then that will definitely make is easier for learners to understand. I think that anything that helps learners' understanding should be part of the classroom.

Raeesa – Can you please give me an example from environment and sustainability education of a way in which Life Sciences/Natural Sciences teachers can be innovative?

Participant 9 – I think in sections like environmental education, teachers can maybe use their surroundings to show learners aspects of the environment. I think it is important to take learners out of the classroom, provided discipline is not compromised, and into the actual science of the environment. Pictures can sometimes do little to help learners understand.

Raeesa – Were you able to identify the need for innovation in environment and sustainability education?

Participant 9 – Yes I could see the need for innovation but the school stops me from being innovative. I am not able to express myself as a teacher. I could not do anything I had to teach in a normal way because syllabus completion is priority.

Raeesa – Is innovating a requirement in terms of a policy, as far as you know?

Participant 9 – No, I did not see that the CAPS document stipulates innovation is required.

Raeesa – In your view do you have to be innovative when teaching content or can you teach it in a traditional manner?

Participant 9 – I think there are spaces where a teacher can be innovative and there are other spaces where the traditional methods of teaching apply. The skill is to be able to identify when it is applicable to be innovative and when it is not. With more professional development like the one module we have been through, teachers can develop this skill.

Raeesa – What innovating strategies for the implementation of curriculum on environment and sustainability education did you gain from being part of this professional development?

Participant 9 – I learnt that innovation is possible and you can be innovative in different ways depending on the context of the classroom and the learners. I feel that innovation cannot just happen and it must be a planned and timeous event that will be effective in the moment.

Raeesa – What innovating strategies of assessment in environment and sustainability education did you gain from this professional development?

Participant 9 – Learners can get bored very easily and assessment can sometimes add to that boredom. When we assess learners they can be uninterested in the same old methods we use to assess. Something like a dance or a role play or a poster may inspire creativity in learners and they may perform better than if they were asked to write a test. So I learnt that assessment should be diverse and not restricted.

Raeesa – In your teaching, what factors enable or enhance innovating when teaching environment and sustainability education? Specifically at your school.

Participant 9 – I can teach using innovation, but because I need to complete the syllabus, and the school gives no support, I just teach in a traditional manner. If I was at a different school with resources and supportive management then I am sure I would have the opportunity to innovate and use the knowledge I have gained in this module.

Raeesa – In your teaching, what factors constrained innovating when teaching environment and sustainability education? Specifically at your school.

Participant 9 – In my school there is a general feeling of apathy amongst the staff and the learners. If you do try to make a difference and try something new, staff see you as rocking the boat or creating waves. Even if I have new ideas the school management is not interested. I think the management is this way because learners demotivate the teachers and vice versa. We can't run out worksheets for learners due to a lack of funds. Innovation is possible but with no support, a lack of resources and school management that doesn't support it, I could not teach using innovation.

Raeesa – Did the professional development (Honours module) bring about any change/transformation in your teaching of environment and sustainability education? If so, describe the change/transformation.

Participant 9 – This professional development has developed me, but my school is severely under-resourced. We only teach using the chalkboard and a limited number of textbooks. Even running out worksheets is difficult due to a lack of paper. We don't have data projectors

for teachers or computers for learners to use. This professional development module has inspired me… I now see a need for innovation. I have identified areas where I can be innovative in my teaching.

Raeesa – Did your current teaching practice of environment and sustainability education change after you engaged with the professional development (Honours module)? Explain.

Participant 9 – I did not use innovation in my lesson and this was due to the contextual factors at my school. My HOD is not very approachable he just wants the work to be completed his way, if I could ask for help I would. But it is not part of the way this school operates, so I just do as I am told without creating too many waves.

Raeesa – Looking at your teaching holistically, has your teaching been transformed after engaging in the professional development? Are you now an innovating teacher?

Participant 9 – Yes I have been transformed from a psychological perspective. I am knowledge that can never be stifled. I hope that maybe in the future I could test the knowledge that I have and try to be innovative, but for now I am constrained.

APPENDIX 11

Reflective Journals of Participants

Participant 1

Question 1

My personal capacity as teacher were highly enhanced during this professional development especially due to the fact that before now, I had very little knowledge and strategies of how to be an effective teacher. During the course of this programme I can confidently say that i have now developed some personal strategies to implement in my classroom which I believe will yield positive result in my teaching. I did not know how to teach EE before the professional development.

The environment and venue of this lecture was really conducive. We sat comfortably and could see and hear the lecturers teach. The resources such as the OHP (overhead projectors), the ink board and the microphones where used when necessary for effective teaching. The use of these resources especially the OHP motivated me to request for one in my school to facilitate learning. Frequent discussing on this module made most of my colleagues become more of friends rather than peers. They were always willing and ready to give me clarity when requested.

Based on my opinion, I will say huge efforts were made in the planning and implementation of this module. A conducive environment was provided for the lecture, all required lecture notes, materials and articles were also provided in a neat and decent format. These efforts made by the managements definitely aided my development in the module. But I would have liked to learn about innovation in other modules because it is really useful in teaching science.

The two lecturers that facilitated this module were first of all qualified to lecture the module and they provided all the assistance we needed while the module lasted. They gave a good example on how we should relate with our students. They provided and encouraged us to call or email them whenever we need assistance with regards to the module.

Our developments in the module where also monitored by the lecturers by means of tests, assignments and presentations. Feedbacks where also given when necessary to enable us take corrections and know where we had shortcomings. I welcomed these monitoring and they heightened my motivation in assessment and feedbacks.

During the lecture, they were patient and prompted participation from us students to aid our understanding of the unit being handled. These supports increased my innovative capacity in terms of teaching and learning.

Yes I do, based on my above responses.

Question 2

Before the course, though I knew of some teaching strategies but I have never had the courage and confidence to implement some of them in my teaching. However during and after this module, after seeing how the lecturer utilised the resources in the venue, implemented and encouraged some of these strategies, I have been able to introduce strategies such as presentation, charts and portfolio tasks while teaching in my class.

One of the assessment requirements of this module was for us students to develop a portfolio of a certain topic we taught in our classes. I did discuss with my peers on the best way to go about doing this tasks as initially it looked difficult. However, after deliberating with my peers who had by then became my friends, we were able to find ways to perform the tasks in our individual classes according to the context of our schools.

I actually didn't engage with my lecturer during these tasks, but I knew they will always available whenever I will need them. I can also include that they really displayed some level of efficiency during our various tasks monitoring and assessment by giving valid feedbacks when necessary.

In terms of utilising physical resources, we were given some form of worksheets during the module which I was able to use in my class while teaching a relevant topic and I must say, the worksheets were really helpful.

Yes I really do.

Question 3

The school where I teach is a moderately resourced school, and hence teaching resources weren't really an issue. As a new teacher, I was encouraged by my principal and head of department (H.O.D) to assess most of these resources if need be while teaching. Resources such as electricity, well equipped laboratory, printers and photocopiers, assorted text books, internet facility, funds for immediate purchase of practical items such as sheep's kidney, gloves etc.

As with all schools, my learners have different learning abilities, however, this did not affect any of my strategy implementations as I was able to a very large extent know and understood my learners hence I could bring out the best in them why implementing any strategy. For example, for a presentation, I organise my learners in balanced groups where each group will have learners of both high and low learning abilities and thereafter, mandate every member of each group to participate during the presentation for maximum scores.

Aside having a good amount of resources, my school allows and encourages teachers to be creative in their teaching. This did not only give me the extra boost I need to be innovative, it also made me to strive more to give my best as a teacher. I could develop a sort of lesson plan knowing full well I wouldn't have a hitch in its implementation.

I find that you naturally have it in you to be innovative, but all you need is the support or the push to do it. This Honours module was actually a catalyst for my change. There was no support from my head of department while planning any of my lesson plans because I never asked of any. However, I got a lot of supports from my colleagues especially the teacher I took over from who handed me her past lesson plans and worksheets. From my H.O.D's continual check-up on my teaching, I know I would have gotten some supports if I had asked or shown that I needed any.

I honestly did not engage any of my peers while planning or teaching any of my lessons. What I often do is discuss with my peers some challenges I experienced while implementing any of my strategies.

Yes I do.

Yes I can.

Question 4

I really didn't have any constraints while teaching. This can be attributed to the fact that I teach in a resourced school where resources where not an issue. Tables, chairs and lockers were sufficient for each classroom. The class sizes where small compared to most schools the smallest class being18 and the largest was 32 learners.

Aside the physical resources, the school makes available funds for other on the spot resources which a teacher might require for one lesson or the other. So with this, I never felt restrained in terms of resources for my teaching.

The different learning abilities of my learners did not affect my teaching. This is because I understood my learners and hence planned my lesson to accommodate the different learning abilities.

I will say my school is very conscious of curriculum completion not 'strict' about it. This gives room for teachers to be innovative in their teaching. Teachers are allowed to plan and teach their lessons in whatever pattern that can improve learning and understanding amongst their learners.

My H.O.D and colleagues are accommodating and do not interfere in my teachings. On several occasions, my H.O.D and some colleagues had on my request swapped their periods with mine to accommodate a specific lesson I had to teach.

From my peers who I am always in contact with, I got lots of supports whenever I ask for it. Sharing each other's experiences in class gives us ideas for our innovations.

Like I mentioned above, I had little or no constraints while teaching. The little constraint being the normal religious, cultural beliefs that one considers while teaching some topics such as "Origin of man" and some practical works such as the "kidney dissection".

Though the pork kidney has the closest resemblance to human kidney, the curriculum recommends sheep's kidney for dissections in schools due to religious beliefs. However, I had a case whereby a student objected to dissecting sheep kidney saying it is against his cultural belief to kill a sheep. This challenge I overcame by going strictly on what the curriculum recommends after politely explaining my decision to the student.

Question 5

Yes. The physical resources I engaged with during this development did allow me to be innovative in my teaching. After going through this module, I can without a doubt say that I am more confident in teaching both the content of this topic and every other topic within my specialisation now than ever before because my thinking has undergone a positive transformation with regards to teaching and learning.

The structure of the module was brilliant, especially the fact that the module was divided in different sections which were taught by specialists of those sections. This was an aspect that impacted mostly on me due to an alarming rate at which teachers are employed to teach courses they are either unqualified or under-qualified to teach.

The lecturers where also flexible with time to accommodate us students. For example, the lecture was originally scheduled for 8am on Saturdays but was later moved to 9am to accommodate students living far away from the venue.

The lectures where always willing and ready to assist provided we seek for the assistance. This act was worthy of emulation for me and I consequently made myself available to me learners for easy access with regards to my subjects.

The physical resources used during the module especially the OHP which made it easier for the lecturer to display the contents of each lesson, also contributed to my enjoying and enhancement during the module.

Since after this module, I have become a more confident teacher, both in my contents knowledge and creativity. I now find myself looking out for new and different ways to teach my subject in order to impact knowledge into my learners irrespective of their learning differences.

Judging from my background, this transformation couldn't have been if I hadn't gone through this professional development. I am very convinced I can take up and do well in future teaching challenges which will require my being innovative. But when I went through the CAPS document I did see that it asked for teachers to be innovative when they teach science.

Personally, I think it is paramount that professional development modules should be taught by professionals who have been actively in contact with the module. It should also be mandatory for all upcoming students who intend to teach professionally or otherwise. Furthermore, the organisation should be supportive, have adequate resources, and lastly should monitor and encourage active participation from students who are participating in the development.

Participant 2

Question 1

a). I have become more aware of the way I teach and the teaching strategies I implement in class. My professional development has made me a more confident teacher and this comes through in my lessons. For me innovation means to be able to teach science in a way that attracts learners' attention and makes science relevant to their own context.

The resources used in the module allowed me to expand my knowledge as a teacher in terms of the curriculum. I had become more aware of how and what I was teaching and how it affects learners. This made me see myself as an innovative teacher. My peers did influence in this capacity as we shared ideas about how to teach certain topics throughout the module and together we thought of creative ways to implement this.

Overall, my capacity to be innovative within the classroom was increased due to the professional development. But only one module included innovation, which I feel was not enough.

b). The lecturer assisted me during the professional (during lectures) but assistance was also given out of the contact times via email. This increased my ability to innovate as I knew that I would have guidance, at any time, if I had any problems.

The lecturer monitored my progress but also gave the class guidelines whenever she saw us, on what she expects. This made how to innovate, simple and structured.

The lesson was very interactive. Opinions were given and meaningful discussions took place which in turn gave me many things to think about. It allowed me to question my methods of teaching and how I could become more innovative as a teacher.

c). After engaging in professional development I do feel more capable as a teacher in teaching innovatively. I would allow myself ample time to teach the section thoroughly with the use of various resources and teaching methods as I am more confident now.

Question 2

a) I felt that I was able to create content specific assessments much more effectively than before. I looked at the skills that learners needed to have developed after a section and I assessed for those. I learnt to move away from the teacher – centred strategies during the professional development. I am more versatile as a teacher, incorporating various strategies to enhance attainment of skills by learners.

I do feel more confident in administering innovative assessment strategies and I am more prepared than I was before. I do find myself capable of being innovative in assessment of environment and sustainability education.

b) I did engage with my peers during the professional development and this allowed me to expand my ability to be innovative as ideas were discussed on how we could become innovative teachers.

Engagement with the lecturer consisted of contact sessions during the module (lectures). During this time, assistance was given that assisted me to enhance my ability as an innovative teacher. During the teaching of plant diversity, I used a variety of plants whilst teaching the section. I found that this increased enthusiasm of the content for learners.

c) I do feel that I am more competent in assessing learners innovatively. I will be using more innovative methods of assessing learners as well the traditional methods. The difference is that I will have a balance between the both, which I feel is important.

Question 3

a) I was able to make use of resources at school, however resources are limited. Being innovative actually gave me the confidence to continue with the lesson in this capacity. I found that learners' interest was piqued and this made me enthusiastic about teaching them. The learning abilities of the learner's in the class were mostly similar but for learners who needed extra time, I assisted once the work had been given out to the class. I found that innovation occurs on the spot as well and I needed to find ways to assist learners that fell behind. So yes, this does need for more innovation to be used. Teachers are able to teach in a way that best suits them and the learners at school however, there are limits and permission has to be asked for activities out of class and for certain resources to be used. The CAPS document also does not state that teachers must be innovative when they teach science.

b) I did not receive any assistance from my HOD or supervisor. My HOD is a maths specialist whilst I only see my supervisor during workshops/ moderation, because my HOD is not helpful I just teach it without any help.

I did engage with my peers from other schools and we reflected on it from there.

c) I can confidently say that I do have the capacity to be an innovative teacher and carry on being one. The professional development did assist me in this aspect.

Question 4

a) I found that group work was difficult to carry out in a large class compared to a smaller class. To arrange the furniture and accommodate all the learners was a bit difficult and in this way it did hinder innovation. However, I continued and found ways around this. The learning abilities differed between learners and this affected my teaching as I had to assist them and explain further at times.

b) My school is strict when it comes to curriculum completion but teachers do have freedom to be innovative in class. This is difficult though due to the lack of physical resources at school. At times, there are not enough desks and chairs for the learners. Teachers within the school have their own methods of teaching and no contact takes place between teachers about

how sections should be taught. At the beginning of my teaching year last year, this was difficult as I was not offered much guidance. After the professional development I found new ways to teach a class and became more confident in my teaching.

c) I find ways to be innovative in class even if it means getting resources on my own for class lessons. At times I confer with my HOD as to what I plan on doing in my lessons and he advises me on how to go about it.

Question 5

a) The resources and structure of the professional development led me to become an innovative teacher. The structure of the professional development did have a direct impact on my capacity to be innovative. The lectures itself gave me an insight of the curriculum and my role in it. My thinking changed during professional development. I am now more confident in my teaching.

b) The lecturers were supportive and the content of the module assisted me in becoming an innovative teacher. The resources used were effective in my development as an innovative teacher. The duration of the lectures were also well spent and gave us enough time to understand the concepts taught.

c) I do feel that the professional development has made me a better teacher. I am able to be innovative and I am more confident in class. I have moved away from traditional methods more than before and I now feel like have the capacity to be innovative. Overall, this has enhanced my teaching capabilities. I found that the assignment given to us was in depth and detailed. It offered me guidance as to how I should teach and carry out my lesson. Such assignments allow teachers to develop on their own as professionals and this is important. I was able to use ideas I came up with to enhance my lesson. This gave me confidence in my teaching.

Participant 3

Question 1

a). I learnt about different teaching methods of which I could apply in my own teaching practice.

I was able to use resources such as the use of my phone to do a quick internet search and get further clarity with what I was unclear about at that time.

It affected me in a positive way. I was encouraged to increase my capacity to innovate because the class discussions were interesting and encouraged me to test out those ideas.

b). I did not feel like I needed any assistance, but the lecturer was approachable. My progress was monitored and the knowledge of that encouraged me to work diligently. I was actively engaged with my peers. However, this was only during contact sessions only.

c). Yes, I feel like I do have the capacity of being innovative. But in the Honours programme only the curriculum development module incorporated innovation. I am not sure if it was by choice.

I feel confident to teach the topic, but since I am still new in the field I am still unsure of the effects of my innovative techniques. Therefore, I would not rush through the topic even though I realise that my learners are struggling with it, but I would try out different ways and hopefully get to one that works.

Question 2

a). I learnt about various teaching strategies and how to apply those in my teaching. I do. I feel like having done this module has served me with that purpose. Having my peers in the venue enlightened me to more ideas that others were implementing in their schools.

I think I do. However, I still think that I can improve in various aspects.

b). I did engage with my peers. Yes, it did. In my classes, there were other well experienced teachers of whom I could engage with and learn a lot from.

I did engage with the lecturer, however briefly and occasionally. However, I did not receive any assistance because I did not require it. But I think that my progress was being monitored since we submitted assignments that were marked and recorded.

I did rely on our textbooks and both my cell phone and laptop as resources.

c). I think I do. However, I still think that I can improve in various aspects. I would use innovative methods, however, occasionally and with caution.

Question 3

a). I was able to. I made use of the school's computer resources.

I did feel that I had the capacity to be innovative. But I am not sure of the effectiveness of these strategies.

This was the case. Some learners will require more time and attention and this uses class time and therefore less time to be innovative.

We are allowed to be innovative at the school I am in. The management of the school is open to new ideas. My capacity to improve was positively affected.

b). I did receive some support from my subject advisor since this is a relatively new topic of which I needed some clarity on in some areas.

I did engage with my peers since at my school there are 3 teachers of N.S. So these were the other people I would engage with.

c). I think I do. However, I still think that I can improve in various aspects. I think I do. However, I still think that I can improve in various aspects.

Question 4

a). At my school has enough resources and that gave me the potential to be innovative in my teaching. I did not have any problems with resources and I believe that it did make a difference to how innovative I could be.

When my innovative strategy did not result in my intended learning outcomes from my learners, I did feel discouraged but I was still motivated to be innovative in my teaching.

This was the case. Some learners will require more time and attention and this uses class time and therefore less time to be innovative.

b). Innovation is encouraged. Even the elderly and more experienced teachers seek advice from the younger and less experienced in this regard. And I think that this could be attributed to curriculum changes… However, curriculum completion seems to be strict for matric teachers. But in the lower grades, teachers are encouraged to apply their innovation in order to deliver content to learners.

This section was a part of school curriculum and so I was just following policy, just with my own innovation.

From hindsight, I would say yes, I think so. In so many ways we can believe that what we are doing is right or maybe even the best, whilst we are so far astray from reality. But in my case, I think that my performance would have been enhanced by consistent interaction with my peers.

My school has a substantial amount of resources of which I utilise.

c). I sought some advice from my HOD with regards to how to teach this section. But I also made my learners watch YouTube videos that were eye opening and enlightening to them.

Question 5

a). I used them in my own teaching and learners used computers to further their knowledge too.

I am more confident. I feel empowered and I am motivated to be a better teachers. But I still feel that I could improve. The learners responded so well to my lesson and I was very motivated by that.

I have undergone some transformation. I am more confident. My thinking has changed and I feel more innovative. I want to teach any lesson using innovation.

Yes, it does because it deals with topics that are directly relevant to my teaching.

Class discussions and going through the activities and readings we were given in our lectures assisted me in building my confidence to be innovative and to want to teach environment and sustainability education successfully.

b). The lecturer was approachable during and after lessons, so I received assistance from her during those times.

These did but I would give more credit to the time spent and resources provided by the teacher.

c). Previously, all I knew was to teach in the traditional way of writing notes on the board for the learners and explain them and hopefully they would be able to conceptualise material taught. But now, I have learnt how to teach by incorporating technology into my classes and I believe that I have grown in that regard. I never was very innovative but now because I've seen how well learners performed in the task I gave them during my lesson, I now want to teach all my classes in the same way.

I believe that I am an innovative teacher. Reasons for that are I have found alternative ways of teaching either than the traditional approaches of teaching, which is incorporating computer technology into the classroom and making its availability conducive towards teaching and learning. I am a transformed teacher.

My understanding of innovating in science teaching is being able to relate concepts to the context of the learner and by doing this make science easier to understand for the learner. I believe that innovation is both a matter of choice and capacity from a teacher and with that said, I think I would be encouraged to be innovative, only thing is the results one might get from this innovation might not reflect the effort it took planning. But that should not discourage one, but rather encourage one to be more innovative than is.

I think that it would be better for lecturers to teach certain sections to prospective teachers in innovative approaches and then assessing the prospective teachers on how they would teach that particular section. I believe that this would be more effective than making teachers plan for something that they have never experienced before.

Participant 4

Question 1

a). I was able to evaluate and critique my own teaching practice thus far. In doing so I identified my strengths and weaknesses. I was able to enhance my strengths by being more creative in my methods, using more group work and various resources. I gained more confidence and my learners found my lessons more enjoyable.

I was able to evaluate and critique my own teaching practice thus far. In doing so I identified my strengths and weaknesses. I was able to enhance my strengths by being more creative in my methods, using more group work and various resources. I gained more confidence and my learners found my lessons more enjoyable.

I was able to increase my capacity to innovate because i was able to be confident in my subject matter. I took more joy in planning and presenting my lessons thus being more creative. My understanding of innovating in science teaching is that the teacher, through different methods of teaching and assessment, brings science concepts closer the learner rather that moving the learner closer to science concepts.

b). The lecturer was approachable and was able to motivate and provide assistance when needed. Course material provided useful resources pertaining to environmental education.

The lecturer did check our progress through assessment activities and group discussions and this made us aware that she was expecting us to work.

c). When I compare the way I taught environment and sustainability education prior to my professional dev and after; I can see there is much more innovation in my approach. It is a positive start.

I am much more confident. I find that I am better at planning and implementing my class activities and assessments in a way that can facilitate learner understanding.

Question 2

a). The use of different assessment methods in assessing environment and sustainability e.g. presentations, posters, role play, hypothesis testing and hands on experiments, working outdoors with learners. There's always a focus on formal assessment but I have learnt that informal and peer assessments are equally important in eliciting learners' prior knowledge, addressing misconceptions, developing learners' skills as well as enabling learners to meaningfully construct concepts related to the environment and sustainability and link it to their personal lives.

I am motivated to be innovative especially after gaining positive feedback from my learners.

I would have preferred a room with desks and chairs arranged in groups. The venue seemed too formal and "cold". It did not inspire an environment conducive to creativity and innovation.

I am aware of different assessment methods especially those which my learners enjoy. I am able to implement them.

b). We always discussed and shared our views on our experiences e.g. what worked and what didn't.

The lecturer was available for consultation when needed. Handouts and resources were made available in the use of environment and sustainability. I found this useful.

Learners have access to the schools media centre where they can use the internet as well as books to access information. Various pictures, outdoor lessons so learners can provide evidence why the school ground is an e.g. of an ecosystem. In learner presentations, learners made charts which is used as a resource

c). I do have the capacity to be innovative when I assess learners.

Prior to my professional development I used a more traditional approach. After implementing more creative techniques I found it yielded positive responses from my learners. As a teacher I enjoy being innovative.

Question 3

a). We are fortunate to have two media resource centres with 1 conveniently situated next to my lab. I also have outdoor lessons when necessary and i bring my own resources e.g. sample of a lichen to show symbiosis

Now I do feel as though I have the capacity to be innovative in my teaching.

I had to be more innovative especially introducing new concepts. Language barrier is a problem.

Fortunately my school does not stifle a teacher's capacity to be innovative as long as it does not interfere with the running of the school.

b). My HOD is always supportive of my ideas and encourages them however there is very little support from the subject advisor.

Not when it came to the planning of lessons. However assessments are discussed regularly.

c). I can be innovative when I teach environment and sustainability education. I have the confidence and motivation to do so because of this professional development.

Question 4

a). To a certain degree I did experience a lack of resources, however I felt that i needed to find ways to work around such constraints e.g. alternate certain activities.

I did feel I lacked the capacity to be innovative, although this was prior to my professional development. I lacked motivation and became stuck in a rut amongst the other traditional teachers.

I felt I did not have the support or the capacity to deal with this. Now I understand that the child who I thought was purposely misbehaving or performed poorly in an activity probably could not identify with the content and therefore could not properly construct his/her ideas. I even went through the CAPS document and saw that innovation was not a requirement, but I still feel that there is space for innovation and the document gives us freedom to be innovative within the guidelines.

b). My school does not stifle classroom innovation. As long as the needs of the curriculum are met teachers are free to be as innovative as they want.

My HOD is always supportive of any ideas that can promote better teaching and learning. My subject advisor does not have much influence.

No not really. I did not feel that the lack of contact that I had with my peers hindered me from being innovative.

To a certain extent. I did that the lack of resources caused a problem but I was motivated to work around those problems and still be innovative in my teaching. Even if it meant creating my own resources such as worksheets or models of diagrams that learners see in the textbook.

c). Where there was a lack of resources, I started using everyday life materials e.g. scraping a sample of moss from the school yard or getting different pictures. Getting learners to make use of the school resource centre.

Question 5

a). Information that I gained from the professional development was used as a source for worksheets etc. I was able to make use of the notes given to create my own resources. This in itself motivated me to be innovative because I had the knowledge of how to be innovative. Previously I did not have this knowledge. I am more comfortable teaching content on environment and sustainability education now. I have the confidence to explore different methods of teaching this section so that it is exciting and interesting for learners. I feel more motivated. I enjoy planning my lessons and their activities. The structure of the professional development made it conducive for me to develop as a teacher. The way the lectures were presented made me comfortable and I wanted to learn.

b). The lecturer was approachable. I would have liked the course to have more hours more peer activities and a better venue.

c). I feel more confident in the planning and presenting of my lessons. I no longer feel stuck in a rut; I try to find solutions to barriers. I enjoy being innovative in the planning and presenting of my lessons. I have been getting positive feedback from my learners who seem more intrinsically motivated.

I learnt the importance of making teaching and learning fun. If learners find the lesson or activity interesting then they work better. I learnt the importance of learners being able to construct and link concepts pertaining to the environment and sustainability to their personal

life. The importance of using different resources for learners to enable to construct such concepts. I believe that innovation in teaching is important irrespective if the curriculum changes or not.

I did not realise just how important professional development is until I started the course. So what happens to the rest of the educators that do not enrol themselves in these courses? I believe that the subject advisors need to take a more active role in the professional development of educators. More workshops need to be held and resources can be made available. Educators should be motivated to undergo professional development. Once-off workshops never gave me anything to help me to teach, they just read through the CAPS document.

Participant 5

Question 1

a). At the time of the professional development module, I had just graduated with my Bachelor of Education Degree and had no previous teaching experience. As a novice teacher I had many insecurities regarding implementing the curriculum as is required and thoughts of innovative was approached with nervousness and extreme caution, avoiding it all together. The professional development helped me to build confidence in my ability to implement the curriculum on environment and sustainability education as well as to innovate by increasing my knowledge, developing my understanding of curriculum implementation, teaching and assessment strategies and methods; and taught me to be innovative, to not be afraid to alter existing teaching and assessment methods and introduce new methods adapted to my classroom context.

The lecture venue of the professional development was not the most conducive to learning environment. There was a data projector, chalkboard and white board available for lectures but the venue itself was poorly lit, lacked colour and stimulating visuals that would usual create a motivating learning environment. The dull venue, for me, dulled my enthusiasm to learn and I believe, did not enhance or encourage my professional growth. I must note that the module co-ordinators chose to include innovation as part of only one of our modules.

My professional development grew as a result of the lecture notes, course resource booklet, slide presentations, library books and journal articles – both print and electronic – to enhance my capacity to be innovative. Resources provided outlines of what is required by the Department of Education for successful education; case studies that provided background information into the need for innovative educators; possible ways to be innovative and to think innovatively; the outcomes of innovative education. Some articles also provided the shortfalls that some teachers had experienced during their initial grapple with innovative teaching and assessing which was helpful in my own development as I could adjust and improve my own innovative strategies to try and overcome those shortfalls to suit my classroom context.

It was also very helpful to interact with my fellow peers who were on this professional development journey with me. They shared incidents from their own experience that enhanced my own professional development by improving my knowledge and understanding as well as introducing me to new teaching and assessment methods.

The professional development was tightly managed – lecturers were well organised and this influenced how I managed my own work and development, completing activities and readings, researching innovation, new techniques and approaches timeously and continuously. The structure of the professional development aided me in increasing my capacity to innovate.

b). The lecturers provided me with much support and assistance during the professional development through facilitated discussion, verbal and written feedback on my development,

responses, ideas, successes and challenges experienced. The lecturer was always suggesting ways to improve my thinking of innovative strategies and methods, discussing possible approaches to implementation of the curriculum. This support was greatly beneficial in assisting me to increase my capacity to innovate.

Through the feedback provided, the lecturer monitored my progress in professional development. It had led to further discussion and open and comfortable dialogue on my progress in professional development that encouraged me to explore innovation and improve my capacity to innovate.

During the professional development we were encouraged to actively engage with our peers during the lectures in discussion, debate, commentary and general interaction. However, a few of my peers and I formed a smaller group who actively engaged with each other outside of the lectures too. The diversity in the group – different number of years of experience, age, ethnicity, nationality and school contexts – richly impacted my development. We engaged with each other on almost every aspect of our professional development, adding our experience from our diverse backgrounds. This probably proved the most beneficial and influential on my professional development. We communicated frequently, texting and emailing each other during the week when we did not have lectures, to clarify concepts, discuss ideas, share advice and give input. The teachers who had more experience in the classroom – the number of years teaching and the many contexts they taught in – really had valuable knowledge to share that guided me in my professional development.

c). I strongly feel that having engaged in the professional development, and my experiences gained has greatly influenced and developed my capacity to be innovative as I teach environment and sustainability education. I am confident to teach this, and the knowledge I gained has given me new excitement about teaching innovatively. The professional development greatly impacted on my professional development as I gained knowledge that I had not been exposed to in undergrad that I believe is so vital to ensuring a successful and enriching educational experience for teachers and learners.

Question 2

a). I have gained many innovative strategies of assessment in environment and sustainability education from being part of this professional development. Some of these strategies were gained through lectures and interaction with my peers but most were gained through the readings and research that we were encouraged to pursue during this professional development. These strategies included alternate forms of examinations such as open-book and take-away examinations; projects and investigations; varied writing tasks; oral assessments such as debates and discussion – which in Science is practically unheard of; problem-solving tasks and case-studies; portfolios and profiles; group assignments (previously known); self, peer and co-assessment (previously known). These are just some of the strategies, since completing the professional development I have come across other strategies that I am interested in learning more about.

Since the professional development I am more confident about administering innovative assessment strategies to learners, but I am only fully confident when I have thoroughly planned and organised the activities, lessons leading up to the assessments and the assessment tools themselves. I am now able to be innovative in my teaching and the learners are excited about the lessons. They are learning and I have now tried to be innovative in other subjects that I teach. It is unlike the traditional strategy of recycling test questions that have been asked religiously year in and year out. Innovative assessment strategies require more time to plan and strategize in order for them to achieve the desired aims and build one's confidence. Nothing is more de-motivating than implementing something that wasn't properly planned and having it fail hopelessly. Learners are aware and can quickly lose confidence in your ability as an educator too, which can be de-motivating. However, I definitely now possess the capacity to be innovative in assessment of environment and sustainability education. The lecture venue was not conducive for my capacity to innovate to be increased.

b). As previously stated engaging with my peers during the professional development had enhanced my capacity to be innovative in both teaching and assessment. Engagement with my lecturer definitely enhanced my ability to be innovative in assessment through the monitoring and feedback previously mentioned. I was able to use many resources such as the lecture notes, but more especially journal articles and books published on innovative assessment strategies to enhance my ability to be innovative in assessment.

c). I feel that having gone through the professional development; I now have the capacity to be innovative when assessing learners on content from environment and sustainability education. Being a topic that lends itself to exciting and creative outdoor activities and hands-on projects, innovative and creative assessment strategies are possible provided they are well planned and learners are given clear guidelines of what is expected of them.

I am now always looking for innovative methods to assess learners. I am aware that innovative methods are not always the most practical or applicable, but if there is an alternate method to the traditional that will excite and engage learners, it is worth a try in the classroom. Learners are just as tired of traditional methods of assessment and are open to exciting new ways of learning and developing their understanding. I am not suggesting that traditional methods should be abandoned completely, there is still a niche for traditional assessment methods, but educators need all the help they can get to motivate and encourage learners to think critically, and I believe that innovative methods of assessment is the way to achieve this.

Question 3

a). During my project I was given full use of the Life Science laboratory which included the laboratory benches, stools, chalkboard, data projector and screen, textbooks, charts and specimens, however there were some limitations as will be outlined in question 4.

I admit that at first the thought of being innovative was overwhelming and I was not able to comprehend the way forward, but as I started teaching the topic and started to focus on planning and seeking advice and guidance from my work colleagues, university peers and

lecturer it became easier and I felt more confident in my capacity to innovate. It was a skill that started to develop as I taught and became more comfortable with the concept. After a little while into the lessons I realised that it was easier for me to be innovative on the spot and adapt my lesson to suit the current context. So if learners had experienced a problem that I had not otherwise expected, it was not intimidating for me to adapt the lesson so that this new problem is addressed with possible solutions. I also didn't feel as nervous if I didn't have all the answers, but used the opportunity as an example of the nature of science and how scientists are faced with new challenges all the time and have to adapt their thinking and problem-solving skills to come to a solution or conclusion. In this way I was also able to influence the learners to think innovatively and critically. One cannot develop critical thinking skills if he/she does not possess innovative thinking too.

My learners fall across the learning ability spectrum. As a school, the learners with the highest scores in Mathematics and Science in grade 9 qualify to do the full science course in grade 10. For my project I had to work with the full science learners as they are the only learners that take life science as a subject. Despite being considered the "elect" the class only had a few exceptionally bright learners but mostly average to below average learners. This has greatly affected the magnitude of the innovation that I was able to use in the classroom. I did not wish to leave the lower level learners behind, because that would defeat the purpose of being innovative, however, I couldn't dull the lesson down where the outstanding learners would become bored or disinterested, so it definitely affected my choices.

The school that I teach at is quite liberal. Educators are given the freedom to be innovative provided that the learners are not disadvantaged in terms of curriculum coverage. If the content which learners need to cover in order to pass their assessments is covered, and learners are not falling behind when compared to learners nationally then we are given all the support and assistance needed. This does affect capacity to innovate as you experience two feelings towards this. Firstly, when the school management is that supportive, it builds your confidence as an educator and secondly, being trusted that much motivates you to ensure that you stay on par and innovate only when it benefits the learners and ultimately the school rather than yourself as the educator. You become aware of your role as the educator and your responsibilities towards the learners and the school. It gives you perspective, especially as a novice teacher. It encourages the talents and creativity that you tried so hard to develop through your many years of study rather than kill it with enforced tradition that learners do not find interesting or motivating.

b). During my project I received support from my HOD to conduct it, but I did not experience assistance or guidance with regards to planning, teaching and reflecting on my lessons.

My fellow science educators, especially the senior life science educator that has been teaching for more than 30years, were a huge help. The senior life science teacher in particular provided guidance and assistance right from the start, from advising me which textbooks and resources were the best choice to discussing my thought processes before, during and after each stage of my lesson. He has asked probing questions into my reasoning and motivation for innovation and the particular innovative strategies chosen. He especially helped me to

focus my lessons on concept development and understanding rather than syllabus coverage, which I believe is a common mistake made especially by novice educators.

c). Since engaging in the professional development course I believe that I now have the capacity to be innovative as I teach environment and sustainability education. I have gained more knowledge, I am more confident and I now have the capacity to be an innovative teacher. I teach with more confidence, I try to be innovative when I teach and find ways of refreshingly teaching. My teaching methods have change, I want to teach using innovation and try my best to.

Question 4

a). Although I had full access to the physical resources at the school, these resources were limited. Due to the large class sizes, furniture was limited and learners had to use the side benches and bring in furniture in order to complete the classroom tasks. The learning environment was not conducive to group activities, and other learning venues were not equipped to include digital media that learners enjoy during teaching and learning. Many of the learners had to share textbooks, but the use of the data projector assisted in curbing those challenges as it outlined all the crucial information on an easy to view presentation that was accessible by all the learners, this ensured that they all received the same information and no one was left out or left behind.

During my teaching I had felt insecure in my capability, and that I lacked the capacity to innovate at the initial planning stage and during my first innovative lesson. During these moments I had felt overwhelmed and lacked confidence in myself. I doubted my teaching ability and felt as if I did not possess the knowledge or skill to be innovative. I was very nervous, despite having thoroughly planned for the lesson as I was unsure of how learners would receive the new approach, however, learners had shown more interest and this boosted my confidence.

The differences in the learners' learning abilities in my classroom had affected my teaching too. Learners with a greater learning ability worked faster and required more of a challenge, they were also more inquisitive and enquired about deeper issues than the learners of a lower learning ability who saw these concepts as abstract and unfamiliar. The learners of a lower learning ability required a much slower pace of teaching and learning. This proved to be challenging as the learners who required extra attention were not open to individual/group teaching that was separate from the rest of the class. They felt it humiliating given that they were selected to be in the "A" based on their intelligence. In this regard I felt that my lessons required improvement that would simplify these difficult concepts in a way that all learners understood or create a more comfortable environment where there was no shame in admitting that one does not understand – this will happen in time.

b). My school promotes an atmosphere that allows teachers to be innovative. The school's management team is always encouraging the staff to be creative and come up with new ideas and ways to improve the learners' school experience, including their interaction with the curriculum, teacher and fellow learners in class.

The school is strict with regards to curriculum completion and policy, but it does allow time for teachers to be innovative and encourage alternate ways of teaching and learning. This is a factor in my teaching as although I may wish to be innovative, I have to limit my choices of innovation that will prevent me from completing the curriculum and it forces me to switch to more traditional methods of teaching especially when faced with time constraints.

The HOD did not constrain me from being innovative. He was supportive, but did not offer much assistance. The senior Life Science educator was most helpful and we spoke daily, reviewing my lesson plans during the lunch break to allow for me to correct any oversights and communicating often, before and after implementation to reflect on my experience.

In some ways the lack of resources had discouraged me from being innovative. The limited resources limited my freedom of choice regarding innovative methods. Learners become frustrated and lose interest when there aren't enough resources available. This disadvantages their progress and affects their work ethic. Most of the learners at my school come from severely impoverished backgrounds. Their socioeconomic background affects their interest, self-esteem and confidence in science. Many do not see a future though they possess the potential to do something great in the future. Planning lessons when there are limited resources greatly affects their views of themselves and de-motivates them. To overcome this and encourage learners, motivating them to drive forward, lessons have to be planned with the resources that are available or that can be accessed, whether it's borrowing from another school or making the resources ourselves. Innovation has to be contextualised in order to be impactful.

c). To overcome these constraints and be innovative in my teaching of environment and sustainability education I opted to make the resources I required using discarded cardboard files found in the recycle room and sourced my own media and visuals to show learners using the data projector in conjunction with the resources that were already available such as the learners' textbooks.

The main limitation to teachers being innovative is the lack of resources and teaching and learning aids, but if there is more support and guidance from the more experienced innovative educators, it is possible to encourage and nurture innovative in novice educators like myself. Innovation is a guided and experiential process. One cannot expect to become innovative if one is not mentored and supported by an "expert" in innovation who has had enough experience in the classroom to have developed the skills required. Regardless of whether an individual possesses creative thinking skills or not, innovative thinking can be learnt through guidance and assisted learning from peers who have expertly developed these skills.

Innovative teaching is possible, but it must be understood that these skills require nurturing and development; it is not an innate set of skills that "good" teachers possess but a set of skills that they have learnt and developed over time through the guidance of those them. I think that professional development needs to be more effective.

Participant 6

Question 1

a). The Honours course has impacted positively on my teaching, not only of science but also of other subject I teach. But if innovation was in other modules it would help my teaching as I would be more exposed to innovation and I could then gain knowledge and skills to be a more effective science teacher.

This professional development has boosted my confidence in teaching the subject content of environment and sustainability education. It has improved in my pedagogical skills and teaching techniques.

I am now using resources more as a source of gathering information and enhancing and make my lessons more interesting for me and my learners.

I access more websites - to give learners background knowledge of the topics to be discussed in class.

Course packs had most relevant information, the information was outlined and structured in a way that it was easy for me to interpret and make sense of it, but at the same time the tasks given by the lecturer encouraged more research on the topics.

The way in which the programme was structured encouraged for critical thinking, especially during questioning and group discussion sessions. The planning and teaching of an innovative lesson gave me the chance to be innovative. I was not very innovative before that. But now I am motivated to be an innovative teacher.

b). Much support was given by the lecturer, even after contact sessions the lecturer could be reached through emails if there was an academic challenge.

Guidance on what was expected in terms of deliverables was outlined throughout the course and that helped in achieving objectives of the course.

Group discussions were equally encouraged as individual activities, this helped me as I gained information and techniques from other colleagues and at the same time sharing my knowledge and expertise with them, the lecturer always gave support through positive criticism and motivation.

c). Teaching topics on environment and sustainability can be a challenge; this course has helped me to look at teaching fundamental aspects of society-nature interactions and interdependences in relation to their present and future conditions. It has seen me using more practices in my teaching that increased participation in learners and motivate them.

Initially I used to rush through this section, not of the lack of content knowledge a s a teacher but a lack of innovative strategies and how to apply them to make the topic more interesting, but through this course I am now much confident in teaching the topic, I find it more interesting to teach it as I can deliver the content with confidence.

Question 2

a). Integrating indigenous knowledge and linking it to the lessons taught at hand

Encourage questions from students as part of their curiosity, thus I can understand where they base their arguments and answers they give to answer some of the question as I also use follow up questions. Use of technology to support the lesson rather than as substitute for a teacher. Use of relevant examples taking into consideration the learner' environment age, gender, etc.

Now that I have learnt how different innovative strategies can help me to improve my teaching in class I am more confident to administer them

The lecture venue per se did not have any noticeable impact on increasing the capacity to be more innovative, but what happened inside the venue was more interesting and intriguing for me as we discussed with fellow students of strategies for different topics.

b). One can only learn more when one interacts and share ideas. Tasks allowed Group discussions and then that gave me the opportunity for me to engage with other peers.

Most of the interaction took place during contact sessions; the lectures always posted guidelines via emails which were helpful for me when working on my own outside the contact sessions.

Library resources were always accessible and textbooks. I always refer to the CAPS document as one of the resources.

c). I do not only use prescribed or already set questions for learners assessments, but I have been using student generated questions in their assessments as well.

I make use of both traditional and innovative methods of assessment. In both methods I consider the environment from which learners come from and structure questions in a way that terms used are relevant to their environment.

Question 3

a). Teaching resources are not at our disposal since the school is under resourced and teaching without worksheets is difficult because drawing and writing notes is time consuming. But support from neighbouring schools has seen one borrowing their resources.

I have seen that most of the time I enjoy my teaching and I can only achieve lesson objectives and be more efficient in my teaching when I bring in innovative strategies in class.

Learners' curiosity and their participation has been noticeable to be improving, and that has encouraged me to bring and use more and different innovative strategies for different lessons to keep them more interested in the lessons, and most importantly for them to make sense of what is being learnt in class and to make connections with their pre-knowledge.

Support from other teachers teaching the same subject makes it less challenging to teach with limited to no resources as we share innovative ideas on different subject topics to maximise the use of minimal resources we have.

b). Regular departmental subject meetings and classroom support visits by HOD makes it easier for me to work and improve on teaching strategies as I reflect on my lessons and seek ways to improve.

Subject meetings look at the way in which subject teachers can improve on their teaching using innovative methods, team teaching and observing each other during classroom teaching to improve on our teaching.

Integrating other subjects with the subject content to make links and relationship with what other teachers are teaching in their respective subjects make it easier for me to plan my work with more relevance to other subjects.

c). Innovation has become part of my teaching as it makes my teaching easier and fun, both for me and the learners, which then makes it easier for me to identify areas of improvement in my teaching. I try and use different teaching strategies in all my teaching; my teaching is now more structured.

Question 4

a). I understand that it takes time for the school to change state of physical resources, therefore I make use of what is available to make the most of my teaching. No I did not feel that I lacked capacity to innovate. Learners come with different learning abilities and existing pre-knowledge of which impacts on teaching, but correct measures and strategies have helped me identify those learning abilities and remedy them.

b). I am guided by policy documents on what to teach and when to complete, but now how to teach it. Using innovating strategies does not hinder progress on my teaching, but enhances it.

No, use of different acceptable strategies is encouraged.

Although lack of resources can have negative impact on one's teaching, but I saw it as a chance for me to come with more innovative ways to make my lessons more effective and interesting for me.

c). I was able to overcome any constraints that I did have. Even though I had a lack of resources I went out and borrowed resources from other schools. I even made my own resources.

Question 5

a). I cannot say the physical resources impacted in any way.

I find the topic more interesting now that I have been using innovating ways of teaching it.

I am now more encouraged to research on the topics I teach before going to class. I now use CAPS document as a guide, not as the only resource for my teaching which I used to do before attending the course. Prior to this professional development, I felt bored teaching but now I feel changed and awake in my teaching.

During group discussions and presentations one had to find more innovative ways to present, ways which encouraged question and answer sessions, which all of this was encouraged during when attending the course.

Yes, each lesson during contact sessions was different, interaction and reflection on each lesson encouraged me to practice such in my teaching after each lesson.

b). Even though at times the course seemed tough, but knowing that I had the support of my lecturer and my peers at all times kept me going.

Initially I felt that I had to work harder than most of my peers, I felt that the course has a lot to offer, but the time was much limited.

c). This course has helped to see the importance of being a transformed teacher, it has helped me in my teaching, content delivery and research. I am more revived and interested in my school work than before attending this course.

Yes I am more confident teaching environment and sustainability education.

Our curriculum keeps changing, but the content knowledge remains the same, just proposed strategies of teaching the content. So I would not be discouraged, but rather I would see it as a change for to bring some new innovative strategies in class, and reflect if that helps me become a better subject teacher.

I think all teachers should undergo this course. Teacher are good and very knowledgeable in their subject content, but the challenge is how to deliver, make sense to the learners and assess this content knowledge in more innovative ways considering the challenges we face in terms of shortage of resources and the environment in which teachers find themselves in.

Participant 7

Question 1

a). I feel as though this professional development gave me an opportunity to evaluate how I was teaching environment and sustainability education. I was not really concerned that I could be teaching it badly. But I know after this professional development I know how I should be teaching it. My personal capacity as a teacher has been changed and I feel renewed because now I can teach innovative lessons. I never used to try new methods but now I am motivated to be innovative and to teach exciting lessons.

The venue where we had lectures was clean and it was easy to work in. I feel that it is important to have a good working space and be able to be free. It was a bit difficult to do group work but it was not impossible. The resources that we were given was very helpful and I made full use of them. I will even use them now after the professional development. I enjoyed working with my peers because I came to realise that they are able to help you work through some of your challenges.

The structure of the professional development sort of built up my capacity to innovate. I was not able to be innovative before this but as I went through this I felt that I could actually teach innovative lessons. I was more confident in the way and planned my lessons. I made sure it was exciting and attractive for learners. Previously I did not bother if the lessons were not interesting; I just wanted to get through the syllabus. But now I am confident and motivated to be innovative in whatever I teach.

b). The lecturer was very helpful and gave us guidance throughout the module. This also helped me become more confident and motivated. She monitored our progress through assessment tasks and group discussions. I was inspired when I worked in groups with my peers. I felt as though I gained so much knowledge that I never had before. It really made me feel empowered.

c). I used to teach environment and sustainability education in a very boring way. I just wanted to get it done. But after this professional development I can see a change in my teaching. I want to be more relevant and teach exciting lessons for my learners. I have confidence to do this.

I am more confident. I find that I am better at planning and implementing my class activities and assessments in a way that can facilitate better learner understanding.

Question 2

a). I learnt that there are other more innovative methods of assessing environment and sustainability education. You can use role play or posters or even outdoor learning. I would have not thought of these methods if it were not for this professional development. Also, informal methods of assessment really do make a difference. Random questions to learners can help them understand better. Sometimes the formal methods of assessment may not

highlight the knowledge learners do actually possess. But if you give them say a poster to make, they are more comfortable and are able to express what they have learnt.

I am confident in using innovative methods of assessment because the learners responded so positively to them. It gave me confidence because they enjoyed it.

b). Working in groups and discussing with my peers was really helpful. I gained knowledge of how to actually use innovative methods of teaching and assessment from those discussions. I was always writing when we were discussing because I had some seasoned teachers in my group and I wanted to listen and learn as much as I could.

The handouts and the notes were useful and the lecturer was available for consults at certain times. This made it easy to understand the content we were discussing and be able to understand how to design innovative assessment activities.

The school I am in is very well resourced and I had a large number of resources to choose from. I made use of pictures and the computers as well as the library at my school. Having all these resources made it easy for me to plan and teach innovative lessons of environment and sustainability education. I was able to create innovative methods of assessment because I had resources to use.

c). I do feel that I have the capacity to create and implement innovative methods of assessment for learners as I teach environment and sustainability education. I am confident to try new and innovative methods.

Prior to this professional development I used a more traditional approach for assessment. After implementing more creative methods I found it produced positive responses from my learners and they enjoyed a different method of assessment. I feel that sometimes we don't look at the learner's reaction to an assessment and just want it to be completed for our mark books. But now after this professional development, I want to ensure learners are enjoying all assessment tasks.

Question 3

a). At my school we have all types of resources. I was able to access various resources to help me plan and teach innovative lessons on environment and sustainability education. I feel that this was something that I needed in order to be innovative. Without these resources I don't think it would be easy to be innovative when you teach environment and sustainability education.

I feel as though I have the capacity to be an innovative teacher. I feel as though I have developed the capacity to be innovative when previously I did not have it.

All learners are different and to teach for all of them is difficult. But I do feel that when you teach an innovative lesson when compared to a normal lesson, more learners are involved in the innovative lessons. But there are barriers that make it difficult. I do feel that I have the capacity and the resources to overcome these barriers.

b). My HOD is always supportive of my ideas and encourages me to be innovative. The principal is also very supportive and encourages teachers to study and enhance learning at the school. I feel that this is also a major boost for me to be innovative because I have the support and guidance to do so.

c). I have the capacity to be innovative. I am an innovative teacher. I can teach innovative lessons on environment and sustainability education. I know possess the tools I need to be an effective teacher of environment and sustainability education.

Question 4

a). I did not have a lack of resources. I had a wide choice of resources to help me. I felt confident to teach an innovative lesson because I had resources.

I did feel that I lacked the capacity to be innovative, before I engaged with this professional development. I lacked motivation and I was not excited about teaching.

b). My school does not restrict me from any innovation. Teachers are free to be as innovative as they can be and the management encourages teachers to express themselves. This is very important to me and I feel supported when I teach, especially now that I know how to be an innovative environment and sustainability education teacher. My HOD is also supportive as I have mentioned and this encourages me further. I feel that I have resources and the support to be innovative in all my teaching.

I have an advantage I feel because I know many other schools don't have resources. I had no excuse not to be innovative after this professional development because I had all the tools needed to be innovative. I did not lack support or guidance from my school management and I had learners that were willing to work.

c). I can say that I did not have any constraints to be innovative. All I had to do was plan and teach the lessons.

Question 5

a). Yes I do feel transformed. But after going through all the modules I feel that maybe the lecturers must change the course next year, innovation should be in more modules. I stated that on the module evaluation.

The knowledge that I gained from the professional development I used as a source for planning and developing resources and my lesson itself. I was able to make use of the notes given to create my own resources. This caused me to be motivated because I was actually creating my own resources and using the knowledge that I had gained in the professional development. I am motivated because now I can innovative and teach exciting lessons. The module exposed me to this knowledge. Before this professional development I did not have this knowledge or the motivation to do this.

The learners responded so well to the lesson I taught. I was very motivated by this. Because the one class responded so well to my innovative lesson, I tried it in other classes. This really gave me confidence to be more innovative.

I feel that I am more comfortable teaching content on environment and sustainability education after going through the professional development. I have the confidence to try and explore different methods of teaching and assessment in this section. I have a desire to make the lessons exciting and interesting for all learners. I want to make learning more exciting for learners. I feel as though the way I used to think has changed and I have a different mind-set now to teaching.

The module itself set the tone for me. It caused me to want to learn and be active in the lectures. I feel that was a great motivation that stirred me up and caused a transformation in my teaching and my thinking. If I am motivated and have the tools to accomplish a task then I feel that my thinking is different and I am able to think outside the box. I feel that this type of thinking is important when teaching environment and sustainability education.

c) This professional development made me realise how important it is to make learning fun for learners. If they are having fun then learning is not seen as a chore or something difficult. Innovation is a way to do this. I am a different teacher now and prior to this professional development I was not interested in attending other programmes like this because I knew how useless it was. But more modules like this one will make me become an even better teacher. I want to be innovative all the time. I don't think I will ever go back to the way I was teaching.

Participant 8

Question 1

a). I learnt that there are more ways to teach environment and sustainability education. I never used to explore different ways of teaching this section. But after engaging in this professional development I have come to know of many new and exciting methods of teaching environment and sustainability education. I had never thought to use something like role play when I taught this section. But from what I have seen and heard during this professional development that kind of teaching strategy works well and learners are understanding better.

We were given an adequate amount of resources and also the lecturer gave us relevant information that I am still making use of in my teaching. It was very beneficial to have those notes and course packs because it gave us an understanding of innovation. It also provided us with an opportunity to do some reading on our own which is helpful.

The other teachers and I in the professional development worked very closely together. I gained a lot of knowledge from my peers and we were able to support each other as we went through this module. I feel that I learnt so much from the group discussions. We were able to share innovative strategies and methods that worked and we also discussed difficulties that we experienced.

I do feel that my capacity to innovate has been increased because I became more confident with the subject content. I felt that previously I was not very confident with the content on environment and sustainability education. But now after that professional development I have developed a new confidence and I believe in my abilities to teach this section.

b). The lecturer was approachable and was able to motivate and provide assistance when we needed it. Sometimes teachers needed extra assistance or explanation and the lecturer was willing and able to do this without any sign of difficulty. As I mentioned the course notes and resources were very helpful and I made full use of them. The lecturer checked our progress and monitored the activities and discussions we had conducted.

c). The way I taught environment and sustainability education before this professional development and after the professional development; I can see there is much more innovation in my teaching. I also see much more learner involvement in the lessons.

I am much more confident. I find that I am a better lesson planner and this impacts on how I deliver my lessons. All of this works together so that learners understand better and produce better results.

Question 2

a). I learnt that teaching environment and sustainability education doesn't have to be boring and something teachers just want to finish. After this professional development I have learnt

of different methods to teach this section. Role plays, outdoor learning, posters, group presentations. All these methods work better that the old way of teaching this section.

The handouts and the notes were useful and the lecturer was available for consults at certain times. This made it easy to understand the content we were discussing and be able to understand how to design innovative assessment activities.

The school I am in is very well resourced and I had a large number of resources to choose from. I made use of pictures and the computers as well as the library at my school. Having all these resources made it easy for me to plan and teach innovative lessons of environment and sustainability education. I was able to create innovative methods of assessment because I had resources to use.

c). I do feel that I have the capacity to create and implement innovative methods of assessment for learners as I teach environment and sustainability education. I am confident to try new and innovative methods.

Prior to this professional development I used a more traditional approach for assessment. After implementing more creative methods I found it produced positive responses from my learners and they enjoyed a different method of assessment. I feel that sometimes we don't look at the learner's reaction to an assessment and just want it to be completed for our mark books. But now after this professional development, I want to ensure learners are enjoying all assessment tasks.

Question 3

a). At my school we have all types of resources. I was able to access various resources to help me plan and teach innovative lessons on environment and sustainability education. I feel that this was something that I needed in order to be innovative. Without these resources I don't think it would be easy to be innovative when you teach environment and sustainability education.

I feel as though I have the capacity to be an innovative teacher. I feel as though I have developed the capacity to be innovative when previously I did not have it.

All learners are different and to teach for all of them is difficult. But I do feel that when you teach an innovative lesson when compared to a normal lesson, more learners are involved in the innovative lessons. But there are barriers that make it difficult. I do feel that I have the capacity and the resources to overcome these barriers.

b). My HOD is always supportive of my ideas and encourages me to be innovative. The principal is also very supportive and encourages teachers to study and enhance learning at the school. I feel that this is also a major boost for me to be innovative because I have the support and guidance to do so.

c). I have the capacity to be innovative. I am an innovative teacher. I can teach innovative lessons on environment and sustainability education. I know possess the tools I need to be an effective teacher of environment and sustainability education.

Question 4

a). I did not have a lack of resources. I had a wide choice of resources to help me. I felt confident to teach an innovative lesson because I had resources.

I did feel that I lacked the capacity to be innovative, before I engaged with this professional development. I lacked motivation and I was not excited about teaching.

b). My school does not restrict me from any innovation. Teachers are free to be as innovative as they can be and the management encourages teachers to express themselves. This is very important to me and I feel supported when I teach, especially now that I know how to be an innovative environment and sustainability education teacher. My HOD is also supportive as I have mentioned and this encourages me further. I feel that I have resources and the support to be innovative in all my teaching.

I have an advantage I feel because I know many other schools don't have resources. I had no excuse not to be innovative after this professional development because I had all the tools needed to be innovative. I did not lack support or guidance from my school management and I had learners that were willing to work.

c). I can say that I did not have any constraints to be innovative. All I had to do was plan and teach the lessons.

Question 5

a). Yes I do feel transformed. But after going through all the modules I feel that maybe the lecturers must change the course next year, innovation should be in more modules. I stated that on the module evaluation.

The knowledge that I gained from the professional development I used as a source for planning and developing resources and my lesson itself. I was able to make use of the notes given to create my own resources. This caused me to be motivated because I was actually creating my own resources and using the knowledge that I had gained in the professional development. I am motivated because now I can innovative and teach exciting lessons. The module exposed me to this knowledge. Before this professional development I did not have this knowledge or the motivation to do this.

The learners responded so well to the lesson I taught. I was very motivated by this. Because the one class responded so well to my innovative lesson, I tried it in other classes. This really gave me confidence to be more innovative.

I feel that I am more comfortable teaching content on environment and sustainability education after going through the professional development. I have the confidence to try and explore different methods of teaching and assessment in this section. I have a desire to make

the lessons exciting and interesting for all learners. I want to make learning more exciting for learners. I feel as though the way I used to think has changed and I have a different mind-set now to teaching.

The module itself set the tone for me. It caused me to want to learn and be active in the lectures. I feel that was a great motivation that stirred me up and caused a transformation in my teaching and my thinking. If I am motivated and have the tools to accomplish a task then I feel that my thinking is different and I am able to think outside the box. I feel that this type of thinking is important when teaching environment and sustainability education.

c) This professional development made me realise how important it is to make learning fun for learners. If they are having fun then learning is not seen as a chore or something difficult. Innovation is a way to do this. I am a different teacher now and prior to this professional development I was not interested in attending other programmes like this because I knew how useless it was. But more modules like this one will make me become an even better teacher. I want to be innovative all the time. I don't think I will ever go back to the way I was teaching.

Participant 9

Question 1

a). I learnt a lot from this professional development module, even though I have been teaching for so many years. I have gained knowledge that can use in my teaching of all subjects not only science. I believe that this kind of professional development is extremely useful to all teachers, even those teaching for many years. I feel as though my personal capacity has been increased through this module. The knowledge that I gained that there are alternative methods of teaching environmental education. I feel motivated by that.

The lecture venue was well structured and conducive to learning. That made it easy to listen and respond to questions. The notes that were given to us were very helpful and gave me a lot of new knowledge. Unfortunately I am in a school that is not very open to innovation. There are a number of contextual factors that restrict me. The school management is very strict and old fashioned. There are not many opportunities to try new methods of teaching or assessment.

The structure of the module helped me become more confident in planning and teaching lessons on environment and sustainability education.

b). I was motivated by the approachable nature of the lecturer. She always provided support and guidance during lectures and was available for consultations.

The lecturer did monitor our progress through the assessment activities and the group discussions that we had conducted.

The collaboration with peers was really helpful as we discussed and worked through certain issues that we were experiencing. The group work was very useful and I learnt a lot from my peers.

c). I do feel that I have the capacity to be innovative but because of the contextual factors at my school I do not have the opportunity or freedom to be innovative. If I was at a different school I would be able to apply that knowledge I have gained.

Because of my many years of teaching I am confident in teaching content related to environment and sustainability education, but this professional development module has increased my confidence to plan and teach this section so that all learners benefit. But previously I rushed through the section on environment and sustainability education just to get through it. The CAPS document was also not very helpful because it does not give any guidelines to help teachers be innovative. It actually doesn't state that innovation is a requirement for teaching science.

Question 2

a). I gained knowledge of how to plan and teach content in different ways. I now feel that it is important to teach using different methods that are attractive and interesting for learners. The way you should teach learners must be thought-provoking.

I am now confident that I can teach a lesson involving role play, posters or even presentations. I learnt that these different methods of teaching greatly help learners make a connection between what they are learning and their personal lives.

Unfortunately I did not actually teach an innovative lesson for this module due to the school I am in. I taught a more traditional lesson because of the lack of resources at my school, the lack of support from my HOD and the poor work ethic of learners. But if I had the opportunity then yes I do feel that I can confidently teach an innovative lesson and also apply innovative assessment strategies. I possess the capacity but I don't have the opportunity to apply what I know.

Question 3

a). I did not use the resources at my school because there are none. Learners share textbooks so teaching is slow and difficult. One textbook was unclear and was very useless I felt. We use the old system of chalk and talk without any new or innovative methods of teaching. We do not have a science lab or a computer room for learners to use. We also don't have a library that the learners can visit to read up on anything related to their education. All of these factors make it incredibly difficult to teach an innovative lesson or lessons. The learners at the school are also not very enthusiastic and getting them motivated to work is a challenge.

b). There are several barriers to learning at the school I am in, especially the lack of resources as I have already mentioned. The school is not open to new ideas and often teachers are in conflict with each other if one has done a certain activity with only one class in the school and not the other classes of the same grade. Teachers get upset if you try something new or different because I think they feel you are making them look bad. The management of the school is very stiff and lack a lot of foresight.

I have learnt how to be innovative and I have also identified the need for innovation, but in the school that I am currently teaching there is no room for innovation due to the contextual factors such as learner apathy, teacher conflicts and the lack of resources. The HOD is strict and instructs teachers to teach according to the methods he prescribes. Even if I do want to teach an innovative lesson other teachers are upset as I only did the lesson with my class. So I don't see myself being innovative in the school I am in. I had no resources so I chose to teach a lesson that had no innovation and that was just using the chalkboard.

c). The school is in decline and they do nothing about it. I suppose it is because many of them are nearing the end of their teaching careers and feel as though the decline of the school is not really their concern. This kind of attitude has filtered through to the teachers as well as the learners of the school and makes innovation almost impossible. There is no support for a teacher wanting to innovative from the HOD or subject advisor. Younger teachers at the school are also following the same direction as the older ones and not interested in making a difference. I don't really blame them. I do have the capacity to innovative because of this professional development module, but I have to freedom to do so.

Question 4

The school is the biggest constrain. The management, teachers and learners are not open to change. Prior to this professional development I did not have the capacity or the motivation to be innovative. I was comfortable teaching the way I was for many years, but now this professional development has inspired me to be an innovative teacher. Unfortunately I don't have the chance to do that.

The learners don't want to work so the teachers just do the bare minimum and nothing more. They use the old orthodox methods of teaching that do not involve any innovation. The school does not promote an environment that allows innovation. The lack of resources is a real deterrent and it is because of this I cannot be an innovative teacher. The lack of support from management is also hard to get over. They don't see the need to improve the teaching methods in the school. I am unable to overcome the constraints and it stops me from being innovative.

Question 5

This professional development gave me the tools I needs to be an innovative teacher. The notes and the course material were extremely well constructed and very helpful. I am now a more confident even though I don't have the opportunity to be innovative in my teaching. I feel that my thinking and the way I view my own teaching has been transformed. I have attended other workshops and found it boring. Just going for 2 hours for a workshop can't really help me to be a better teacher all it does is give me more work when I get back to school to catch up syllabus. If I learnt something useful then I would not mind. But this professional development was different.

I feel motivated; I was very motivated before this professional development. I think I was caught in the cycle of teaching and not interested in changing. But now I am open to change and I realise that my old methods of teaching will not work in this new generation. I feel that if I move to another school, my new mode of thinking will propel me to be innovative in my teaching and I can be an innovative teacher. I now know that innovation is a necessity if you want to teacher environment and sustainability education successfully. I feel empowered by this professional development and will advise other teachers to get involved in other module just like this. I am empowered by this module and will strive to be innovative in whatever curriculum I am asked to teach.

Participant 10

This professional development opened my eyes to strengths and weaknesses I never knew I had. I must state at the outset that the school I teach at is very under-resourced and the management of the school is against teachers experimenting with new or unique methods of teaching, especially young teachers. Teaching environment and sustainability is very difficult I must say. To teach it is hard, I struggled to find a method that simplified the concepts for learners to understand.

During this professional development I discovered that it is possible to teach environment and sustainability education in an exciting and innovative manner. I never knew this previously. I think it is because I got so used to teaching in the normal way at my school and did not explore the other options that are out there. My capacity to innovate has been greatly increased. I can say that I never had a capacity to innovate before this module and now I am able to be an innovative teacher. I realised through this model that the way I was teaching is really not effective and is not benefiting the learners. This professional development increased my confidence to be innovative although I don't have the opportunity to do it at my current school. But even so, I have a new desire and passion to teach environment and sustainability education in a new way using the knowledge and skills I have gained from this module. But we only learnt about innovation in this one module and I think there were opportunities for us to learn about innovation in other modules.

I felt the lectures were well constructed and presented very well. I feel that the presentation of the lectures set the tone for what was to come. It made learning very easy and the atmosphere was created for us to develop. Sometimes the atmosphere at the workshops we attend are so drab and dull that you don't feel like attending. But this module made me want to attend and want to learn something new.

The resources given to us in the form of notes and handouts were very helpful and contained new knowledge for me. I liked reading it because it contained new knowledge and not something I already knew. I particularly enjoyed working in groups with the other teachers. This provided an opportunity to them from each other, but also to gather if they were experiencing challenges similar to your own. I found that many teachers had similar challenges to me as we taught environmental education and as we discussed our issues we were able to find solutions. I was able to pick up innovative strategies of teaching and assessing certain concepts. The way the professional development module was structured made it possible for me to learn and be motivated by my peers.

The facilitator was always on hand to provide support and guidance. This in itself was a motivating factor that if you had a problem you knew there was someone to assist you. She monitored our progress and checked the activities we had to complete.

I do feel that I would be able to teach environment and sustainability in an exciting and innovation manner if I had the opportunity. I know my capacity to innovate has increased but I am still not able to do so at the school I am in. If I moved to a different school I would be

happy to teach innovative, interesting lessons that really captured the attention of learners. I now have the skills and the knowledge.

In this professional development I learnt that the old fashion methods of assessment do not work when teaching environment and sustainability education. From my own experience I know that learners do feel it boring but I had no other way to teach it. But now I do know of other more exciting methods of teaching this content because of this professional development. I learnt that learners find it difficult to understand concepts when taught and assessed with orthodox methods. But if you use exciting, innovative and attractive methods learners start performing better and improving their results. From the group discussion that I had with peers during this module I picked up that presentations, posters, role plays and outdoor learning are good methods of teaching environment and sustainability education, and learners respond positively to these innovative methods. If I had not gone through this professional development I would have not have even thought of attempting such types of teaching and assessment methods.

As I said earlier I do feel that this professional development has motivated and given me confidence to try innovative methods of teaching and assessment. But I do still have the contextual factors at my school that don't allow me to be innovative. It is really depressing to know that I have such exciting ideas for my teaching but I am restricted and not allowed to even try and make learning more exciting for learners. The management are not happy when learners are outside of the class because their behaviour is so bad. So methods like outdoor learning will not be allowed and I found, from my peers, that this type of strategy works very well with the content in environment and sustainability education.

The resources given to us during this module laid a foundation for us to build knowledge on. Before this professional development I would have not thought about using other methods to teach environment and sustainability education. I was content teaching and assessing learners using the normal formal methods. But now I feel confident to try a role play or outdoor learning.

My school is not functioning, it is declining and majority of the staff do not care. Teachers attend school and walk out without making a difference to learners. I am not allowed to be innovative by the HOD and the staff who believe that our learners are not worth it. I have tried to introduce some innovative methods but with little success. I don't think I will be able to use the knowledge gained in the Honours module.

The school I am in is highly under-resourced. There are limited textbooks, no labs, no computers and the library has only outdated books. There is no media centre for learners to conduct research and this is something learners are always complaining about. The management of the school is weak and don't see that need for the school to make any advancements towards technology. It is amazing that one school can be moving with technology and another school can be so far behind technology, and yet both schools are teaching the same syllabus. My HOD is not open to teachers trying new methods in the classroom. If you try a new method other teachers are upset and question you about it

because it is not happening to all classes. It's hard but I don't have support from the management, some help when I am stuck would benefit my teaching. This stifles me and I cannot be innovative. I was unable to teach an innovative lesson so I just taught a normal lesson without any resources; I used only the chalkboard and the one textbook. I just do my job and don't try anything new because I don't want to rock the boat as such. I think that the narrow-minded thinking of the school has impacted on the learners and they also are not willing to work hard or smart. This is a real barrier that I cannot overcome and I will say that I am not practicing being and innovative teacher because of these contextual factors.

I do feel that I have undergone a transformation in my thinking and in my teaching practice, even though I cannot show it yet. This professional development has transformed me and I am motivated me be innovative in my teaching. The way I see concepts in environment and sustainability education now is totally different to how I viewed them previously. I have confidence now and the capacity to plan and successfully teach environment and sustainability education. I have realised that my old ways of teaching will not work and if I don't change then I will not be an effective teacher.

This effective professional development has shown me how to be an effective, innovative science teacher. I strongly feel that more professional development like this must be conducted with teachers from all subjects because it is something that can change the face of education in South Africa. Hopefully in the future I am in a school that is well resourced and the management is supportive of teachers being innovative because I am very motivated to teach innovative lessons on environment and sustainability education. I used to teach in one way but now after the Honours module, I can be an innovative teacher. Professional development like this module is worthwhile, unlike the workshops the department schedules for teachers. The workshops never taught me anything and I lost out on time to teach. I asked my HOD not to ask me to go for the next workshop because I lose out on time to teach as well.

APPENDIX 12

TO WHOM IT MAY CONCERN

CRITICAL READING OF PHD THESIS BY RAEESA ISMAIL

EXPLORING HOW SCIENCE TEACHERS ENGAGE IN CURRICULUM INNOVATING IN ENVIRONMENT AND SUSTAINABILITY EDUCATION

This is to verify that I undertook a critical reading of the above thesis and have discussed the necessary recommendations with the student.

R Sookrajh (Honorary Professor)

Edgewood Campus

University of KwaZulu Natal

DURBAN

APPENDIX 13

PONTE Since 1945 Florence, Italy
International Scientific Researches Journal
Via L.Mascagni, 10/12. FLORENCE, ITALY

PJ-X7ZM4
3 August 2016

ACCEPTANCE LETTER

Dear Author(s),

We are pleased to inform you that your paper,
Entitle: **'NAVIGATING BEYOND THE BOUNDARIES OF ROUTINE PRACTICE: TRACKING SCIENCE TEACHERS MOVEMENT INTO THE ZONE OF FEASIBLE INNOVATION THROUGH PROFESSIONAL DEVELOPMENT'**
Author(s): **Ronicka Mudaly,Raeesa Ismail**
has been accepted for publication in **PONTE Journal** after the peer-review process. It will be published in an upcoming issue (**Vol. 72, Issue 8**) and available on the PONTE Journal website.
Also the DOI link of your paper is: http://dx.doi.org/10.21506/j.ponte.2016.8.8
Thank you for submitting your paper to this journal.

Sincerely yours,

Dr. Maria E. Boschi
Editor-in-Chief
PONTE International Scientific Journal

Southern African Journal of Environmental Education

Environmental Learning Research Centre, Rhodes University, PO Box 94, Grahamstown, 6140, SOUTH AFRICA
Tel +27-(0) 46 603 8390; Fax +27-(0) 46 622 8028; elrc@ru.ac.za; eeasa@eeasa.org.za

21 December 2016

Att: Ronicka Mudaly and Raeesa Ismail

Dear Ronicka and Raeesa

Acceptance and publication of your research paper in the Southern African Journal of Environmental Education, Vol. 32 (2016)

We have received your revised contribution to the *Southern African Journal of Environmental Education* (SAJEE), Volume 32 (2016). This letter serves to confirm that your paper entitled, **'Professional development in environment and sustainability education: Voices, practices and reflections of science teachers',** has been peer-reviewed and accepted for publication in the 2016 volume of the SAJEE. The *Southern African Journal of Environmental Education* is an accredited journal with the Department of Higher Education and Training in South Africa.

This edition of the SAJEE will be uploaded on the open access Africa Journal Online platform by March, 2017 (www.ajol.info/index.php/sajee). You will receive a PDF copy of your paper once it is ready for uploading.

We thank you warmly for your contribution.

Yours sincerely,

Prof Eureta Rosenberg (Editor-in-Chief),

With Dr Ingrid Schudel, Prof Chris Reddy & Prof Lesley le Grange
(Guest Editors of SAJEE Special Edition).

Please note that as the SAJEE is now an online publication the new ISSN details are as follows:

ISSN 2411-5959 Key title: Southern African Journal of Environmental Education (Online)
Abbreviated key title: South. Afr. j. environ. educ. (Online)

APPENDIX 14

Turnitin *Originality Report*

- Processed on: 09-Jan-2017 9:52 AM CAT
- ID: 757611029
- Word Count: 56278
- Submitted: 1

Exploring how Science Teachers Engage in Curriculum Innovating in Environment and Sustainability Education ... ***By Raeesa Ismail***

Similarity Index
10%
Similarity by Source
Internet Sources:
5%
Publications:
3%
Student Papers:
5%